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## **Abstract**

Green space has beneficial impacts on health, and there is increasing interest in how to modify green space in order to promote use. We identified effective behavior change techniques in environmental interventions that aimed to encourage use of green space. Fifteen studies met the inclusion criteria. Interventions were coded by reviewers using the Behavior Change Technique taxonomy (BCTTv1). Eleven studies reported an increase in green space use post-intervention. Techniques involving physical environment changes ('adding objects to the environment' or 'restructuring the physical environment') were commonly delivered alongside additional techniques such as 'restructuring the social environment', introducing 'prompts or cues' and 'demonstration of the behavior'. Risk of bias was high or unclear for all, and the quality of evidence was very low. Intervention content was poorly described according to current reporting guidelines. More rigorous evaluations of green space interventions are needed, coupled with full descriptions of intervention content to allow replication.

## Introduction

Numerous health benefits have been linked to contact with green space, including improved self-perceived health (Maas, Verheig, Groenewegen, de Vries, & Spreeuwenberg, 2006), reduced risk of low birth weight (Dadvand et al., 2014), reduced cardiovascular mortality (Gascon et al., 2016), improved general mental health (de Vries, van Dillen, Groenewegen, & Spreeuwenberg, 2013), and reduced likelihood of depressive symptoms (McEachan et al., 2015). Four main mechanisms for this relationship have been identified: improved air quality, opportunity for physical activity, facilitation of social contact, and stress reduction and attention restoration (Hartig, Mitchell, de Vries, & Frumkin, 2014).

The health benefits of green space may be moderated by socioeconomic status, with lower socioeconomic groups seeing greater benefit (Dadvand et al., 2012; McEachan et al., 2015). As a result green spaces are increasingly recognized as a valuable resource for health promotion at a population level (Lee & Maheswaran, 2011), which may be useful as a tool to reduce health inequalities (Mitchell & Popham, 2008).

Lee, Jordan, and Horsley (2015) argue the green space associated health benefits are more likely a result of the activities undertaken in green space rather than simply provision per se. In other words, the health benefits of green space are brought about by its functionality and its use rather than presence alone. Moreover, White et al. (2016) calculated that over 8 million adults in England undertake physical activity in natural environments each week, demonstrating how green spaces might be actively used to improve health. It is therefore important to understand how a green space might be optimized in order to encourage use.

Environmental interventions on green space offer clear potential to target a large population. Understanding how a green space might be designed or adapted to maximize the potential health benefits is useful for many disciplines that have an interest in modifying open

space to improve health, including public health professionals and urban planners. Previous research into physical activity in urban green space has indicated that interventions that involve physical activity programs combined with a built environment change are likely to produce positive results (Hunter et al., 2015). At present there is little guidance beyond this broad recommendation on what changes in a green space might be effective. One challenge is the degree to which intervention components are adequately described. If one wishes to replicate successful interventions it is imperative that there is a clear description of the ‘active ingredients’. Recently there have been moves to standardize the terminology associated with description of intervention. The BCT Taxonomy v1 (BCTTv1) is a generalizable nomenclature of behavior change techniques developed to specify the ‘active ingredients’ employed in complex interventions (Michie et al., 2013).

In addition, the value of community involvement in developing and maintaining changes to green spaces is increasingly recommended to ensure their sustainability (Buck & Gregory, 2013; Faculty of Public Health, 2010), but little research has examined how effective this is in practice (Derose, Marsh, Mariscal, Pina-Cortez, & Cohen, 2014).

At present there is little understanding of what changes might be made to green spaces to encourage use, and to what extent involving the community in deciding on these changes leads to a more effective intervention. The aim of this review is to identify previous environmental interventions whose goal was to encourage use of green space, and describe the behavior change techniques implemented. A secondary aim was to examine the effectiveness of community input in the intervention design process. The final aim of the review was to evaluate the quality of the evidence available.

## **Method**

This review followed PRISMA guidelines (Moher, Liberati, Tetzlaff, Altman, & PRISMA Group, 2009) and was registered on PROSPERO (registration number: CRD42015017665), where the protocol is detailed.

### **Search strategy**

A literature search was conducted on four databases using OvidSP: PsycINFO, Medline, Global Health and Embase from inception to August 2016. Search terms were related to ‘adults’, ‘intervention’, ‘use’ and ‘green space’ (see supplementary Figure S1 for search strategies). Records were downloaded to EndNote bibliography software and duplicates removed.

Reference lists of studies screened at full-text level were searched for additional studies. Appropriate websites identified between reviewers were also searched for relevant resources (see supplementary Table S1). Where only an abstract or presentation of a potentially suitable study could be found from the databases searched or online, the authors were contacted directly for further information. Authors were also asked about other studies suitable for inclusion.

### **Study selection**

Studies were eligible if they: reported an environmental green space intervention was delivered with a measure of use as an outcome, change in use of green space was compared at baseline and post-intervention and/or with a control, non-intervention green space and; had a study population over 18-years-old. Studies with children only were excluded as children’s park use is likely guided by parental preferences (Veitch, Bagley, Ball, & Salmon, 2006), and so are not responsive to environmental interventions in the same way. Abstracts and conference proceedings were excluded. No geographical area was excluded, however only studies written in English were considered. Green space was generally understood as

‘amenity’ green space, e.g., parks and trails. Green space with an explicit function was excluded, e.g., cemeteries, school grounds and community gardens. Interventions were understood to be environmental when the natural or built environment was altered in some way. Studies with additional intervention content beyond the environmental changes were also eligible.

A total of 1649 studies were returned following the database search. After removing duplicates, 1255 records were screened at the level of the abstract then 114 at the level of full-text by one reviewer (see supplementary Figure S2 for a flow diagram). A second reviewer screened at random a 20% sample of the full texts for inclusion ( $n = 23$ ), and perfect inter-rater agreement was achieved ( $\kappa = 1.00$ ).

### **Data extraction**

Key study characteristics were extracted using a standardized form by one reviewer. The study design, method(s), outcomes and outcome measures, findings and conclusions were noted. Intervention and control group descriptions were noted verbatim for further assessment. Six studies from a total of 17 were double data extracted by two independent reviewers. The results were discussed and deemed to be consistent between reviewers.

Risk of bias was assessed using the Cochrane Risk of Bias tool (Higgins et al., 2011). This tool was developed primarily for randomized controlled trials (RCTs), which may be difficult to carry out within this line of research. Nevertheless, the tool may be used for non-randomized studies as it demonstrates where weaknesses are present in the current literature.

Quality of evidence was assessed using the ‘Grading of Recommendations Assessment, Development, and Evaluation’ (GRADE) approach (GRADE Working Group, 2004). This approach offers a standardized way of rating the quality of evidence and is applicable to both clinical and wider public health settings (Guyatt et al., 2011). This approach considers risk of bias, consistency of results, indirectness, imprecision and effect size, and publication bias.

These indicators were discussed for each outcome between reviewers until consensus was reached. Papers were not excluded based on quality due to the limited number of studies eligible for inclusion in this review, but the level of quality is an aspect included in the Discussion.

### **Data synthesis**

Following consideration of the outcome measures, the results were deemed too heterogeneous for a meta-analysis. Interventions were coded using Michie et al.'s Behavior Change Technique taxonomy v1 (BCTTv1) (2013), to facilitate comparison of behavior change techniques employed across studies. Three reviewers completed coding independently, and any disagreement was resolved by discussion (see Table 1 for a full categorization). Studies were also coded for co-design of the intervention. Co-design was understood as whenever the local community was consulted during the design process.

### **Results**

Of 1649 articles identified in the database search, 1255 records were abstract screened and 114 were screened at full-text level. Ten articles met the inclusion criteria and seven were retrieved through the grey literature search (see supplementary Figure S2). One was identified after searching the reference lists of full-texts. Following a search of relevant websites, one full-text public report was found on the Natural England website, and two were found after identifying relevant presentations on the Active Living website. Lastly, three were obtained where the returned abstract was deemed appropriate but the full-text could not be found and the author was contacted.

In total, 17 papers reporting 15 studies were identified for review. Two studies were reported in both a peer-reviewed journal and a public report; the peer-reviewed article is referenced throughout this review (Mowen, Hickerson, & Kaczynski, 2013; Veitch, Ball, Crawford, Abbott, & Salmon, 2012).

## Study characteristics

Key study characteristics are detailed in Table 2. Thirteen studies had a quasi-experimental pre-post design: eight were controlled (Cohen et al., 2009, 2015; Cohen, Marsh, Williamson, Golinelli, & McKenzie, 2012; Gidlow, Ellis, Smith, & Fairburn, 2010; Mowen et al., 2013; Slater, Pugach, Lin, & Bontu, 2016; Tester & Baker, 2009; Veitch et al., 2012) and five had no comparator (Bell & Austin, 2014; Cranney et al., 2016; King, Litt, Hale, Burniece, & Ross, 2015; Reed, 2013; Reed, Grost, & Mantinan, 2010). One study ran a randomized control trial (RCT) (Cohen et al., 2013) and one study measured a comparator at post-test only (Cohen et al., 2014). Eleven studies were conducted in the US, many of which were by the same group (Cohen et al., 2009; Cohen et al., 2012; Cohen et al., 2013; Cohen et al., 2014; Cohen et al., 2015). Three occurred in Australia (Bell & Austin, 2014; Cranney et al., 2016; Veitch et al., 2012) and one in the UK (Gidlow et al., 2010).

In 13 studies, green space use was measured using the System for Observing Play and Recreation in Communities (SOPARC), a validated direct observation tool that assesses park users' physical activity levels, gender, activity mode/type, estimated age and ethnicity (McKenzie, Cohen, Sehgal, Williamson, & Golinelli, 2006). Gidlow et al. (2010) adapted a version for the UK. Twelve studies utilized self-report techniques such as surveys; one study carried out surveys only (Mowen et al., 2013).

A risk of bias table and graph are shown in supplementary Figure S3. Cohen et al. (2013), the only study to run an RCT, was designated with a low risk of bias in terms of sequence generation but it is not known if those involved in allocation were aware of intervention assignment to the green spaces. The remaining non-randomized studies received a high risk of bias in terms of sequence generation and allocation concealment. All studies were highly biased in terms of failing to blind participants and outcome assessors; this was expected as blinding participants is impossible within this context. All studies received an



unclear risk of bias in terms of attrition: it is not clear at follow-up who is a new user and who experienced the intervention. Some studies were noted for reporting bias when, e.g., outcomes reported in a public report were not reported in a peer-reviewed article (Mowen et al., 2013), or results that were not significant were not reported (Reed et al., 2010). Further bias was attributed to three articles when the intervention delivery deviated from protocol: control parks received the intervention between baseline and follow-up (Slater et al., 2016), some intervention parks and control parks received new equipment when this was not a part of the intervention (Cohen et al., 2013), and unforeseen budget cuts reduced activity programming (Cohen et al., 2009).

Supplementary Figure S4 shows the quality of evidence as assessed using GRADE guidelines. The RCT (Cohen et al., 2013) received a ‘moderate’ rating as the study was seen to be suitable for our research question and a small effect was calculable, albeit risk of bias was serious. The observational studies that used SOPARC to measure use were given a ‘very low’ quality rating. They were seen to be highly biased, the results were inconsistent and no effect sizes were reported, leading to serious imprecision. Studies where use was self-reported in a survey also received a ‘very low’ quality rating for high risk of bias and inconsistent results. Imprecision was seen as not serious for these studies due to the typically large sample sizes, ranging from 209 (Gidlow et al., 2010) to 15,262 (Cohen et al., 2013).

### **Intervention effects**

Interventions were delivered in a total of 136 green spaces across the 15 studies. One hundred and one green spaces reported across 11 studies experienced an increase in use post-intervention (Bell & Austin, 2014; Cohen et al., 2009; Cohen et al., 2012; Cohen et al., 2013; Cohen et al., 2014; Cohen et al., 2015; King et al., 2015; Reed et al., 2010; Slater et al., 2016; Tester & Baker, 2009; Veitch et al., 2012). The remaining interventions resulted in either a decrease in use or the results were different between objective and self-report measures. The

outcomes of 17 of a total 31 green spaces studied by Reed et al. (2010) were not reported as the results were not significantly different from baseline, and are not referred to hereafter.

Overall the majority of study parks experienced an increase in use following the intervention.

### **Intervention coding**

Interventions typically were comprized of two behavior change techniques (see Table 1). The maximum number of techniques delivered in one intervention green space was seven. ‘Adding objects to the environment’ was identified in 108 green spaces covering all studies, and ‘restructuring the physical environment’ was coded in 22 green spaces in 11 studies. These techniques are defined as adding to or changing the physical environment in some way so as to facilitate performance of the wanted behavior. In this context such techniques encourage use of the green space, and may take the form of the addition of new fitness equipment or the upgrade of an existing play area.

‘Restructuring the social environment’ was identified in 87 green spaces in 10 studies. This restructuring is defined as making changes to the social environment that facilitate performance of the wanted behavior, and was typically identified when use of the green space was marketed through outreach events or meetings were held with residents to raise awareness of the intervention and contribute to the design. ‘Prompts or cues’, usually represented by new information signs and posters within the green space, was coded in five studies, and ‘demonstration of the behavior’, whereby an observable sample of the behavior is provided, was coded in eight studies. A new or updated activity program was seen as providing an observable sample of the behavior. ‘Instruction on how to perform a behavior’ was coded twice and a further five were identified once (see Table 1).

## **Environmental changes**

The technique ‘adding objects to the environment’ was employed in isolation in 15 parks across three studies (Cohen et al., 2012; Reed et al., 2010; Tester & Baker, 2009). Results were mixed: eight parks experienced an increase in use, and seven a decrease. Cohen et al. (2012) added fitness zones to 12 parks in Southern California. At follow-up 12 months after baseline, six of the parks experienced an increase in users, and six experienced a decrease. Overall there was an 11% increase in users from 7105 to 7906. They note the parks with the increase in use were primarily those with a larger surrounding population density. At second follow-up a few months later, the number of users was similar to baseline (7017).

This technique was combined with ‘restructuring the physical environment’ in 6 green spaces reported in 3 studies (Cohen et al., 2014; Reed et al., 2010; Veitch et al., 2012). Five had an increase in use and one a decrease. The changes were substantial, particularly in Cohen et al. (2014), where vacant lots were converted into pocket parks. Use increased from three users in one space and none in the other two to 32, 147 and 267. Veitch et al. (2012) described an intervention whereby a leash-free area for dogs, a playground, walking track, BBQ area, and additional fencing were installed and gardens were landscaped. Use increased from 235 at baseline to 985 12 months later. On the other hand, Reed et al. (2010) report a park where a basketball court was repaired and a walking path was installed; use fell from 474 to 176.

Altogether these findings suggest that upgrading existing infrastructure as well as providing new equipment may be more effective than adding new equipment alone. However, the number of green spaces where only these changes were made is limited, and so no strong conclusion can be made.

### **Other behavior change techniques**

In seven intervention green spaces, either one or both behavior change techniques whereby the physical environment is altered were combined with ‘restructuring the social environment’ only (Cohen et al., 2009; Mowen et al., 2013; Tester & Baker, 2009). Of these seven, three had an increase in use. One park studied in Tester and Baker (2009) experienced a nine-fold increase in the number of adult visitors, and two of the five parks investigated by Cohen et al. (2009) experienced an increase. The remaining three in Cohen et al. (2009) had a drop in use post-intervention; the authors’ state there was a decline in organized activities from baseline to follow-up, and the drop in those observed in organized activities accounted for 39% of the total decline in the average number of park users. Findings were conflicting for Mowen et al. (2013): there was no significant change in self-reported frequency of park use, however, 54% of respondents (who had visited the park prior to the renovations and were aware of the renovations) said they perceived they visited the park more often because of the changes.

A physical environment change was augmented with a ‘prompt or cue’ in two parks and two trails reported on in one study - Reed et al. (2010). A prompt or cue was also used in isolation on two trails in Reed et al. (2010). A prompt is understood to be an environmental or social stimulus that normally occurs at the time or place of performing the behavior. The authors’ report signage was added along the pathways within these green spaces, and all green spaces experienced a significant increase in use. This indicates a prompt or cue may be an effective intervention within this context, however the evidence is limited.

Interventions in 46 green spaces in eight studies were coded for ‘demonstration of the behavior’ (Bell & Austin, 2014; Cohen et al., 2015; Cranney et al., 2016; Gidlow et al., 2010; King et al., 2015; Reed, 2013; Slater et al., 2016; Tester & Baker, 2009). Ninety-five percent of these spaces ( $n=42$ ) experienced an increase in use. Gidlow et al.’s (2010) results were

mixed: while the proportion of respondents who self-reported using the park up to once a week increased from 15.4% (winter) and 17.3% (summer) to 24% and 30.6% respectively, direct observation indicated use had declined. In Reed (2013), direct observation indicated use had increased by 163% in the first trail and 16% in the second, although self-reported outcomes were unclear. In both trails, the proportion of residents who indicated regular use during the week dropped; it is unclear whether this is because more people reported very frequent use, or infrequent use. Cranney et al. (2016) reported a decrease in overall use (8560 at baseline and 7097 post-installation). On the other hand, the proportion of renovated outdoor gym users of all park users doubled from baseline to post-installation and this remained significantly higher compared to baseline for male children and seniors at follow-up. An evaluation of this technique is precluded as in all studies it was delivered in conjunction with multiple other techniques.

Cohen et al. (2013) was the only study coded for ‘material incentives’, whereby 18 of 33 intervention parks provided incentives such as giveaways, alongside new signage and materials for activities. Intervention parks saw a relative significant increase at a magnitude of 7-12% ( $p = .035$ ) and use of the control parks declined ( $p = .06$ ) albeit it is not clear whether this technique is more or less effective than those it was delivered alongside.

### **Community co-design**

Twelve studies reported on interventions that were co-designed with input from the local community (all except Cohen et al., 2012; Cohen et al., 2014; Cranney et al., 2016). This typically involved meetings with local residents and organizations to understand their needs and obtaining their feedback on designs. For example in King et al. (2015), residents were asked to produce a ‘wish list’ for their park and voted on their favorite suggestions. The results were shared with a subset of community members who designed three different park

plans which were again put to a vote. King et al. (2015) report an increase in use from 2888 in 2010 to 4225 in 2012.

Overall 109 of 120 spaces that received community co-designed interventions experienced an increase in use. Moreover, of the studies that did not involve the community, almost half of the intervention spaces ( $n=7$  of 16 in total) saw a decrease in use post-intervention. This suggests the community co-design of an intervention may produce more effective results.

## **Discussion**

This study systematically reviewed literature on environmental interventions on the use of green space. One hundred and one of a total 136 green spaces covered by 15 included studies demonstrated an increase in green space use post-intervention, suggesting environmental interventions may be effective. ‘Restructuring the physical environment’ as well as ‘adding objects to the environment’, as opposed to solely adding a new object appeared to be more effective in encouraging use, although this is based on a small number of studies. Delivering a ‘prompt or cue’ alongside one of the physical environment changes also appeared to be effective, but again the evidence base was limited.

Most interventions were comprised of multiple behavior change techniques, meaning it is difficult to isolate their effectiveness - it may be one technique influencing use or a combination. This limits the ability to make specific recommendations for future interventions.

## **Study design**

One study conducted an RCT (Cohen et al., 2013) while the remaining studies were quasi-experimental. Ten studies measured a control that was matched by size, facilities and surrounding population characteristics. In several studies the control also went through changes between baseline and follow-up. For example in Cohen et al. (2009) it is stated the

park director of a control park scheduled additional baseball games during the intervention period, which drew in extra people. This directly contaminates the results, and it is not known to what extent this practice might have occurred in other studies. Additionally in some cases intervention and control parks were markedly different from each other. For example, in Veitch et al. (2012) the control park (10,000m<sup>2</sup>) was half the size of the intervention park (25,200m<sup>2</sup>). Ideally the control green space should be as closely matched as possible to the intervention green space.

All studies were assigned a high risk of bias except Cohen et al. (2013) which was given an unclear bias rating. This was primarily based on lack of allocation concealment, lack of blinding and unclear bias in terms of attrition. Allocation concealment and blinding of participants would be difficult within this area of research; however, outcome assessors may be blinded to reduce detection bias. Reporting bias due to under-reporting of data and other biases introduced due to deviation from protocol also affected the bias rating assigned.

Several biases within this area of research will be difficult to control as studies are often opportunistic. It is advised that studies make use of relevant guidelines to make reporting as transparent as possible, ensuring the study can be assessed and interpreted accurately. Standardization of reporting also improves the replicability of studies. The suggested guidelines for the most common study designs in this field are: CONSORT guidelines (Schulz, Altman, & Moher, 2010) for RCTs; STROBE guidelines (Von Elm et al., 2007) for observational studies and TIDieR for intervention studies (Hoffmann et al., 2014). These are informed by evidence and designed following expert collaborative effort.

### **Follow-up period**

Most studies collected post-intervention data 12 months after baseline. This ensured follow-up measurements were taken in the same season to reduce any seasonal difference. Some studies were vague as to when the intervention was complete, meaning it was unclear

how long it had been present when collecting post-intervention data. It is important to be exact about when the intervention was delivered as this can influence the interpretation of results.

Four studies collected post-intervention measurements at more than one time point. Cohen et al. (2012) and Veitch et al. (2012) observed use twice post-intervention: Cohen et al. (2012) at 12 and 15 months, and Veitch et al. (2012) at 3-4 months and 8-9 months. Cranney et al. (2016) had nine data collection periods: three at baseline, three immediately post-installation and three at 12-months after baseline. Finally King et al. (2016) measured use monthly for four months from June when the intervention was completed in the spring.

Multiple post-intervention observations may be worthwhile for future studies to understand intervention sustainability; however, it is important to note that seasonal changes are likely to impact the level of use and so scheduling should be done with this in mind.

### **Outcome measures**

Thirteen studies used SOPARC to measure park use (Bell & Austin, 2014; Cohen et al., 2009; Cohen et al., 2012; Cohen et al., 2013; Cohen et al., 2014; Cohen et al., 2015; Cranney et al., 2016; King et al., 2015; Reed, 2013; Reed et al., 2010; Slater et al., 2016; Tester & Baker, 2009; Veitch et al., 2012). SOPARC does not detail an observation schedule, leading to inconsistent use. In a recent systematic review of interventions to promote physical activity in green space (Hunter et al., 2015), the authors state a validated protocol is required to facilitate comparison of SOPARC across studies. It is also not known when using direct observation whether users had visited the park prior to the intervention; therefore restricting understanding of whether the intervention has encouraged new users.

Park use was also measured using household surveys (Bell & Austin, 2014; Cohen et al., 2009; Cohen et al., 2013; Cohen et al., 2014; Cohen et al., 2015; Gidlow et al., 2010; Tester & Baker, 2009; Veitch et al., 2012) or on-site surveys (Cohen et al., 2012; Cranney et al.,



2016; Mowen et al., 2013; Reed, 2013; Reed et al., 2010). Household surveys allow identification of both users and non-users, but are limited by poor response rates, and exclude those who live outside the designated buffer zone.

It is recommended that studies make use of both direct observation and surveys to capture both users and non-users, and balance objective and subjective measures.

### **Population characteristics**

Eleven studies were carried out in the US, three in Australia and one in the UK. Widening the geographic area of research would further our understanding of cultural differences in green space use. Eight studies reported their study area was located in an area of high deprivation or high proportion of ethnic minorities (Bell & Austin, 2014; Cohen et al., 2009; Cohen et al., 2013; Cohen et al., 2014; King et al., 2015; Slater et al., 2016; Tester & Baker, 2009; Veitch et al., 2012). It is important to include a description of the demographic characteristics of the study population, such as age, gender, ethnic origin and socioeconomic status. Previous research has indicated park use varies across these characteristics (Cohen et al., 2007; Herbert et al., 2015; Kaczynski et al., 2014). It is advised in relevant reporting guidelines, e.g., CONSORT, STROBE, that this information is included as it allows readers to judge the generalizability of the findings.

### **Intervention content**

Studies were coded for behavior change techniques using BCTTv1. The taxonomy was adequate in its purpose to identify behavior change techniques that appealed to individuals, e.g., ‘demonstration of the behavior’ as it was primarily designed for individual level interventions. However, the relevant environmental techniques (‘restructuring the physical environment’, ‘adding objects to the environment’) at present cover a potentially diverse set of actions that may be delivered in an environmental intervention. It is

recommended that the taxonomy is extended to allow for a more nuanced understanding of how the environment might be modified.

The quality of intervention descriptions was found to be poor. TIDieR guidelines (Hoffmann et al., 2014) recommend intervention descriptions include information on materials used. Several studies did not do this, for example, where new signage was installed, it was not specified what information was displayed. TIDieR also states the mode of delivery of the intervention should be outlined. Again, where some studies introduced an activity program, little or no information was given on how they were received or how many people participated. It is crucial interventions are outlined in sufficient detail for replication purposes.

### **Recommendations for researchers**

This review found the current literature on environmental interventions into the use of green space is biased and of poor quality. Given that multiple behavior change techniques were often delivered at once in the included studies, future research should look to explicitly test the techniques on an individual basis in order to understand the effect of a single technique within this context of encouraging green space use.

The intervention descriptions within the included studies in this review provided inadequate detail regarding exactly what was delivered, how and when. It is imperative to provide this information so that future studies may replicate successful interventions. It is encouraged that researchers make use of relevant reporting guidelines to raise the standard of reporting.

This review had substantial input from grey literature, indicating a potentially large practitioner knowledge base. It is advised that researchers expand their network and cultivate a multidisciplinary environment, from which existing knowledge can be drawn.

## **Recommendations for policy makers**

Providing rigorous evaluations of green space interventions currently is a challenge due to difficulties with randomization, matching control parks and collecting longitudinal data. The cost of implementing environmental improvements is usually borne by local authorities, meaning evaluators may have limited leverage to design, for example, randomized evaluations. Policy makers and funders are encouraged to prioritize more methodologically sound study designs.

This review also found the inclusion of the community in the intervention design process appeared to be beneficial in producing a more effective intervention. It is recommended that policy makers recognize the growing importance of community co-design and increase the opportunities for local communities to have a platform in intervention design discussions.

## **Conclusion**

There is a need to understand how environmental green space interventions might be designed to encourage use in order to promote health. One hundred and one of 136 green spaces covered by 15 studies experienced an increase in green space use following an environmental intervention, which is promising for future work; however the low quality of evidence means it is difficult to have confidence that this would be repeated in higher quality studies. Moreover the delivery of interventions that used multiple behavior change techniques limits identification of specific effective techniques. This limitation is compounded by a poor standard of reporting, and it is recommended that future studies make use of standardized guidelines to improve this.

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**Table 1**

*BCTTv1 Coding*

Author and Year	Study Area	BCTTv1 Coding											Outcome
		2.2 Feedback on behavior	4.1 Instruction on how to perform a behavior	4.2 Information about antecedents	5.1 Information about health consequences	6.1 Demonstration of the behavior	7.1 Prompts/ cues	10.1 Material incentive (behavior)	12.1 Restructuring the physical environment	12.2 Restructuring the social environment	12.3 Avoidance /reducing exposure to cues for the behavior	12.5 Adding objects to the environment	
Bell & Austin, 2014	Boreham Park	X	X			X	X		X	X		X	INC
	Schuhkraft Hub			X	X	X	X			X	X	X	INC
Cohen et al., 2009	5 parks								X (2/5)	X (5/5)		X (3/5)	MIX
Cohen et al., 2012	12 fitness zones											X	MIX
Cohen et al., 2013	33 parks						X (32/33)	X (18/33)		X (33/33)		X (32/33)	INC
Cohen et al., 2014	3 pocket parks								X			X	INC
Cohen et al., 2015	Hayes Valley					X			X	X		X	INC
	West Sunset					X			X	X		X	INC
Cranney et al., 2016	1 park		X			X						X	DEC
Gidlow et al., 2010	1 large green space					X	X		X	X		X	MIX
King et al., 2015	1 undeveloped green space					X			X	X		X	INC
Mowen et al., 2013	Allentown Park								X	X		X	MIX
Reed, 2013	Mary Black Foundation Trail					X	X		X	X		X	MIX
	Wadsworth Trail					X			X	X		X	MIX
Reed et al., 2010	Gladstone Park						X			X		X	INC
	Parkridge Park						X		X	X		X	INC
	Benjamin Davies Park									X			INC
	Hunter Park								X	X		X	INC
	Richland Park									X		X	INC

	Wilson Park				X	X	DEC
	Recreation Park				X	X	DEC
	Gladstone Trail				X	X	INC
	Manistee		X			X	INC
	Riverwalk Trail						
	Iron Ore		X		X	X	INC
	Heritage Trail						
	(Negaunee Trail						
	Head)						
	Iron Ore		X		X	X	INC
	Heritage Trail						
	(Ishpeming Trail						
	Head)						
	Big Rapids		X			X	INC
	Riverwalk						
	Kalkashka					X	DEC
	Northside				X	X	DEC
	Pathway Trail						
Slater et	39 parks	X				X	INC
al., 2016							
Tester &	Garfield Square	X			X		INC
Baker,	(Park A)						
2009							
	Silver Terrace						X
	(Park B)						INC
Veitch et	Venn Wright				X	X	INC
al., 2012	Reserve						

Note. INC, MIX, DEC refer to an increase, mixed result, and decrease in green space use respectively.

**Table 2**

*Key study characteristics*

Reference	Study Design	Country	Population	Intervention	Comparison	Outcome	Follow-up period	Outcome Measures	Risk of Bias
Bell & Austin, 2014	Quasi-experiment, uncontrolled, pre-post design	Wide Bay, Queensland, Australia	77% of the Wide Bay population in lowest two quintiles related to the Index of Relative Socio Economic Disadvantage (IRSD)	2 intervention parks; both held open days to gauge public opinion and suggestions. Changes organized into framework of: access, facilities, programs and enhancements	Baseline data from both parks collected via audits, systematic observations and household surveys	At Boreham Park, visitation increased from 170 at baseline to 562 at follow-up; at Schuhkraft Hub, visitations counts increased dramatically from 2 to a total of 231 across all data collection points.	Construction completed Feb and Mar 2014 at Boreham Park and Schuhkraft Hub respectively; park audits completed in immediate weeks following and systematic observations completed almost 3 months after re-opening	Park audits to assess physical environment; direct observation using SOPARC	High
Cohen et al., 2009	Quasi-experiment controlled, pre-post design	California, USA	Predominantly Latino and African-American; low-income; surveyed lived within 2 miles of park and recruited systematically	5 intervention parks: 3 parks had new gyms, 1 had refurbished gym and field improvements, 1 had improvements to picnic area, walking path and playground area	Comparison parks had no upgrades. Matched by size, features and amenities and served similar population as counterpart	On average, 2000 people seen using a intervention and control park per week at baseline, 1500 at follow-up	Baseline collected Dec 2003- Nov 2004; follow-up Apr 2006-Mar 2008	Direct observation of use using SOPARC; interviews with residents with a 2-mile radius	High
Cohen et al., 2012	Quasi-experiment controlled, pre-post design	LA, USA	Observed users of both the Fitness Zone spaces and all other park activity areas; systematically interviewed park users from busiest and least busy activity areas	12 parks had Family Fitness zones installed (outdoor gyms)(average \$45,000 for 8 pieces of equipment	10 matched control parks that did not install Family Fitness zones	Across the 12 parks, at first follow-up, difference represented 11% increase in users. At second follow-up, user counts similar to baseline	Baseline collected winter 2008-2009; follow-up in winter 2009/2010 and again in spring 2010	Direct observation of use using SOPARC; intercept survey on park use, perceptions of park	High
Cohen et al., 2013	RCT – parks were randomized into 3 study arms: park-director (PD) intervention (n=16), PAB/PD intervention (n=17) and a control arm (n=17).	LA, USA	Parks selected on racial/ethnic diversity within 1-mile radius; households for interview randomly selected within 1 mile of each park (25 in each stratum, totalling	Parks received \$4000 each to spend in ways they thought appropriate to increasing PA. PDs/PAB members given training on outreach and	Measurement-only control arm	Relative significant increase in park use in both PD-only and PAB/PD parks at magnitude 7-12% over 28 observations (p=.035). Use in	Baseline collected Apr 2008-Mar 2010; follow-up conducted Apr 2010-Apr 2012	Direct observation of use using SOPARC; survey of random residents within 1-mile of the park; interviews with users pre- and post-intervention	Unclear

	Randomized on park size, number of facilities and programs offered by the park and the socio-demographic characteristics of the population within a 1-mile radius		75)	marketing; purchases categorised into signage, promotional incentives and outreach and support for group activities			control parks declined 6-10% (p=.06). No significant difference between PD-only and PAB/PD parks	(n=75)		
Cohen et al., 2014	Quasi-experimental post-test only comparison	LA, USA	High rate of household poverty (30-41%); large minority population: Latino 70-80%, African-American 3-17%, Asian 0-16%; randomly sampled households within 0.25 mile of pocket park were surveyed – intercept surveys conducted within 0.5 mile where this was not possible	3 ‘pocket parks’ converted vacant lots and urban parcels. Less than 1 acre, limited facilities, few/no programs, lack indoor facilities, not fenced and locked when not open. All had playground equipment/ benches installed	Compared with playgrounds in larger (on average, 15-50%) neighbourhood parks that were matched to each of the pocket parks by the percentage of households in poverty		Pocket parks had significantly more users than comparison park playgrounds. After adjusting for all covariates, the comparison park playground areas had approximately 70% fewer users than the pocket parks on a daily basis	Baseline observations conducted mid-Jul and mid-August 2006; follow-up assessments in same season of 2008. Assessments of comparison parks during 2008-2009	Direct observation of use using SOPARC; survey on park use for residents and users	High
Cohen et al., 2015	Quasi-experiment controlled, pre-post design	San Francisco, USA	Interviews conducted with residents from randomly selected households within ½ mile of the park. If household could not be accessed, on-street intercept interviews were conducted.	In the two renovated parks, new play equipment was installed, landscaping and ground surfaces. Hayes Valley also added fitness equipment and a recreation centre	2 parks (Margaret Hayward and Boeddeker Park) were not renovated. Two further parks were continuing renovation – no significant change in use was noted.		In Hayes Valley, person-hour visits increased from 156 to over 1000 person-hour visits per week. Use of West Sunset increased from 5500 person-hour visits to more than 9,300 person-hour visits per week. In the comparison parks, combined number of visits declined by 49%.	Baseline data collected May 2009; follow-up data collected May 2012.	Direct observation using SOPARC; interviews with 75 parks users and 75 residents from randomly selected households within ½ mile of the park	High
Cranney et al., 2016	Quasi-experiment, uncontrolled, pre-post design	Maroubra, Sydney, Australia	Relatively high SES neighbourhoods, with some pockets of disadvantaged suburbs. Two-thirds of housing is medium to high density; one-third of residents speak a	Study park is 16.08ha. Outdoor gym installed at a cost of AUS\$60,000. Marketing and promotional strategies implemented to engage older adults in	Three data collection periods (Dec 2012, Jan 2013, Feb 2013) prior to installation of gym in March 2013.		23,905 park users observed during the study period: 8560 at baseline, 7091 at post-installation and 8248 at 12-month follow-up.	Immediate data collection post-installation in Mar 2013, Apr 2013, May 2013. 12-month follow-up from baseline in Dec 2013, Jan 2014,	Direct observation using SOPARC; interviews; environmental audits	High

			language other than English at home	use of the gym. A guide to use was produced and exercise sessions were held with a professional.			Feb 2014.		
Gidlow et al., 2010	Quasi-experiment controlled, pre-post design	Stoke-on-Trent, UK	Survey distributed to all households within 300m of the park	4.6ha site identified through focus group; intervention involved program of child/parent and youth activities, new natural play area and improvements to coppice area	Similar neighbourhood green space site (2.4 ha, adjacent to primary school), only included in baseline observation	Proportion who self-reported using the park rarely/never was lower at follow-up than baseline; observation data found lower levels of use at follow-up compared with baseline.	Baseline data collected spring 2009; follow-up data collected in spring/summer 2010. 12-month intervention ran July 2009-June 2010	Survey of green space use, perception and PA; focus groups for barriers/motivations; direct observation of use (4x1hr periods on 2 weekdays and Sat/Sun); audit of green space quality	High
King et al., 2015	Quasi-experimental, uncontrolled pre-post design	Denver, USA	Two acre undeveloped green space, situated between transitional housing for refugees	Community designed 'wish list' for the park and voted on best ideas. New park had a multi-purpose playing field for team sports, a play area with equipment, half courts for basketball, a shaded area, benches, a community garden and walking path	Baseline observations collected June-Oct 2010	Total count at baseline: 2888; total count at follow-up: 4525. Average monthly visitors observed using the improved park significantly increased from 180 to 651 (p=.002).	Park renovations completed spring 2012; follow-up data collected June-Oct 2012	Direct observation using SOPARC	High
Mowen & Hickerson, 2012; Mowen et al., 2013	Quasi-experimental controlled pre-post design	Allentown, Pennsylvania, USA	Centrally located park, often used for special events	109.6 acre regional park; investment in new playground, expansion and enhancement of the trail system, expansion of picnic opportunities, renovated trellis and walkway, improvements to park sculptures, additional parking and support amenities	Control park not slated for significant renovation	Few significant changes in short-term park visitation frequency (last 30 days) and length of stay between 2008 and 2011. Of post-intervention visitors, 54% stated they visited more frequently	Baseline data collected June-Sept 2008 and 2011 at intervention and control. Facilities upgraded in 2009-2010	On-site surveys conducted – used randomized sampling schedule to survey users at different times of day and week and throughout different park areas	High

Reed, 2013	Quasi-experimental uncontrolled pre-post design	Spartanburg, South Carolina	Observed park users (SOPARC); 13 adults in focus groups (all White, 10 college-educated, 92% lived within 1-mile of the trail)	Two trails – installed way-finding signs, initiated community education; implemented tailored programs; facilitate policy changes and capital improvements; convened Advisory Committee; assisted in soliciting funding to complete connection to elementary school; increased number of activities	4 observation periods on Wadsworth trail conducted pre-intervention (2010/2011); 15 quarterly observation periods conducted pre-intervention at the Mary Black Foundation Trail (2006/2009)	Wadsworth Trail saw 16% increase from 6615 in 2010/2011 to 7665 in 2012/2013 (adjusting for seasonality). Mary Black Foundation Trail experienced 163% increase from approximately 24,820 2006-2009 to approximately 65, 449 post-intervention	Initial evaluation from 2006-2009 (15 quarterly observations); secondary evaluation period post-intervention 2010-2013. Interventions administered 2010-2013	Systematic observation using SOPARC (4 times a day 4 days a week); intercept surveys on trails and focus group of users and non-users of the trail	High
Reed et al., 2010	Quasi-experimental non-control pre-post design	Michigan, USA	Intercept survey (n=876) and systematic observation cohort	Trails- building new trails, extending the distance of current trails, enhancements with trailheads, benches, signage and lighting, trail promotion with signage and building connecting trails between cities. Parks- extend length of trail, benches, signage, replaced play equipment, new bike racks, new or renovated walking path	Interviewer-administered survey conducted prior to interventions	Trails: 7125 users observed on 17 trails 2007-2009. Significant increase in use identified in five interventions. Two had significant decreases and 10 had no significant change. Parks: 4137 users observed in 14 parks. Five interventions had significant increases in park use. Two had significant decreases; the remaining parks had no significant change	Unclear – evaluation period from 2007-2009.	Systematic observation using SOPARC – 4 times a day for 4 days; intercept surveys on park use	High
Slater et al., 2016	Quasi-experimental, controlled, pre-post design	Chicago, Illinois, USA	Neighbourhood median household income ranged from \$12,333 to \$121, 541. 55%, 23%, 16% and 6% of study parks were located in predominantly African	Community groups went through application process to nominate their local playground and provide input on design and maintenance. Average	39 intervention parks; 39 matched control parks. Control parks mapped to select those that were similar in size and park features, and	Park utilisation significantly increased between baseline and follow-up in intervention compared with control parks at .05	Baseline data collected July- Oct 2013. 12-month follow-up period July-Oct 2014. Intervention installed Aug-Nov 2013.	Direct observation using SOPARC	High

			American, White, mixed race and Latino neighbourhoods.	size 3.86ha.	located near to intervention sites to ensure similar neighbourhood characteristics.	significance level. 35.71 average people/day to 42.46, compared with 29.38 to 27.33.			
Tester & Baker, 2009	Quasi-experiment controlled, pre-post design	San Francisco, CA, USA	Systematic observation cohort; all parks located in low-income neighbourhoods, control park selected because of similar socio-demographics	Two parks had intervention at a cost of \$5.5m. In both: artificial turf replaced uneven dirt fields, new fencing, landscaping, lighting and picnic benches added. In first park, permanent soccer goals; in the second, a walkway around the field was restored.	Third park (Jose Coronado) did not receive any renovations or upgrade	Both intervention park playfields saw significant increases in male and female visitors, with over a 4-fold increase in the average number of visitors per observation among children and adults of both genders, but not in the control park	Data collected in two intervention parks and a control park from May 30 to June 5 in 2006 and post-intervention in 2007. Intervention implemented in the summer of 2006.	Direct observation using SOPARC - each park's target area was observed 8 times a day for 7 consecutive days at baseline and follow-up, giving 112 observations per park playfield	High
Veitch et al., 2012a; Veitch et al., 2012b	Quasi-experiment controlled, pre-post design	Victoria, Australia	Systematic observation, all residents living within 1km of intervention park and control park received survey. Neighbourhood within most disadvantaged decile in state of Victoria	Residents established priorities for redevelopment: secure leash-free area for dogs; fenced, accessible all-abilities playground; a 365m walking track; access to a sheltered BBQ area; landscaping of gardens; additional fencing/ bollards	Control park selected based on having similar features as the intervention park at baseline and located in same neighbourhood	Total number of observed park users increased immediately after refurbishment was complete, and continued at second follow-up (235 – 582 – 985). This was not reflected at the control park (83- 114- 51)	Observations completed at 3 time points: T1: 6 Aug – 30 Aug 2009 T2 (after refurbishment): 4 Mar – 18 Apr 2010 T3(12-months after): 15 Aug – 16 Sep 2010	Direct observation using SOPARC - conducted every 15 minutes during three different 1.5 hour periods on each day of data collection; data collected for nine days over 4 weeks.	High