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Review article

The effect of place-based nature interventions on human health: A systematic review

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ABSTRACT

Objective: Although increasing evidence highlights the health benefits of living near green environments, little research has focused on physical interventions that increase the provision of greenspace. City, park, school, and forest managers are in need of program and practice guidance with health endpoints in mind.
Material and methods: We conducted a systematic review of longitudinal evaluations of place-based greening interventions and their effects on health outcomes or behaviors. Included studies evaluated the effects of changes in outdoor spaces intended to increase the quantity, quality, or accessibility of greenspace on a quantitatively assessed human health outcome or behavior.
Results: We screened 18,831 unique citations for inclusion and included 98 manuscripts. Studies examined interventions including park improvements, garden creation, greenway construction, tree planting, and vacant lot greening. Studies varied widely in quality. Few studies applied randomized designs, and many did not adequately address confounding. Outcomes related to physical activity, body mass index, and dietary quality were frequently examined across studies. However, meta-analysis was not feasible due to high heterogeneity in outcome measurements. Findings suggest that park projects that included community engagement were more likely to improve physical activity than those that did not; school garden projects were inconsistent in improving students' diet; vacant lot greening projects consistently reported reductions in violent crime; new trail and greenway constructions did not appear to improve physical activity levels; and home garden projects tended not to improve dietary quality but did improve food security in some contexts.
Conclusion: While the number of studies and the quality of evidence remains low, there is some support for the value of place-based greenspace interventions for public health. Researchers should coordinate with community stakeholders before starting greening projects to develop evaluation strategies. Improved evaluation work could develop causal evidence to direct cities and community groups in effective greening projects.

1. Introduction

Greenspace, including vegetation, natural environments, and parkland, is increasingly understood as an important public health asset. The body of evidence on the population-level associations between greenspace exposure and human health is growing more robust, with increasing access to greenspace datasets of high spatial and temporal resolution, as well as growing access to population-scale health datasets made more accessible by digitization of health records. The beneficial associations between living in greener environments and human health outcomes, including mortality (Rojas-Rueda et al., 2019), cardiovascular disease (Liu et al., 2022), mental wellness (Houlden et al., 2018), and

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birthweight (Hu et al., 2021), have been well established.

Although much of the research investigating greenspace-health associations is not designed to demonstrate causality, researchers have described theoretical frameworks that propose causal relationships between greenspace and health outcomes. The body of research relating exposure to greenspace, parks, and other kinds of natural environments with human health outcomes therefore reflects at least six distinct causal hypotheses.

(1) Exposure to greenspace can improve health and well-being through innate human preference for natural environments (Gaekwad et al., 2022).
(2) Exposure to natural environments can improve mental wellbeing by restoring systems of directed attention (Ohly et al., 2016).
(3) Vegetation acts as a buffer to urban environmental hazards such as particulate matter air pollution, heat, and noise (Diener and Mudu, 2021; Dzhambov and Dimitrova, 2014; Knight et al., 2021).
(4) Parks and trails are safe and accessible physical activity environments (Bedimo-Rung et al., 2005).
(5) Public parks provide a forum for social contact (Bedimo-Rung et al., 2005).
(6) Participation in and access to gardens improves diet and food security (Garcia et al., 2018).

These hypotheses suggest vastly different mechanisms of action, targets for interventions, presumed health outcomes to study, and strengths of association to expect. However, research has generally treated "exposure to greenspace" as a monolithic construct, with little consideration for the diverse mechanisms through which exposure to greenspace could vary from person to person. This lack of discrimination in exposure assessment precludes clarity in causal thinking. Summaries and reviews that do not carefully consider the differences between exposure routes and intervention types and simply describe "exposure to greenspace" are insufficient to direct future theoretical development, intervention planning, or policy recommendations (Jimenez et al., 2021).

Further, many of the studies relating greenspace, parkland, and natural environments to public health outcomes have employed study designs that associate a measure of exposure at a single point in time with a health outcome or with changes in that health outcome over time. These studies provide lower evidence of causality than do designs that relate a change in exposure to a subsequent change in a health outcome, or that evaluate an experiment or intervention. Findings from these associational studies can largely be interpreted as "greener is better" for public health. While this information is useful, the agencies, groups, and actors that maintain, care for, and grow natural features in urban environments require more relevant evidence of the specific impacts of their projects, programs, policies, and plans. In a time when jurisdictions, municipalities, and other land and recreation managers are responsible for serving multiple competing costs with finite resources, the establishment of new nature resources and the maintenance of existing resources is often an underfunded priority. Studies of nature interventions can provide evidence of the health benefits and economic savings that these amenities can provide, which can be used in decision making about budgets and spending.

More recent reviews of the relationship between greenspace and health have focused on studies that evaluate the effects of interventions aimed at changing participants' greenspace exposure (Hunter et al., 2019; Silva et al., 2024; Sivak et al., 2021; Wallace et al., 2022). These greenspace interventions can either be *person-based* or *place-based. Person-based* interventions operate by increasing study participants' exposure to greenspace or natural environments through a behavioral change, such as a guided nature walk or forest bathing. *Place-based* interventions operate through physical changes that increase the quantity, quality, or accessibility of greenspaces. For example, installing a new school garden could increase the amount of greenspace experienced by students and teachers; remediating unmaintained vacant lots can improve the quality of greenspace experienced by proximate residents; constructing a park trail could increase the accessibility of greenspace for people who live or work near the park.

Prior reviews of greenspace interventions have commonly not made distinctions between the person- and place-based approaches, which is an important gap in evidence synthesis for several reasons. First, some kinds of place-based greening could improve population health without requiring that participants adhere to lifestyle changes, a critical distinction from person-based approaches. Second, local governments and community organizations that are interested in improving greenspace access through park renovations, street tree planting, and vacant lot remediations need evidence that is specific to the nature of their proposed projects to direct, plan, and prioritize interventions. Third, prior reviews of greenspace intervention studies have identified many more person-based interventions than place-based ones; the strength of the causal evidence for place-based interventions is therefore unclear.

This review summarizes evaluations of place-based interventions that increase the quantity, quality, or accessibility of greenspace through physical changes to outdoor environments and that employ human health outcomes as evaluation metrics. We also consider studies that use longitudinal methods to describe the effect of physical changes in the quantity, quality, or accessibility of greenspace on subsequent changes in human health outcomes. Even given this narrowed scope, there is a wide variety of interventions that have been applied; we therefore seek to categorize similar interventions and summarize results within and between these groups.

As far as we are aware, our review is the first to focus solely on place-based greenspace interventions. We restrict this review to place-based interventions to provide cities, community organizations, and other stakeholders with specific, actionable evidence that can be used to plan and implement greenspace interventions and to identify evidence gaps for future research. Not all exposure to greenspace is equivalent, nor are all interventions designed to increase greenspace exposure. By narrowing our focus to place-based greenspace interventions and carefully characterizing the types of interventions that have been evaluated, we hope to provide conceptual clarity for both researchers and practitioners. This systematic review was pre-registered in the PROSPERO system under IDCRD42023449041 (Fry et al., 2023)

2. Methods

2.1. Search strategy

We conducted a systematic search of peer-reviewed English-language literature to identify manuscripts that evaluate place-based greenspace interventions. We searched Web of Science, PubMed, PsycInfo, and Embase for terminology related to the relevant topic (interventions), aim (evaluation), intervention target (greenspace), and outcomes (human health). Searches were applied to titles and abstracts. An example search format for Web of Science is included below.

Experiment OR Evaluat* OR Trial OR difference-in-differences OR "difference in differences"
[AND] Intervention OR Intervene Or Implement OR Implementation OR program OR planting
[AND] Health OR wellbeing OR well-being OR"well being" OR wellness
[AND] Green* OR Greening OR Greenway OR Greenery OR greenbelt OR stormwater OR Park* OR Tree* OR Nature OR Streetscape* OR Garden* OR Farm* OR Orchard* OR Woodland* OR Wetland* OR Trail* OR vegetation OR forest

In addition, we screened related citations from reviews with similar goals to ours to ensure a comprehensive set of included studies beyond

those that would be identified in the above reference search. When included studies referenced other manuscripts reporting the same project, we attempted to identify and screen these manuscripts as well. Finally, when we encountered protocol papers, we sought follow-up publications reporting the results of these protocols, either through database searches or by contacting the authors of the protocol papers.

2.2. Inclusion and exclusion criteria

The articles included in the review assessed a specific place-based intervention aimed at enhancing the quantity, quality, or accessibility of outdoor green spaces. These studies also targeted at least one human health outcome or health behavior as part of the intervention and utilized data collected both before and after the intervention to carry out a randomized experiment, quasi-experiment, or longitudinal study design. We excluded studies that described a proposed or hypothetical intervention that was not implemented (e.g., some health impact assessments), those where the intervention did not involve physical changes to outdoor spaces (e.g., guided nature walks), studies that did not consider human health as an outcome, or studies that were cross-sectional or only used data collected after the intervention's implementation.

We used the Covidence platform (Covidence systematic review

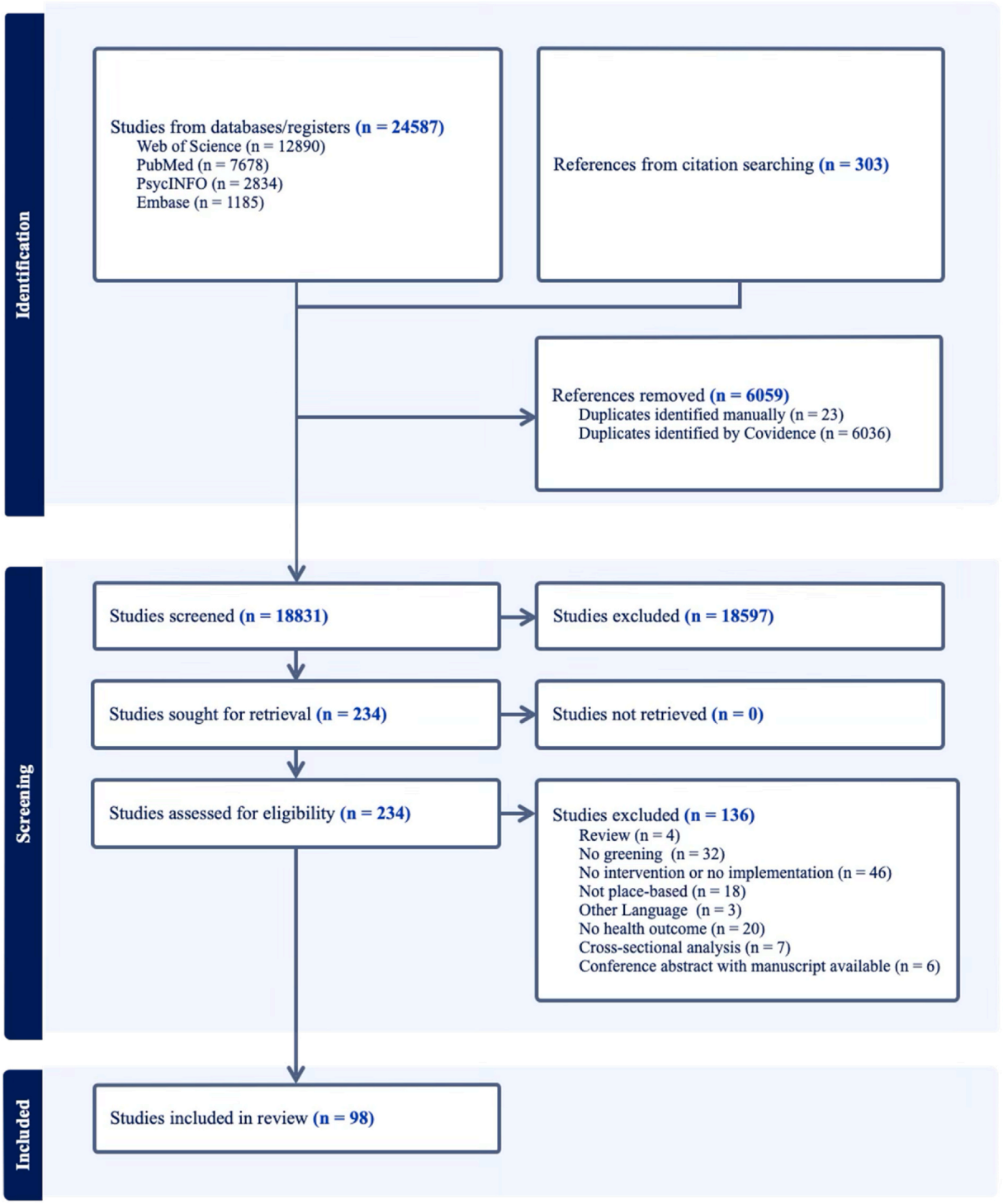

Fig. 1. Prisma reporting.

software, n.d.) to manage citations and coordinate screening and data extraction. All titles and abstracts were double-screened by the research team, and disagreements about inclusion and exclusion criteria were resolved by a quorum consensus at regularly scheduled meetings. Citations deemed relevant by consensus advanced to full-text screening by two members of the research team, and any disagreements were resolved by quorum consensus.

2.3. Data extraction

To summarize relevant information from included studies, we developed a flexible data extraction form that captured information about project aims, study design, study setting, characteristics of the intervention, the analysis design, the measurement of health outcomes and covariates, and quantitative and qualitative results. We first piloted the data extraction process on five included studies that reflected a range of intervention types, study designs, and analytic methods. Following several iterative revisions, the research team shared the extraction process with the full writing group for final revisions. The final data extraction form was then applied to all included studies, which we categorized according to the nature of the assessed intervention. We present the results of this review, organized by these intervention classifications, and provide summaries of the study types and outcomes for each intervention category.

3. Results

From searching online repositories, we returned 24,587 studies, and an additional 303 were identified through citation searching over the course of the review process. After removing duplicate records, we screened 18,831 abstracts and assessed 234 full-text manuscripts for inclusion. We included 98 studies that met our inclusion and exclusion criteria (Fig. 1). Publication dates of included studies ranged from 2007 to 2025, with 27 studies published after 2020 (Fig. 2).

3.1. Intervention classifications

Although all the studies included in this review report on evaluations of place-based greening interventions, there is a wide variety of reported intervention types. These intervention types are described in detail below and summarized in Table 1. We categorized studies based on the target of the place-based intervention: for example, interventions that create green spaces within schools or childcare centers are classified as school garden interventions, and interventions that install vegetable plots in participant homes are classified as home garden interventions. Some interventions included components in multiple kinds of spaces and are classified into combined categories. For example, Gustat et al., 2012 (Gustat et al., 2012) evaluates an intervention that installed both a playground and a neighborhood walking trail and is therefore classified as "combined parks and trails/greenways." Interventions associated with institutions other than childcare facilities were more difficult to classify. We classified interventions located in or around a correctional facility (Lee et al., 2021), churches (Derose et al., 2019), and a senior welfare center (Park et al., 2020) within the "community garden" category, under the logic that these gardens are accessible to the community of people defined by the institution, and that splitting this

Table 1
Intervention categories.

Intervention Category	Examples	n Studies
School Gardens	Installing new garden beds and planting gardens	26
Parks	Improvements to landscaping and walkways	16
Trails/Greenways	Creation or renovation of walking trails	12
Vacant Lot Greening/ Pocket Parks	Cleaning and greening of vacant lots	13
Home Gardens	Supporting participants in the creation and maintenance of home gardens	11
Community Gardens	Creation of new community gardens	7
Tree Canopy	Street tree planting programs	5
Multi-Component Public Space Renovations	Landscaping improvements to streetscapes and public squares	4
Combined: School Gardens and Home Gardens	Interventions that combine the creation of new school gardens along with support for home gardens	2
Combined: Parks and Trails/Greenways	Interventions that combine new trails with renovated park areas	1
Green Stormwater Infrastructure	Installation of tree trenches or rain gardens	1

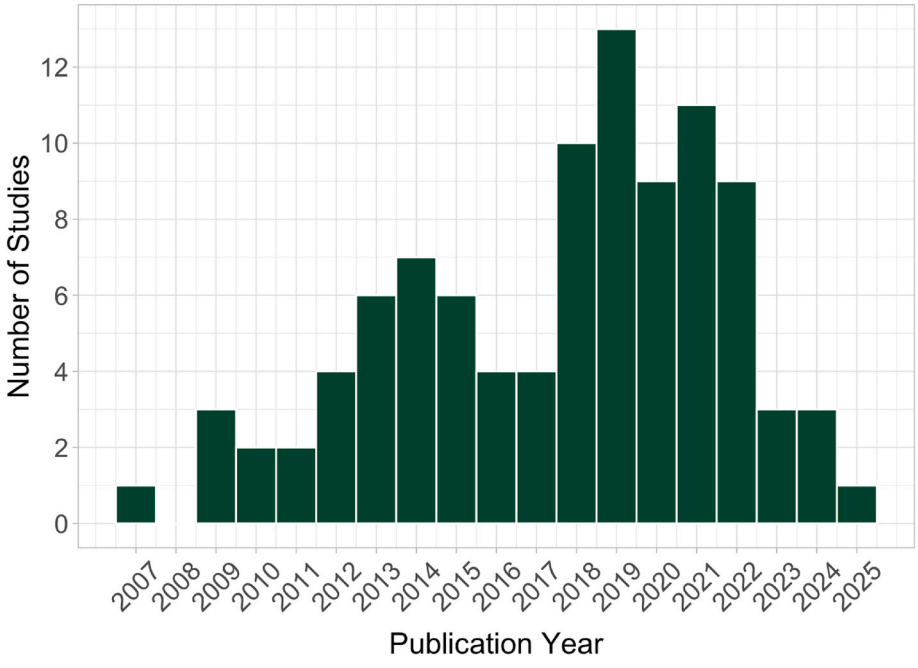

Fig. 2. Publication dates of included manuscripts.

already-small group of studies further would be over fragmented.

The greatest number of manuscripts (n = 26) reported on school garden projects, followed by park-based interventions (n = 16), trails and greenways (n = 12), vacant lot greening projects (n = 13), and home garden interventions (n = 11). Two manuscripts reported on interventions that combined school garden and home garden projects, and one reported a combined park and trail/greenway intervention. Fewer studies reported on community gardens, tree canopy interventions, multi-component public space renovations, or green stormwater infrastructure.

Although the inclusion criteria restrict to studies with place-based interventions of physical outdoor space, many included studies also included person-based components. In 53 manuscripts, physical interventions were paired with behavioral or social interventions, such as community engagement activities (Thompson et al., 2019), nutrition education (Schreinemachers et al., 2017), or volunteering (Gagliardi et al., 2020). These components generally aim to magnify the effect of the place-based interventions by ensuring direct participant engagement with the intervened spaces.

The majority of included studies (n = 51) reported on interventions implemented in the United States, followed by the United Kingdom (n = 10) and Australia (n = 9). Reflecting a growing geographic diversity of greenspace studies not represented in older reviews, eight studies reported interventions from Asia, seven from European countries other than the United Kingdom, six from Africa (West, Central, and East), three from Canada and Mexico, and two from South America (only Brazil and Colombia).

Included studies reported quantitative health results at the individual level, household level, or by quantifying health-relevant variables at the level of the intervened unit (i.e., counts of exercising park users or level of crime surrounding a vacant lot) or at the neighborhood level. Because few of the studies targeted individuals for interventions, we could not precisely categorize studies by population sociodemographic sub-categories, such as age groups. However, in general, school garden interventions were conducted with children, while most of the remainder of studies measured outcomes among the general population irrespective of demographic characteristics. All vacant lot greening studies, as well as seven school garden studies, were conducted in low-income areas.

Across all intervention categories, the most commonly assessed health outcomes related to nutrition (either healthy diets, adequate nutrition, or household food security), exercise (either physical activity levels or active use of parks and trailways), or variables related to weight or body mass index. Fewer studies assessed mental or emotional health status or diagnosable disease states. Table 2 provides summary information across all included studies, categorized by intervention category. Additional information for each study is provided in the supplementary material.

3.2. School gardens

We included 26 studies that evaluated school garden interventions. Eligible interventions included the installation or cultivation of new school gardens, with one (Huys et al., 2019) that focused on resource provision for garden construction rather than construction itself (Huys et al., 2019). Where manuscripts provided details as to the nature and scale of the garden areas, interventions frequently involved raised beds or planter boxes, but two studies involved larger-scale open space renovations on school grounds, combining garden plots, play areas and pathways (Cosco et al., 2014; Khan, 2019) (Cosco et al., 2014; Khan and Bell, 2019). Intervention gardens generally included edible vegetable and fruit crops. In all cases, garden cultivation was coupled with an educational component consisting of gardening lessons, nutrition education, and/or cooking classes.

Most studies focused on younger children, with intervention schools being childcare centers or primary schools. Three studies evaluated interventions in schools with older adolescents (Figueroa-Piña et al., 2021; Massarini, 2019; Wang et al., 2024) (Figueroa-Piña et al., 2021; Massarani et al., 2019; Wang et al., 2024). Some studies additionally targeted schools in low-income areas (Davis et al., 2016; Davis et al., 2021; Gatto et al., 2017; Landry et al., 2019; Spears-Lanoix et al., 2015; van den Berg et al., 2020; Wells et al., 2014) (Davis et al., 2021; Gatto et al., 2017; Landry et al., 2019; Spears-Lanoix et al., 2015; van den Berg et al., 2020; Wells et al., 2014; Davis et al., 2016).

The combined gardening and educational programs represented in this category were aimed at improving the quality of student diets. Twenty-three studies used healthy diet metrics as an outcome, and eight used a measure relating to BMI or weight. These measures were conceptualized differently between studies with little evidence of standardization, but frequently involved survey reports of levels of fruit and vegetable consumption of participating students. Several studies in low-resource settings also included measures relating to nutritional adequacy, including food security, thinness, and anemia (Shrestha et al., 2020; van den Berg et al., 2020; Wang et al., 2024) (Shrestha et al., 2020; van den Berg et al., 2020; Wang et al., 2024).

Fig. 3 reports the summarized results from school garden studies. Results for school garden studies were mixed. Of the studies assessing healthy diet metrics among individual students, 12 found a statistically significant improvement and 10 found no change. Similarly, of studies assessing measures relating to body mass index, five found a statistically significant decrease and three found no change. While studies also evaluated predictors of diet, such as nutritional awareness, knowledge of fruits and vegetables, and preference for fruits and vegetables, these measures did not necessarily correspond with dietary changes. Notably, one study found that children in childcare centers with installed gardens did not report an increase in liking fruits and vegetables but did consume more fruits and vegetables during snack time than did children at control sites (Cosco et al., 2022) (Cosco et al., 2022). Importantly, although there is variation in the nature of interventions applied, this variation does not seem to reliably predict effectiveness, as evidenced by replicated interventions. Two studies reported on the Texas-based “Grow! Eat! Go!” program (Spears-Lanoix, 2025; van den Berg et al., 2020) (Spears-Lanoix et al., 2015; van den Berg et al., 2020), two on the Los Angeles-based “LA Sprouts” intervention (Gatto et al., 2017; Landry et al., 2019) (Gatto et al., 2017; Landry et al., 2019), and two on the Australian “Stephanie Alexander School and Kitchen Garden” program (Eckermann et al., 2014; Gibbs et al., 2013)[31,34]. In each case, inconsistent results were demonstrated between the manuscripts reporting on these respective interventions. This may suggest complexity in design and implementation that could be inadequately captured in quantitative health studies.

Twelve studies employed randomized controlled designs that randomized between intervened and non-intervened schools. Most non-randomized studies did not include a place-based control group. In three studies, participant-level controls were provided by students receiving differential access to garden programming (Figueroa-Piña et al., 2021; Khan, 2019; Parmer et al., 2009) (Figueroa-Piña et al., 2021; Khan and Bell, 2019; Parmer et al., 2009). In these instances, all students were exposed to the same newly developed garden at their school. Therefore, these studies can only estimate the impact of the garden-related educational programming, rather than the effect of the location-specific intervention.

Future studies of school garden interventions may benefit from greater standardization of outcome measurement to help understand mixed results. Further, given inconsistent results when the same intervention is replicated in multiple studies, detailed program evaluations with high-quality qualitative data from multiple stakeholders (such as students, teachers, and parents) may be needed to understand the success factors for this kind of intervention.

Table 2
Summary of included manuscripts.

Study	Aim	Design	Intervention	Intervention Units	Health Outcomes	Results Summary
School Gardens						
Christian et al., 2014	To evaluate the impact of a school gardening program, the Royal Horticultural Society (RHS) Campaign for School Gardening, on children's fruit and vegetable intake.	Randomized controlled trial	School gardens either run by teachers or RHS (greater dose and degree of intervention).	Schools/ school gardens: 16 Control Areas: 16	Individuals: Healthy diet metric(s)	There were no significant changes in fruit and vegetable consumption related to the interventions.
Cosco et al., 2014	To evaluate the effectiveness of outdoor renovation and teacher training in increasing physical activity and improving environmental quality in childcare centers.	Pre-post evaluation	Renovation of outdoor spaces in childcare settings.	Childcare centers: 27 Control Areas: 0	Intervened Areas: Active use of parks or other public space	Renovations led to increased physical activity in playground areas as well as positive behavior changes.
Cosco et al., 2022	Examine effect of a garden intervention on fruit and vegetable consumption among children aged 3–5 in childcare centers.	Randomized controlled trial	Installation of six raised beds with prescribed fruit and vegetable plantings.	Childcare Facilities: 5 Control Areas: 10	Individuals: Healthy diet metric(s)	Children in the intervention group showed greater increases in fruit and vegetable consumption during experimental snack times than did children in the control group, and experienced greater increases in fruit and vegetable identification as well. There was no significant effect on reported fruit and vegetable liking.
Davis et al., 2021	Evaluate the effects of a school-based gardening, nutrition, and cooking intervention on dietary intake, obesity outcomes, and blood pressure among elementary school children.	Randomized controlled trial	A 0.25 acre school garden was created in each intervention school.	Schools/ school gardens: 8 Control Areas: 8	Individuals: Healthy diet metric(s), BMI, weight, body fat percentage, or waist circumference, Biomarkers	The intervention increased vegetable intake by 0.48 servings/day compared to control but had no significant effects on BMI, waist circumference, body fat percentage, or blood pressure.
Duncan et al., 2015	To examine the impact of a 12-week, theory-based school gardening intervention on intention and behavior related to children's fruit and vegetable consumption.	Quasi-Experiment, Natural Experiment, or Difference in Differences	School gardens, with garden construction involving participating children.	Schools/ school gardens: 1 Control Areas: 1	Individuals: Healthy diet metric(s), BMI, weight, body fat percentage, or waist circumference	The intervention significantly increased daily fruit and vegetable consumption, but no significant difference was observed in BMI between groups.
Eckermann et al., 2014	Examine the impacts of a school-based kitchen garden program on student attitudes, lifestyle, and behavior.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Construction of garden and kitchen facilities.	Schools/ school gardens: 28 Control Areas: 14	Individuals: Healthy diet metric(s)	The school and kitchen garden program did not improve reported student eating behaviors, despite an increased reported willingness to try new foods.
Figueroa-Piña et al., 2021	Evaluating the effect of an educational intervention alongside a school garden on fruit and vegetable consumption in private middle-high school students.	Randomized controlled trial	Inside the school premises, an outdoor vegetable garden was designed for the study, consisting of 25 boxes were made. Participants of the Food Education + School Gardening group (FE + SG) were given a class in the garden once a week.	Schools/ school gardens: 1 Control Areas: 0	Individuals: Healthy diet metric(s)	Students in the FE + SG group increased vegetable consumption and frequency of vegetable intake compared to the control group, showed a greater understanding of and reflection upon information they received from their environment about fruit and vegetable consumption, and reported more willingness to develop healthy diet characteristics.
Gatto et al., 2017	Explore effect of a 12-week gardening, nutrition, and	Randomized controlled trial	Raised bed planter boxes placed on unpaved,	Schools/ school	Individuals: Healthy diet metric(s), BMI,	Participants in the intervention schools

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Table 2 (*continued*)

Study	Aim	Design	Intervention	Intervention Units	Health Outcomes	Results Summary
	cooking intervention on dietary intake, obesity parameters, and metabolic disease risk among low-income, primarily Hispanic/Latino youth.		grassy areas of the school yard or on areas where asphalt was removed.	gardens: 2 Control Areas: 2	weight, body fat percentage, or waist circumference, Blood pressure, Fasting blood glucose, Metabolic syndrome	experienced decreases in BMI and in metabolic syndrome relative to controls and had generally improved dietary metrics relative to controls. Blood pressure and fasting blood glucose did not change relative to controls.
Gibbs et al., 2013	Assess the effect of a school-based kitchen garden program on healthy eating behaviors of participating students.	Pre-post evaluation	Students participated in the preparation of garden beds, planting seeds, and cultivating edible plants.	Schools/ school gardens: 6 Control Areas: 6	Individuals: Healthy diet metric(s)	No quantitative changes in the consumption of fruits and vegetables were reported. However, teachers described a better awareness of healthy diets among participating students and improvements to the healthy qualities of packed lunches following the intervention.
Huys et al., 2019	Assess the impact of a nine-week school garden intervention on children's dietary determinants.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Schools received materials and support for constructing school gardens.	Schools/ school gardens: 5 Control Areas: 8	Individuals: Healthy diet metric(s)	The intervention had no significant effect on vegetable and fruit consumption but had a small significant impact on knowledge of fruit and vegetable consumption recommendations.
Jaenke et al., 2012	Assess whether a garden-enhanced nutrition education program increases fruit and vegetable consumption, taste preference, and willingness to try, and assesses gender differences in these outcomes.	Quasi-Experiment, Natural Experiment, or Difference in Differences	School garden planted and maintained by students.	Schools/ school gardens: 1 Control Areas: 1	Individuals: Healthy diet metric(s)	No consistent effect was seen for the gardening intervention in fruit and vegetable consumption, although girls in the gardening intervention reported less fruit consumption post-intervention than did girls in the nutrition education intervention. Boys and girls in the gardening intervention had greater increases in willingness to taste fruits and vegetables and overall taste rating of fruits and vegetables, with a stronger effect size found among girls.
Kararo et al., 2016	Evaluate the effect of a garden-based nutrition education program on healthy food choice self-efficacy and fruit and vegetable consumption among third graders.	Pre-post evaluation	New school gardens installed either outdoors or inside the classroom.	Schools/ school gardens: 25 Control Areas: 0	Individuals: Healthy diet metric(s)	Post-intervention, students reported greater healthy food choice self-efficacy and greater fruit and vegetable consumption diversity.
Khan and Bell, 2019	Assess impact of a school gardening intervention on physical activity and diet.	Quasi-Experiment, Natural Experiment, or Difference in Differences	An open area on the school grounds was converted to a garden area.	Schools/ school gardens: 1 Control Areas: 0	Individuals: Physical activity, Healthy diet metric(s)	No significant intervention effects were found for diet or physical activity measures. However, in qualitative data, children reported that their willingness to try fruits and vegetables was improved by the intervention and that the intervention led to physical activity and socialization benefits.
Kim 2020 (Kim and Park, 2020)	Assess impact of a gardening, nutritional education, and cooking	Pre-post evaluation	Creation by students of garden plots.	Schools/ school	Individuals: Healthy diet metric(s)	Following the intervention, reported daily vegetable

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Table 2 (*continued*)

Study	Aim	Design	Intervention	Intervention Units	Health Outcomes	Results Summary
	program on the eating behavior of third and sixth graders.			gardens: 2 Control Areas: 0		consumption increased in both third and sixth graders.
Landry et al., 2019	Assess the impact of cooking and gardening behaviors on dietary fiber, vegetable intake, and obesity parameters in Hispanic/ Latino youth participating in a 12-week intervention.	Randomized controlled trial	Raised-bed gardens built at participating schools.	Schools/ school gardens: 2 Control Areas: 2 schools	Individuals: Healthy diet metric(s), BMI, weight, body fat percentage, or waist circumference	The intervention had no significant impact on cooking and gardening behaviors, but greater changes in cooking and gardening behaviors were associated with increased dietary fiber consumption in this sample.
Massarani et al., 2019	Evaluate success of school-based integrated healthy eating promotion program, including the installation of school gardens, on dietary habits of adolescents.	Pre-post evaluation	A school garden with experimental kitchen was planned, designed, and constructed with the involvement of teachers and parents.	Schools/ school gardens: 1 Control Areas: 0	Individuals: Healthy diet metric(s)	Following the intervention, the mean reported consumption of minimally processed foods, including salads and fruits, increased.
Morgan et al., 2010	Investigate the impact of a school garden-enhanced nutrition education program on children's vegetable consumption, preferences, and quality of school life.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Planting and tending of a school garden.	Schools/ school gardens: 1 Control Areas: 1	Individuals: Healthy diet metric(s), Quality of life or subjective wellbeing	The nutrition education and gardening program did not significantly change students' vegetable or fruit intake or school-related quality of life relative to control, but students receiving the program showed improvements in reported vegetable preferences and willingness to taste specific vegetables.
Parmer et al., 2009	To examine the effects of a school garden on children's fruit and vegetable knowledge, preference, and consumption.	Pre-post evaluation	Students in planted, maintained and harvested vegetables, culminating in a group activity of preparing food using the grown produce.	Schools/ school gardens: 1 Control Areas: 0	Individuals: Healthy diet metric(s)	Students participating in the school garden program experienced greater increases in vegetable consumption during lunch than did students who did not participate in the garden.
Scherr et al., 2017	Evaluate the effectiveness of a garden-integrated school nutrition program in improving nutrition-related outcomes, knowledge, and obesity reduction in 4th-grade students.	Randomized controlled trial	Gardens constructed on school grounds.	Schools/ school gardens: 2 Control Areas: 2	Individuals: Healthy diet metric(s), BMI, weight, body fat percentage, or waist circumference	Participants at intervention schools experienced significant reductions in BMI, but no changes in fruit and vegetable intake were measured. However, participants at intervention schools also reported increases in nutrition knowledge and vegetable identification.
Schreinemachers et al., 2017	Evaluate the effects of school gardening interventions on children's vegetable consumption, knowledge of nutrition, and food preferences.	Randomized controlled trial	Establishment of school gardens.	Schools/ school gardens: 9 Control Areas: 9	Individuals: Healthy diet metric(s)	Increases in the probability of consuming vegetables, awareness of vegetables, knowledge of sustainable agriculture were reported following the intervention, relative to controls. No changes in fruit consumption were reported.
Schreinemachers et al., 2019	Assess the impact of school garden programs linked to nutrition education on dietary knowledge, awareness, preferences, and behaviors among schoolchildren aged 8–14 years.	Randomized controlled trial	Development of school gardens for cultivating vegetables.	Schools/ school gardens: 20 Control Areas: 20	Individuals: Healthy diet metric(s)	No changes in dietary behaviors, preferences for fruits and vegetables, or awareness of vegetables. However, children reported an increase in knowledge of food, nutrition, WASH, and

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Table 2 (*continued*)

Study	Aim	Design	Intervention	Intervention Units	Health Outcomes	Results Summary
						sustainable agriculture following the intervention.
Shrestha et al., 2020	Evaluate the effects of a school garden program paired with complementary nutrition and WASH interventions on children's health and nutrition.	Randomized controlled trial	Teachers received training on establishing and managing school gardens: leveling and raising land beds, drainage construction, planting. They were given different vegetable seeds, tools and equipment.	Schools/ school gardens: 8 Control Areas: 4	Individuals: Healthy diet metric(s), Height for age, Thinness, Hemoglobin level/ anemia, Parasitic infections	The intervention group with additional health and nutrition education experienced decreases in anemia, stunting, and parasitic infection compared to the garden-only and control groups. Small improvements in fruit and vegetable consumption were noted for the intervention groups relative to control. No changes were observed in thinness.
Spears-Lanoix et al., 2015	To assess the efficacy of enhancing existing school-based efforts with two family-focused, experiential gardening, nutrition, and physical activity extension programs on the prevalence of child overweight and obesity.	Pre-post evaluation	Students participated in the construction of a school garden.	Schools/ school gardens: 1 Control Areas: 0	Individuals: Physical activity, Healthy diet metric(s), BMI, weight, body fat percentage, or waist circumference	Following the intervention, students reported increases in fruit and vegetable consumption, fruit and vegetable preferences, and physical activity. BMI scores also decreased following the intervention.
van den Berg et al., 2020	To assess the effects of school-based gardening and physical activity interventions on children's healthy eating, physical activity, and weight-related outcomes.	Randomized controlled trial	Construction of school gardens.	Schools/ school gardens: 21 Control Areas: 7	Individuals: Physical activity, Healthy diet metric(s), Food security or adequate nutrition, BMI, weight, body fat percentage, or waist circumference	Both interventions showed a reduction in BMI relative to control. Neither intervention alone or in combination increased reported physical activity or vegetable consumption, but the gardening and combined interventions increased vegetable preference, vegetables tasted, and nutrition knowledge relative to control.
Wang et al., 2024	Evaluate the effect of an integrated, school-based nutrition intervention package including school garden implementation on diet quality.	Randomized controlled trial	Installation of school gardens as part of multi-component nutrition intervention.	Schools/ school gardens: 4 Control Areas: 2	Individuals: Physical activity, Food security or adequate nutrition, BMI, weight, body fat percentage, or waist circumference, Hemoglobin level/ anemia	Both the full and partial intervention conditions included the installation of school gardens, and both were associated with increases in diet quality relative to controls. Neither intervention was associated with greater hemoglobin concentrations.
Wells et al., 2014	Examines the effects of a school garden intervention on elementary school children's physical activity.	Randomized controlled trial	Installing a $4' \times 8'$ raised bed for each class.	Schools/ school gardens: 6 Control Areas: 6	Individuals: Physical activity, Active use of parks or other public space	Following the intervention, children's reported sedentary behavior decreased relative to the controls. During the school day, children in the intervention garden showed a greater increase in percent of time spent in moderate and moderate-to-vigorous physical activity relative to controls.
Parks						
Baldovino-Chiquillo et al., 2023	Assess the effects of the TransMiCable project on physical activity.	Quasi-Experiment, Natural Experiment, or	Installation of urban cable car and renovations to public parks.	Parks or other public spaces: 2	Individuals: Physical activity Intervened Areas:	Time spent doing moderate-to-vigorous physical activity did not change. An increase in the

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Study	Aim	Design	Intervention	Intervention Units	Health Outcomes	Results Summary
		Difference in Differences		Control Areas: 2	Active use of parks or other public space	proportion of male individuals engaging in moderate or vigorous physical activity was observed in a renovated zonal park. Female users of a renovated neighborhood park were less likely to become engaged in moderate or vigorous physical activity than female users of the control area neighborhood park.
Bohn-Goldbaum et al., 2013	Determine if an urban park renovation that included playground alterations affects playground usage and physical activity, as well as parental perceptions of the park and of children's physical activity.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Park renovation including upgrading paths and adding new greenery, lighting, and facilities. More green space was created by opening the adjacent sports field to public use.	Parks or other public spaces: 1 Control Areas: 1	Individuals: Physical activity, Active use of parks or other public space Intervened Areas: Physical activity, Active use of parks or other public space	Following playground renovation, usage between the intervention and comparison parks did not differ. Among boys, park usage increased more at the renovated playground. In addition, frequent visitors were less inclined to perceive the equipment as safe and in good condition than infrequent visitors.
Cohen et al., 2009	Assess the impact of park improvements on park use and physical activity.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Improvements to five parks, including safety and facility upgrades.	Parks or other public spaces: 5 Control Areas: 5	Individuals: Physical activity, Active use of parks or other public space	Overall decline in park use and activity, though perceptions of safety improved.
Dobbinson et al., 2020	Assess the impact of park refurbishments on park use, physical activity, shade use, social engagement, and psychological wellbeing.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Refurbishments included walking paths, playground equipment, and built shade to promote physical activity and sun protection.	Parks or other public spaces: 3 Control Areas: 3	Individuals: Overall mental health status Intervened Areas: Physical activity, Active use of parks or other public space	Significant increases in park use and shade use at intervention parks; no significant changes in physical activity or psychological wellbeing; social engagement trends increased but were not statistically significant.
Gagliardi et al., 2020	Assess effect of environmental volunteering on the well-being of older adults.	Pre-post evaluation	Older adult volunteers worked to improve and maintain public urban greenspaces.	Parks or other public spaces: 2 Control Areas: 0	Individuals: Physical activity, Quality of life or subjective wellbeing	Older adults participating in park maintenance and improvement activities experienced improvements in self-reported physical activity and satisfaction with life. In qualitative focus groups, participants reported benefits to well-being, agency, and social support.
Gubbels et al., 2016	To assess the impact of perceived and objective changes in greenery on physical activity and mental health of adolescents and adults living in severely deprived neighborhoods.	Longitudinal cohort	Improvements in greenery and public green spaces.	Parks or other public spaces: 10 Control Areas: 10	Individuals: Physical activity, Depression and related symptoms	The greenery intervention was associated with a reduction in depressive symptoms in adults and an increase in leisure-time cycling among children, but results were not consistent.
Hong et al., 2024	Evaluate the impact of park redesigns on the quality of life of children living nearby.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Renovating neighborhood parks with trees and vegetation, restored lawns, renovated equipment, childrens' play areas, and shaded seating.	Parks or other public spaces: 13 Control Areas: 11	Individuals: Overall physical health status, Overall mental health status	Following park renovations, the physical well-being of proximate children increased relative to controls, but emotional well-being did not change.

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Study	Aim	Design	Intervention	Intervention Units	Health Outcomes	Results Summary
King et al., 2015	Evaluate changes in physical activity resulting from the renovation of a greenspace into a recreational park.	Pre-post evaluation	Community-advised renovation of a greenspace including landscaping and garden expansion, improved soccer fields, playground equipment, basketball courts, benches, and picnic tables.	Parks or other public spaces: 1 Control Areas: 0	Intervened Areas: Active use of parks or other public space	Following renovation, the total number of park users increased, and the physical activity levels of park users increased.
Kodali et al., 2024	Assess the impact of park renovations on active park use.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Park improvements including tree plantings and increased vegetation, shaded seating, restored lawns, and renovated equipment.	Parks or other public spaces: 33 Control Areas: 21	Intervened Areas: Active use of parks or other public space	Following the intervention, the number of active park users did not change at intervened parks, but decreased at control parks, leading to a relative increase in active park use comparing intervened parks to control parks.
Lal et al., 2019	Evaluate the effect of the installation of a new park playscape on park use.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Installation of a new play-scape, including a nature play area and landscaping.	Parks or other public spaces: 1 Control Areas: 1	Intervened Areas: Active use of parks or other public space	An increase in metabolic equivalent hours was observed in the intervention park after the intervention, both in absolute terms and relative to the control park. The greatest increases in physical activity were seen in children.
Poppe et al., 2023	Examine the effect of urban park renewal on park-based physical activity.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Extensive renovations and enlargements, including landscaping beds, walking and cycling paths, and amenities and equipment.	Parks or other public spaces: 1 Control Areas: 1	Intervened Areas: Active use of parks or other public space	Following the intervention, the number of park users and the number of active park users increased in the intervention park, while the control park experienced small declines in park use and active park use.
Sami et al., 2020	Evaluate the physical activity of park users before and after installation of outdoor exercise equipment and other features, including a walking path, in two parks.	Pre-post evaluation	Improvements to increase access were made to two recreational parks. In one park, exercise equipment was installed and a walking path with green space was created. In the second, exercise equipment was installed in a mixture of green space and paved areas.	Parks or other public spaces: 2 Control Areas: 0	Intervened Areas: Active use of parks or other public space	Following the intervention, overall numbers of park users were reduced, but the physical activity levels of park users increased.
Thompson et al., 2013 (Thompson et al., 2013)	Explore how changes to the urban woodland environment might impact levels of outdoor physical activity.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Clearing of rubbish and signs of vandalism, the construction of improved footpaths, signage and entrance gateways. They also involve silvicultural work to improve the appearance and safety of trees and vegetation, including clearing sightlines along pathways to extend visibility and views.	Parks or other public spaces: 1 Control Areas: 1	Individuals: Active use of parks or other public space	Respondents living near the intervention site reported an increase in outdoor physical activity following the intervention, relative to the control. Intervention participants also reported an improvement in the perceptions of the quality of the physical neighborhood environment.
Thompson et al., 2019	Evaluate whether the implementation of a program designed to improve the quality of, and access to, local woodlands in	Quasi-Experiment, Natural Experiment, or	New or resurfaced and drained footpaths, clearing rubbish and overgrown vegetation,	Parks or other public spaces: 3 Control Areas: 3	Individuals: Physical activity, Active use of parks or other public space, Stress, Quality of	At the second follow-up wave, participants reported increases in moderate and vigorous physical activity, but

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Study	Aim	Design	Intervention	Intervention Units	Health Outcomes	Results Summary
	deprived communities was associated with lower perceived stress.	Difference in Differences	signage, and entrance features,.		life or subjective wellbeing	decreases to walking activity and no change to overall PA. Participants also reported increased stress levels following the intervention, and no changes to health-related quality of life.
Veitch et al., 2012	To examine weather improvements to parks increase park use and physical activity.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Establishment of landscaping, a walking track, an all-abilities playground, a fenced leash-free area for dogs, and fencing.	Parks or other public spaces: 1 Control Areas: 1	Intervened Areas: Active use of parks or other public space	Active park use, and total park visitations, increased at the intervened park both in absolute terms and in comparison with the control park.
Veitch et al., 2018	Examine whether park improvements increase usage and physical activity.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Park refurbishment, including the installation of a nature play area and landscaping.	Parks or other public spaces: 1 Control Areas: 1	Individuals: Active use of parks or other public space Intervened Areas: Active use of parks or other public space	Observations of park users found a significant increase in active park users at the intervened park relative to the control park after the intervention, but resident surveys found no change in reported park use attributable to the intervention.
Combined: Parks and Trails/Greenways						
Gustat et al., 2012	Assess effect of a walking path and school playground on the physical activity of proximal neighborhood residents.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Built a 6-block walking path and installed a school playground in an intervention neighborhood and a committee supported the installation and use of a school playground.	Parks or other public spaces: 2 Control Areas: 2	Individuals: Physical activity Neighborhoods or Administrative Units: Active use of parks or other public space	Observed public physical activity increased in intervention neighborhoods relative to controls, but self-reported physical activity did not increase in intervened neighborhoods relative to controls.
Trails/Greenways						
Anthun et al., 2019	Evaluate whether improvements to a coastal path increased use and improved health outcomes.	Pre-post evaluation	Construct more accessible path on railway track with benches, fishing sites, barbecue sites, informational signs, and historical artifacts.	Parks or other public spaces: 1 Control Areas: 0	Individuals: Physical activity, Overall physical health status	While no significant changes in self-rated health, life satisfaction, or levels of physical activity were found, the study indicates that factors such as location, availability, and designated places for social interaction are important motivating factors for use.
Benton et al., 2021	Evaluate the impact of canal improvements on canal usage, physical activity, social interactions, and taking notice of the environment.	Quasi-Experiment, Natural Experiment, or Difference in Differences	New footpaths, resurfacing existing footpaths, improved entrance points to park, removing vegetation, new benches, added play equipment.	Parks or other public spaces: 1 Control Areas: 2	Intervened Areas: Active use of parks or other public space	Following the intervention, the number of total park users and the number of active park users increased relative to the control site; this effect cannot be fully explained by displacement.
Burbidge and Goulias, 2009	To quantify the impact on physical activity levels of the installation of a neighborhood trail.	Pre-post evaluation	Construction of a trail-way along an existing canal.	Parks or other public spaces: 1 Control Areas: 0	Individuals: Physical activity, Active use of parks or other public space Households: Physical activity, Active use of parks or other public space	The construction of a trail in a suburban neighborhood setting did not have an impact on the active travel behavior or physical activity levels of neighborhood residents in the short term. In addition, residential proximity to the local trail had limited correlation to total physical activity and active travel behavior.

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Study	Aim	Design	Intervention	Intervention Units	Health Outcomes	Results Summary
Fitzhugh et al., 2010 (Fitzhugh et al., 2010)	Assess the impact of an urban greenway on physical activity levels.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Retrofit of a neighborhood with an urban greenway to enhance pedestrian connectivity.	Parks or other public spaces: 1 Control Areas: 2	Neighborhoods or Administrative Units: Active use of parks or other public space	Physical activity counts increased significantly in the intervention neighborhood relative to controls.
Goodman et al., 2014	To evaluate the effects of Connect2 intervention on overall walking, cycling, and physical activity levels.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Construction of a path or bridge for walking and cycling.	Parks or other public spaces: 3 Control Areas: 0	Individuals: Physical activity	At 2-year follow-up, those living closer to intervention sites increased their weekly walking and cycling.
He et al., 2022	Identify BMI changes following a large-scale greenway intervention.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Conversion of a major road into a traffic-free lakeside greenway.	Parks or other public spaces: 1 Control Areas: 0	Individuals: Physical activity, BMI, weight, body fat percentage, or waist circumference, Overall mental health status	Residents living closer to the greenway experienced decreases in BMI relative to residents living farther away, with this result partially mediated by moderate-to-vigorous physical activity levels.
Hunter et al., 2021	Assess impact of a new urban greenway on physical activity and wellbeing of surrounding residents.	Quasi-Experiment, Natural Experiment, or Difference in Differences	9-km greenway constructed along riverside.	Parks or other public spaces: 1 Control Areas: 1	Individuals: Physical activity, Overall mental health status, Quality of life or subjective wellbeing	No effects were found for physical activity or mental wellbeing, but participants in the intervention area experienced a lesser decline in quality of life than did participants in the control area following the intervention.
McGavock et al., 2019	Examine the impact of a frozen waterway trail on physical activity, visitor counts, and perceived health benefits during winter months.	Pre-post evaluation	A 10-km trail network created on two frozen rivers during winter, maintained for ~10 weeks following the winter holiday season. Featured art displays, kilometer markers, and warming huts to encourage usage.	Parks or other public spaces: 1 Control Areas: 0	Individuals: Active use of parks or other public space Intervened Areas: Active use of parks or other public space	Mean daily trail network visits increased fold when the frozen waterway was open compared with when it was closed.
McGavock et al., 2022	Evaluate the effect of an urban multi-use trail expansion on cardiovascular disease among proximal residents.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Construction of four paved greenways between 4 km and 7 km in length.	Parks or other public spaces: 1 Control Areas: 1	Individuals: Heart disease(s)	Difference-in-difference estimates found no change in cardiovascular disease events attributable to the intervention.
Vert et al., 2019	Evaluate the effect of an urban riverside regeneration project in terms of changes in users' physical activity and changes in local residents' use and perception of the urban riverside and their corresponding self-perceived health.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Construction of two paved walkways, four new access points to the riverbank, two wheelchair-accessible ramps and two sets of stairs connecting the upper and the lower parts of the river.	Parks or other public spaces: 1 Control Areas: 1	Intervened Areas: Active use of parks or other public space	Following the intervention, there was an increase in sedentary and moderately-active users of the renovated area. Counts of moderately-active people increased, but due to a larger increase in sedentary users, mean energy expenditure did not increase.
West and Shores, 2011	Determine the effect of a new greenway development on the physical activity levels of proximate residents.	Quasi-Experiment, Natural Experiment, or Difference in Differences	An existing riverside greenway was expanded with an additional 5 miles of pathway.	Parks or other public spaces: 1 Control Areas: 1	Individuals: Physical activity	No intervention effect on physical activity was detected, but both residents living within 0.5 miles of the new greenway and residents living farther away from the greenway experienced increases in physical activity following construction.
Xie et al., 2022	Explore the causal effects of greenway construction on proximate residents' mental and physical health.	Quasi-Experiment, Natural Experiment, or	Construction of a 102-km-long East Lake Greenway in Wuhan, China.	Parks or other public spaces: 1	Individuals: Overall physical health status, Overall mental health status	East Lake Greenway had a positive effect on the self-reported mental health of residents who lived within

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Study	Aim	Design	Intervention	Intervention Units	Health Outcomes	Results Summary
		Difference in Differences		Control Areas: 1		2 km, and these benefits decreased with distance. The physical health benefit was insignificant.
Vacant Lot Greening/Pocket Parks						
Beam et al., 2021	Assess the impact of vacant lot to garden conversions on crime and violent crime.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Vacant lots converted into community gardens.	Vacant lots: 53 Control Areas: 159	Intervened Areas: Violent crime or assault	In adjusted models, violent crime rates showed greater decreases over time near control units at a 250-m buffer size but not a 100-m buffer size.
Branas et al., 2011	Determine relationship between vacant lot greening and health and safety outcomes.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Removing trash and debris from vacant lots, grading the land, planting grass and trees to create a park-like setting, and installing low wooden post-and-rail fences around each lot's perimeter to show that the lot was cared for and deter illegal dumping.	Vacant lots: 4436 Control Areas: 26616	Intervened Areas: Physical activity, Stress, Quality of life or subjective wellbeing, Violent crime or assault, Biomarkers	Vacant lot greening associated with reductions in gun assaults and with residents reporting less stress and more exercise in select sections of the city.
Branas et al., 2018	Assess the impact of vacant lot greening on crime and perceptions of crime.	Randomized controlled trial	Remediation of vacant lots, including mowing, litter removal, grass seeding, and constructing fences.	Vacant lots: 375 Control Areas: 166	Intervened Areas: Violent crime or assault	Neighborhoods with clusters of greened vacant lots experienced greater decreases in gun assaults than did neighborhoods with control clusters, and stronger effects were observed in neighborhoods below the poverty line. Residents of neighborhoods below the poverty line expressed greater positive sentiment about the intervention than did residents of a rapidly developing neighborhood.
Cohen et al., 2014	Asses the use of new pocket parks in low-income neighborhoods.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Creation of pocket parks in low-income areas.	Parks or other public spaces: 3 Control Areas: 15	Individuals: Physical activity, Active use of parks or other public space Intervened Areas: Physical activity	Establishment of pocket parks increased use of intervened areas as well as self-reported park use and physical activity of neighborhood residents.
Garvin et al., 2013	Test the impact of vacant lot greening on police reported crime and residents' perceptions of safety and disorder.	Randomized controlled trial	Removing debris, grading the land and adding topsoil, planting grass and trees, building a low, post-and-rail wooden fence with entry openings around the perimeter, and maintenance every 2 weeks.	Vacant lots: 1 Control Areas: 1	Intervened Areas: Violent crime or assault	Greened vacant lots experienced a reduction in gun assaults and total crimes compared with control lots, and surrounding residents perceived greater levels of safety.
Heinze et al., 2018	Assess effect of a community-led vacant lot greening program on violent crime.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Community-led cleaning and greening of vacant lots (minimum mowing, also could including weeding and planting flowers or garden).	Vacant lots: 216 Control Areas: 446	Intervened Areas: Violent crime or assault	Community-led cleaning and greening was associated with significant reductions in assaults and total violent crime.
Kondo et al., 2016	Assess impact of vacant lot greening on surrounding crime.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Cleaning and greening of vacant lots, with and without community involvement.	Vacant lots: 244 Control Areas: 959	Intervened Areas: Violent crime or assault	Significant reductions in all crime outcomes, including violent assaults, found at intervention sites.

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Study	Aim	Design	Intervention	Intervention Units	Health Outcomes	Results Summary
Kondo et al., 2018	Assess impact of vacant lot remediation on nearby crime.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Removal of debris and mowing of vegetation on vacant lots with code violations.	Vacant lots: 204 Control Areas: 612	Intervened Areas: Violent crime or assault	Rates of violent crime post-remediation were not significantly different between intervened and control lots, but drug violations per square mile were significantly reduced at intervened sites relative to controls.
Macdonald et al., 2022	Assess the extent to which the effect of vacant lot greening on crime is modified by surrounding land uses.	Randomized controlled trial	Vacant lot remediation including grading land, planting and mowing grass, and removing trash.	Vacant lots: 4046 Control Areas: 8742	Intervened Areas: Violent crime or assault	Aggravated assaults decreased at greened vacant lots compared to controls, but this result was not modified by any surrounding land uses.
Moyer et al., 2019	Determine if remediating blighted vacant urban land reduced firearm shooting incidents resulting in injury or death.	Randomized controlled trial	Half of intervened lots received an intensive greening remediation, and half of intervened lots received trash pickup and grass mowing.	Vacant lots: 73 Control Areas: 37	Intervened Areas: Violent crime or assault	Both the mowing and greening treatment groups experienced significant decreases in nearby shootings compared to control clusters, with results more consistent at geographies closer to the clusters.
South et al., 2015	Assess effect of a vacant lot greening intervention on dynamic stress responses.	Pre-post evaluation	Cleaning and removing debris, planting grass and trees, and installing a low wooden post-and-rail fence on vacant lots.	Vacant lots: 1 Control Areas: 1	Individuals: Stress	In difference-in-difference estimates, in-view proximity to a greened vacant lot decreases heart rate (as a measure of dynamic stress) compared with in-view proximity to a nongreened vacant lot.
South et al., 2018a	Assess impact of vacant lot greening program on the mental health of nearby residents.	Randomized controlled trial	Half of intervened lots received trash removal and mowing, while another half received a more intensive greening intervention.	Vacant lots: 375 Control Areas: 166	Individuals: Overall mental health status, Depression and related symptoms	Participants in the greening intervention experienced significant decreases in depression and in poor mental health, but participants in the trash cleanup intervention had no significant changes in mental health measures.
Theall et al., 2025	Assess the impact of a program to remediate vacant lots and vacant buildings on well being, health interconnectedness, social capital markers, neighborhood disorder, and worry.	Randomized controlled trial	Lot greening and abandoned building remediation.	Vacant lots: 135 Control Areas: 95	Individuals: Stress, Overall physical health status, Quality of life or subjective wellbeing	The intervention did not significantly affect perceived well-being, stress, or overall perceived physical health status. However, residents of intervened neighborhoods reported improvements in sense of community and reductions in perceived neighborhood disorder, fear of victimization, and worry about community violence.
Home Gardens						
Bail et al., 2018	Assess the impact of a home gardening intervention on health-related outcomes among cancer survivors.	Randomized controlled trial	Home-based garden, either one raised bed or 4 grow boxes added at participant residences.	Homes/home gardens: 44 Control Areas: 38	Individuals: Physical activity, Healthy diet metric(s), BMI, weight, body fat percentage, or waist circumference, Overall physical health status, Physical functioning, Physical performance, Overall mental health status, Biomarkers	Following the intervention, self-reported physical activity and physical performance improved relative to controls, but other outcomes did not change.
Blair et al., 2013	Evaluate a vegetable gardening intervention on fruit and vegetable intake,	Pre-post evaluation	The survivor-Master Gardener dyads worked together to plan, plant,	Homes/home gardens: 10	Individuals: Physical activity, Healthy diet metric(s), BMI, weight,	40 % of survivors increased their fruit and vegetable intake and 60 %

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Study	Aim	Design	Intervention	Intervention Units	Health Outcomes	Results Summary
	physical activity, quality-of-life, and physical function among adult and child cancer survivors.		maintain, and harvest three seasonal gardens at the participants homes.	Control Areas: 0	body fat percentage, or waist circumference, Physical functioning, Quality of life or subjective wellbeing, Biomarkers	increased their physical activity. Among caregivers, an increase of physical activity and improvement in physical functioning was observed.
Blair et al., 2021	Explore changes in vegetable and fruit intake, physical activity, and health-related quality of life associated with a mentored gardening intervention.	Pre-post evaluation	Three seasonal gardens established and maintained at participants' homes.	Homes/home gardens: 30 Control Areas: 0	Individuals: Physical activity, Healthy diet metric(s), Overall physical health status, Depression and related symptoms, Anxiety and related symptoms, Fatigue, Pain, Sleep disturbance/ impairment	An increase in the daily servings of vegetables and fruits was documented, but steps per day decreased and sedentary behavior increased. There was no average change in physical or mental quality of life, but there was a modest improvement in social functioning.
Blakstad et al., 2021	Examine the effect of homestead food production on dietary diversity and quality.	Randomized controlled trial	Inputs for home gardens.	Homes/home gardens: 454 Control Areas: 422	Individuals: Healthy diet metric(s), Food security or adequate nutrition Households: Food security or adequate nutrition	Women in the intervention group consumed more food groups per day than women in the control group, but the difference in household food security between groups was not significant in weighted models.
Budowle, 2022	Examine the effect of a home garden on the physical and mental health of multiple chronic disease patients, compared to a participant-designed wellbeing program.	Randomized controlled trial	Four foot by eight foot or equivalent raised beds at participant homes.	Homes/home gardens: 10 Control Areas: 9	Individuals: BMI, weight, body fat percentage, or waist circumference, Overall physical health status, Overall mental health status, Quality of life or subjective wellbeing	Physical and mental wellness improved in both groups, but physical wellness improved more in the garden intervention and mental wellness improved more in the menu intervention. Statistical significance was not tested.
Carney et al., 2012 (Carney et al., 2012)	Describe the impact of a community gardening project on vegetable intake, food security and family relationships.	Pre-post evaluation	Resources were provided for participants to grow a home garden.	Homes/home gardens: 42 Control Areas: 0	Households: Healthy diet metric(s), Food security or adequate nutrition	Vegetable intake increased while gardening efforts contributed to a decrease of food insecurity and created a sense of togetherness within the family.
Cases, 2018	Assess changes in physical functioning, health-related quality of life, and sustainability in senior cancer survivors who participated in a gardening intervention.	Randomized controlled trial	12-month home-based vegetable gardening intervention.	Homes/home gardens: 44 Control Areas: 21	Individuals: Physical functioning, Quality of life or subjective wellbeing	No significant trends in objective physical functioning, but the program experienced high participant retention and garden expansion.
Demark-Wahnefried et al., 2018	Evaluate feasibility and health outcomes of home vegetable gardening among older cancer survivors.	Randomized controlled trial	Three seasonal vegetable gardens established with guidance from master gardeners.	Homes/home gardens: 24 Control Areas: 22	Individuals: Physical activity, Healthy diet metric(s), BMI, weight, body fat percentage, or waist circumference, Stress, Physical functioning, Physical performance, Quality of life or subjective wellbeing	No statistically significant differences between control and intervention arms in terms of physical health, functioning, stress, or wellbeing were observed, but intervention participants reported improved vegetable consumption and a greater increase in feelings of worth.
Depenbusch et al., 2021	Test the hypothesis that home garden interventions increase vegetable consumption in rural households.	Randomized controlled trial	Home garden promotion project with training and seed provision.	Homes/home gardens: 775 Control Areas: 734	Households: Healthy diet metric(s)	No significant impacts on vegetable consumption. Increase in vegetable production found in Tanzania, but not in Kenya or Uganda.
Marquis et al., 2018	Evaluate home garden and poultry farming evaluation	Randomized controlled trial	Planting materials to establish home gardens.	Homes/home gardens: 287	Households: Food security or adequate	Adjusting for covariates, children in the

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Study	Aim	Design	Intervention	Intervention Units	Health Outcomes	Results Summary
	on children's dietary diversity and stunting.			Control Areas: 213	nutrition, Weight and height for age	intervention group had higher odds of minimum diet diversity at endline compared with children in the control group, and the intervention group experienced slower stunting than did the control group.
Sharma et al., 2022	To examine potential factors associated with maintaining or improving self reported physical function (PF) among older cancer survivors participating in a gardening intervention impacted by the COVID-19 pandemic.	Pre-post evaluation	The participant and Master Gardener dyads worked together to create and maintain three seasonal gardens (spring, summer, and fall). Key materials were distributed to participants, including gardening supplies, plants, and seeds.	Homes/home gardens: 30 Control Areas: 0	Individuals: Physical activity, Physical functioning, Quality of life or subjective wellbeing, Depression and related symptoms, Anxiety and related symptoms	This study does not report a direct effect of the intervention, but found that worse quality of life scores before and during the intervention were significantly associated with worse physical functioning over follow-up.
Combined: School Gardens and Home Gardnes						
Baliki et al., 2023	Test if an integrated school and home garden intervention, implemented at pilot stage, improves hemoglobin levels among school children in a rural district.	Randomized controlled trial	Installed school gardens, plus inputs for home gardens.	Schools/ school gardens: 15 Control Areas: 15	Individuals: Healthy diet metric(s), Hemoglobin level/ anemia	Despite a trend for improvements in dietary metrics, these changes were not significant and were not sufficient to reduce anemia.
Schreinemachers et al., 2020	Evaluate the impact a combined school and home garden intervention on children's food behavior, vegetable consumption, and caregivers' agricultural knowledge.	Randomized controlled trial	School gardens for hands-on gardening and nutrition education. Home garden support for caregivers, including training, seeds, and technical visits.	Schools/ school gardens Homes/home gardens: 15 Control Areas: 15	Individuals: Healthy diet metric(s)	At later follow-up periods, participants in the treatment group reported an increase in the proportion of meals containing at least one vegetable, relative to controls. Caregivers reported improved household food practices, but no significant changes were reported to children's food and nutrition knowledge.
Community Gardens						
Derose et al., 2019	Evaluating feasibility and preliminary effectiveness of an obesity intervention including church gardens.	Randomized controlled trial	Creation of fruit and vegetable gardens on church grounds.	Church gardens: 5 Control Areas: 4	Individuals: Physical activity, Healthy diet metric(s), BMI, weight, body fat percentage, or waist circumference, Blood pressure	Members of intervened churches experienced lessened weight gain and improved dietary measures relative to controls.
Lee et al., 2020	Assess the impact of a six-week care farming program on the mental health of mother-child pairs.	Pre-post evaluation	Creation and maintenance of a garden plot by participants.	Care farm: 1 Control Areas: 0	Individuals: Depression and related symptoms	Following the intervention, participating mothers reported significant reductions in depression.
Lee et al., 2021	Determine the association between participation in a horticultural therapy program and psychological health.	Pre-post evaluation	Prisoners participated in developing garden plots in the farmyard and greenhouse of a correctional institution.	Prison: 1 Control Areas: 0	Individuals: Depression and related symptoms	While this study did not test statistical significance, participants tended to report reductions in depression along with improvements in self-esteem and life satisfaction.
Lombard et al., 2021	Evaluate the impact of community garden construction and associated community garden workshops on fruit and vegetable consumption,	Pre-post evaluation	Community garden sites were upgraded with raised beds, hoops, and other installations.	Parks or other public spaces: 2 Control Areas: 0	Individuals: Healthy diet metric(s)	No significant changes in fruit and vegetable consumption were found following the garden and garden workshop intervention.

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Table 2 (*continued*)

Study	Aim	Design	Intervention	Intervention Units	Health Outcomes	Results Summary
	gardening behaviors, and attitudes towards gardening.					
Meore et al., 2021	Assess the effectiveness of horticultural therapy in reducing suicide risk among veterans.	Pre-post evaluation	Accessible planting beds installed in edible garden.	Parks or other public spaces: 1 Control Areas: 0	Individuals: Stress, Depression and related symptoms, Pain	Significant reductions were found post-intervention for stress, pain, depression, and loneliness.
Park et al., 2020	Assess the effect of a gardening program on brain-derived neurotrophic factors and associated metabolites among elderly participants.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Gardens planned and established by participants.	Senior welfare center: 1 Control Areas: 0	Individuals: Physical functioning, Physical performance, Cognitive functioning, Neurotrophic factors	Gardening participants showed increases in cognitive function and in some neurotrophic metabolites following the intervention and relative to controls, but results for physical functioning were inconsistent.
Ura et al., 2022	To examine the feasibility of a dementia-friendly care farm in urban areas.	Pre-post evaluation	Transforming a deserted flowerbed into a small farm.	Vacant lots: 1 Control Areas: 0	Individuals: Depression and related symptoms, Cognitive functioning	Participants in the care farm reported reductions in depressive symptoms and improvements to cognitive functioning.
Tree Canopy						
Donovan et al., 2013	Assess the relationship between tree loss from emerald ash borer presence and county-level cardiovascular and lower-respiratory-tract infection mortality rates.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Introduction of emerald ash borer, resulting in tree loss.	Counties: 244 Control Areas: 1052	Neighborhoods or Administrative Units: Cardiovascular mortality, Lower-respiratory-tract infection mortality	Emerald ash borer presence was associated with greater levels of mortality in affected counties, and the effect on both lower respiratory infection mortality and cardiovascular mortality increased with increasing years of infestation.
Donovan et al., 2015	Quantify the relationship between the loss of trees to the emerald ash borer and cardiovascular disease.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Tree loss due to emerald ash borer.	Counties: 245 Control Areas: Not stated	Individuals: Heart disease(s)	Women living in a county infested with emerald ash borer had an increased risk of cardiovascular disease.
Donovan et al., 2022	Study the impact of tree planting on mortality.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Street tree planting.	Census tracts: 140 Control Areas: 0	Neighborhoods or Administrative Units: Overall mortality, Non-accidental mortality, Cardiovascular mortality, Accidental deaths, Chronic lower respiratory deaths	Tree planting in Portland Oregon is associated with reduction in cardiovascular and non-accidental mortality with a stronger magnitude of association as trees continue to age and grow.
Kondo et al., 2017	Assess impact of tree loss due to the emerald ash borer on violent crime.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Tree loss due to emerald ash borer.	Parks or other public spaces: 130 Control Areas: 177	Neighborhoods or Administrative Units: Violent crime or assault	Census blocks with greater levels of tree removal experienced significantly larger increases in assaults and violent crimes.
Sabin et al., 2019	Describe the effects of a community-level reforesting intervention on peace and public health in two watersheds.	Pre-post evaluation	Community-based environmental restoration activities, including tree planting.	Watersheds: 1 Control Areas: 1	Households: Food security or adequate nutrition	Although the study did not detect significant changes in forest cover between the treatment and control watersheds, households in the treated watershed reported increases in number of meals per day, nutrition diversity, and the number of trees planted per year relative to controls.
Public Space Renovations						
Cummins et al., 2018	Assess the health impacts of the London 2012 Olympic	Quasi-Experiment, Natural	Urban regeneration associated with the London Olympics.	Parks or other public spaces:	Individuals: Physical activity, Overall mental health status	Limited evidence of improvements in physical activity and mental health.

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Table 2 (*continued*)

Study	Aim	Design	Intervention	Intervention Units	Health Outcomes	Results Summary
	Games and urban regeneration.	Experiment, or Difference in Differences		3 Control Areas:	Households: Physical activity, Overall mental health status	Qualitative study found that the Olympic Games served to reduce and alleviate stressors in the social and physical environment; however, this was viewed by respondents as temporary.
Droomers et al., 2016	Assess the impact of changes in green space on physical activity in deprived neighborhoods.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Redevelopment of garden allotments and green strips; greening vacant lots to vegetable gardens; trail improvement; renovation of gardens; development of playground; cleaning and refurbishing of green strip.	Parks or other public spaces Vacant lots: 24 Control Areas: 12	Individuals: Physical activity, Overall physical health status	No significant improvements in physical activity or health observed.
Semenza et al., 2007	Test whether the restoration of public squares improved social capital and community well-being.	Pre-post evaluation	Installed planters on the street corners, trellises for hanging gardens, along with benches and public art.	Parks or other public spaces: 3 Control Areas: 0	Individuals: Depression and related symptoms	Reductions in reported depression, an increased sense of community, and an overall expansion of social capital were reported for residents surrounding the intervened sites after the intervention.
Ward Thompson et al., 2014	To evaluate the effect of changes to the residential street environment on a cohort of older adults' activity, well-being and quality of life.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Residential street upgrades, including the installation of planters.	Parks or other public spaces: 9 Control Areas: 9	Individuals: Physical activity, Overall physical health status, Quality of life or subjective wellbeing	The intervention had no reported impact on overall activity levels, health, or quality of life, but did improve perceptions of street walkability and safety at night.
Green Stormwater Infrastructure						
Kondo et al., 2015	Assess impacts of green stormwater infrastructure installation on blood pressure, cholesterol, stress levels, and safety.	Quasi-Experiment, Natural Experiment, or Difference in Differences	Green stormwater is installed and regularly cleaned and maintained.	Parks or other public spaces: 52 Control Areas: 186	Intervened Areas: Stress, Violent crime or assault Neighborhoods or Administrative Units: Stress, Violent crime or assault, High cholesterol, High blood pressure	No significant impacts found of green stormwater infrastructure on high cholesterol, high blood pressure, or stress. Homicides were slightly higher at intervention sites at the 1/16th-mile buffer level, but not at other geographic scales.

3.3. Parks

We included 16 studies that considered various greening interventions in parks. Most interventions involved the renovation or restoration of existing parks; one study (King et al., 2015) (King et al., 2015)documented the community-informed creation of a new formal park on undeveloped land that had been used informally as garden and parkland by nearby refugee groups. Most studies evaluated a combination of greenery and landscaping improvement with additional park-based interventions, such as the installation of playground equipment, exercise equipment, and walkways. Five studies included a social intervention alongside physical changes to parks, such as engagement events (Sami et al., 2020; Thompson et al., 2019) (Thompson et al., 2019; Sami et al., 2020), community meetings and park activities (Cohen et al., 2009; Thompson et al., 2013) (Cohen et al., 2009; Thompson et al., 2013), and environmental volunteering (Gagliardi et al., 2020) (Gagliardi et al., 2020).

All but one study (Hong et al., 2024) (Hong et al., 2024) assessed an outcome related to physical activity. The majority of studies that assessed changes to active park use within intervened areas found a significant increase in park-based physical activity following park renovations. However, three studies assessed the overall physical activity levels of proximate neighborhood residents (Baldovino-Chiquillo et al., 2023; Cohen et al., 2009; Gubbels et al., 2016) (Baldovino-Chiquillo et al., 2023; Cohen et al., 2009; Gubbels et al., 2016) and all found either null or mixed results, suggesting that park renovations may displace physical activity from other settings rather than increasing overall population physical activity levels.

Only three studies assessed mental health outcomes (Gubbels et al., 2016; Hong et al., 2024; Thompson et al., 2019) (Thompson et al., 2019; Gubbels et al., 2016; Hong et al., 2024). Of these three, Gubbels et al., 2016 (Gubbels et al., 2016) found a decrease in depressive symptoms among children associated with improved greenspace; Thompson et al., 2019 (Thompson et al., 2019) found an increase in stress among proximate residents and no change to health-related quality of life; and Hong 2024 (Hong et al., 2024) found no changes to proximate children's mental wellbeing following park interventions.

Most studies employed quasi-experimental approaches, while one study used a longitudinal cohort design (Gubbels et al., 2016) (Gubbels et al., 2016), and three studies relied on pre-post evaluations without control groups (Gagliardi et al., 2020; King et al., 2015; Sami et al., 2020) (Gagliardi et al., 2020; King et al., 2015; Sami et al., 2020). The

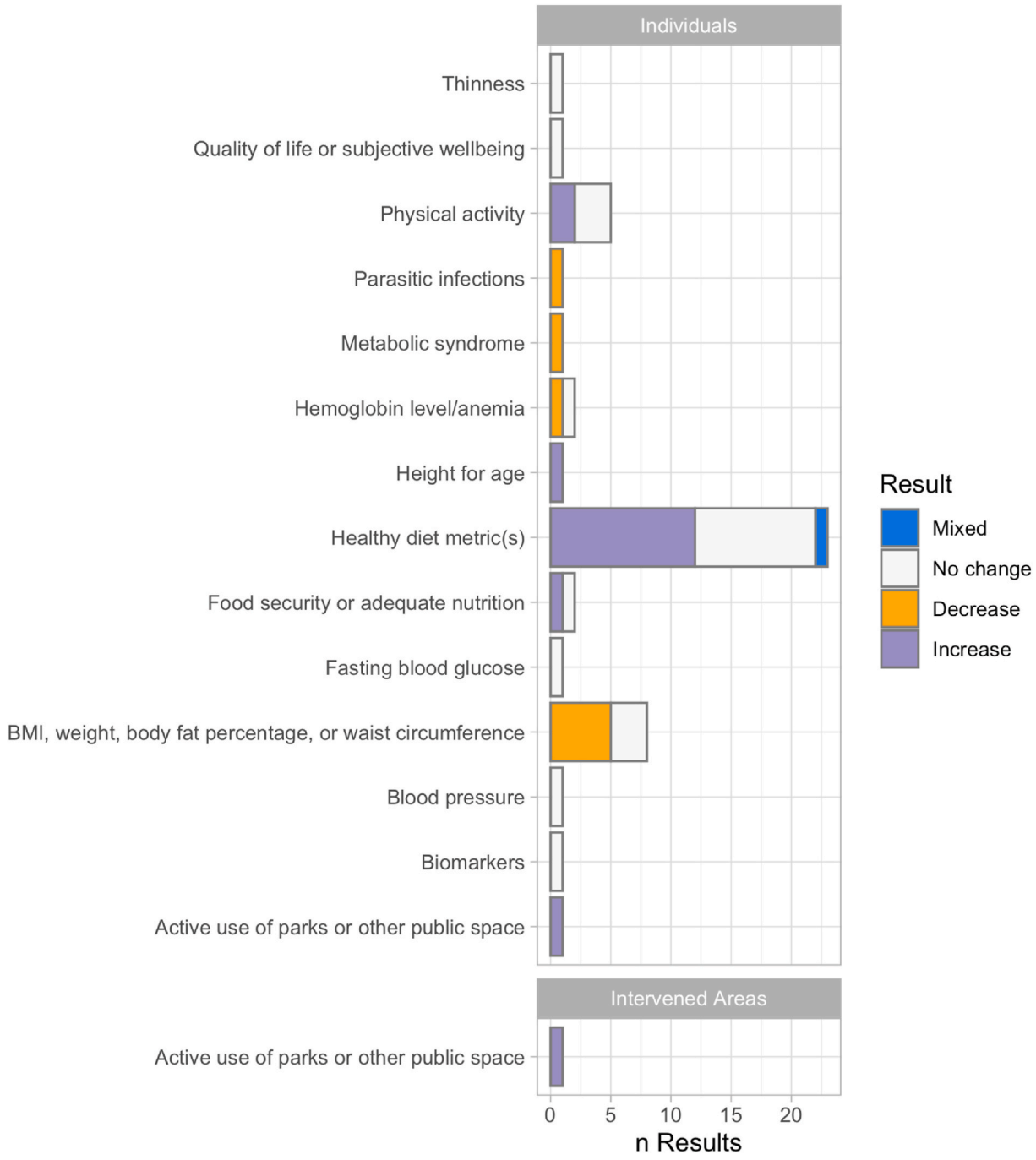

Fig. 3. Results from School Garden Studies
Summarized results from studies of school garden interventions. Outcomes are listed according to the level of analysis at which they were assessed. Multiple results may be reported from the same manuscript. A result is listed as "decrease" or "increase" for an outcome if statistical significance was reported for that outcome in the manuscript.

strength of evidence from quasi-experimental studies of park interventions is limited by very small sample sizes. In seven such studies (Bohn-Goldbaum et al., 2013; Lal et al., 2019; Poppe et al., 2023; Thompson et al., 2013; Thompson et al., 2019; Veitch et al., 2012; Veitch et al., 2018) (Thompson et al., 2013, 2019; Bohn-Goldbaum et al., 2013; Lal et al., 2019; Poppe et al., 2023; Veitch et al., 2012, 2018), a single intervened park is compared to a single control park.

Summarized results from park papers are presented in Fig. 4. Park-based greening interventions consistently found increases in park use and counts of active park users in intervened park areas. However, the experiences and health outcomes of residents living near renovated parks are significantly understudied, as most park-based studies only capture data from park users through systematic observation and intercept surveys. Future research on park interventions would benefit from longitudinal surveys of neighborhood residents living near intervened and control park areas to better understand changes to park perceptions, physical activity levels, and mental health symptoms associated with park improvements.

3.4. Trails and greenways

We identified a total of 12 studies assessing the construction,

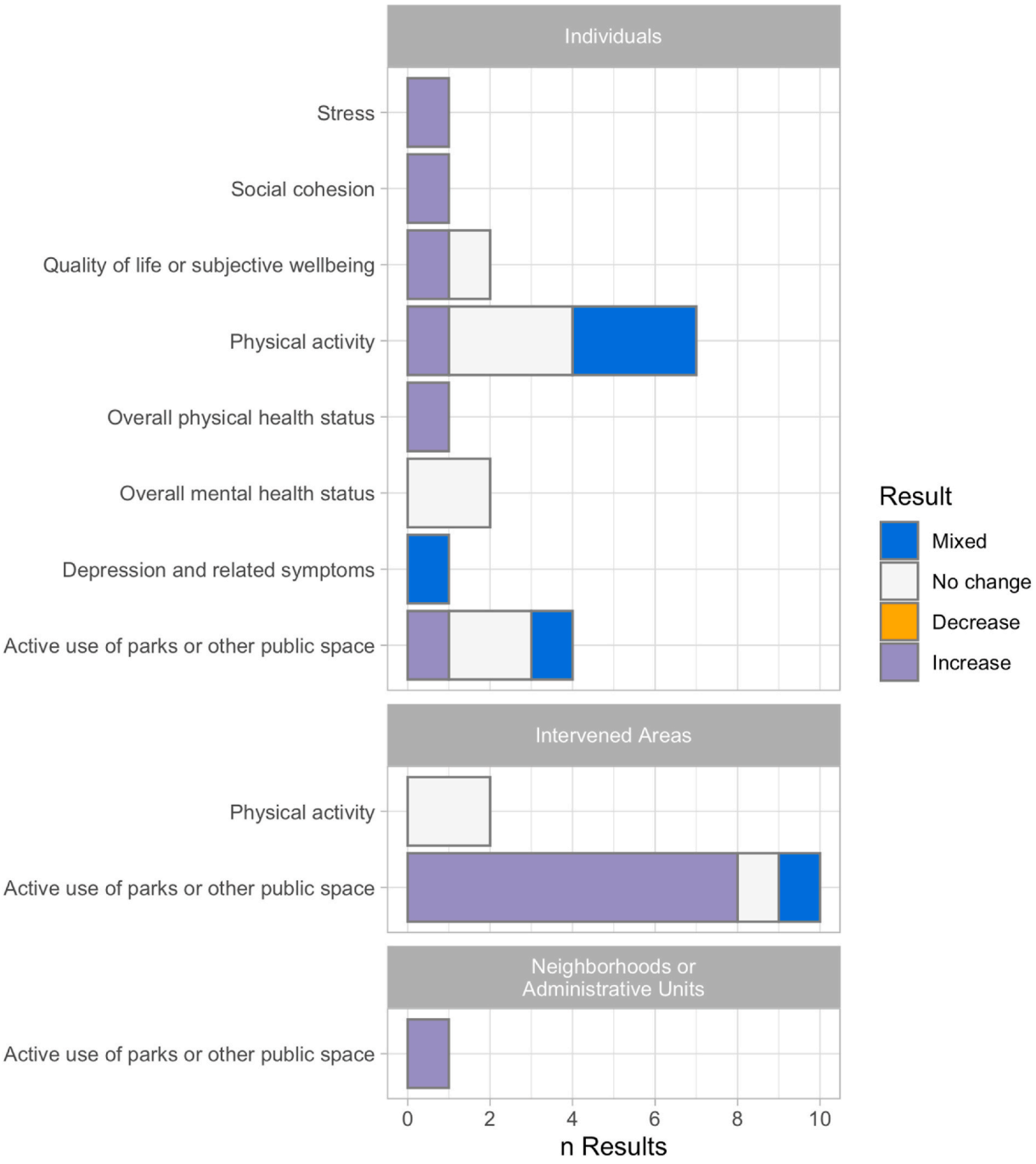

Fig. 4. Results from Park Papers
Summarized results from studies of park-based interventions. Outcomes are listed according to the level of analysis at which they were assessed. Multiple results may be reported from the same manuscript. A result is listed as "decrease" or "increase" for an outcome if statistical significance was reported for that outcome in the manuscript.

lengthening, or upgrading of trails, greenways, and walkways, and one study that assessed a combined intervention of a playground construction and greenway construction (Gustat et al., 2012) (Gustat et al., 2012). Eight studies evaluated the construction of new trails or greenways (Benton et al., 2021; Burbidge, 2009; Fitzhugh et al., 2010; Goodman et al., 2014; Gustat et al., 2012; He et al., 2022; Hunter et al., 2021; McGavock et al., 2022; Xie et al., 2022) (Gustat et al., 2012; Benton et al., 2021; Burbidge and Goulias, 2009; Fitzhugh et al., 2010; Goodman et al., 2014; He et al., 2022; Hunter et al., 2021; McGavock et al., 2022; Xie et al., 2022) with two studies assessing the same new large-scale lakeside greenway in Wuhan, China (He et al., 2022; Xie et al., 2022) (He et al., 2022; Xie et al., 2022). One study evaluated the lengthening of an existing trail (West, 2011) (West and Shores, 2011), two studies evaluated upgrades to accessibility and amenities on an existing trail (Anthun et al., 2019; Vert et al., 2019) (Anthun et al., 2019; Vert et al., 2019), and one study evaluated a temporary trail made possible by the freezing of a river during wintertime (McGavock et al., 2019) (McGavock et al., 2019).

The majority of trail and greenway studies measured physical activity outcomes. Seven studies assessed the physical activity of proximate residents before and after trail and greenway interventions. Of these, only He et al., 2022 (He et al., 2022) found increases in resident

physical activity in the proximal intervention area, relative to a control group, that can be attributed to the greenway intervention itself. Notably, this study also tested the largest-scale intervention by far: a newly constructed 102-km lakeside greenway.

Summarized results for the trail and greenway papers are presented in Fig. 5. Six studies assessed observed active use of the intervention trails, with each of them finding statistically significant increases in active use associated with the intervention. However, these observations within the intervened area cannot determine whether physical activity increased overall among the exposed population or if the heightened use of the newly improved trail simply represented a shift in activity from other areas that became comparatively less appealing for physical activity after the intervention. Vert et al., 2019 (Vert et al., 2019) found that although active use of the intervened side of a river increased, active use of the control side of the same river decreased, providing evidence for this displacement effect. Benton et al., 2021 (Benton et al., 2021) found that the combined user counts at both the intervention and control sites increased, so not all of the user increase at the intervention site can be explained by displacement from other trail areas, although displacement from other physical activity settings such as homes, gyms, or playgrounds could have taken place.

Of the twelve studies assessing trails and greenways, nine were

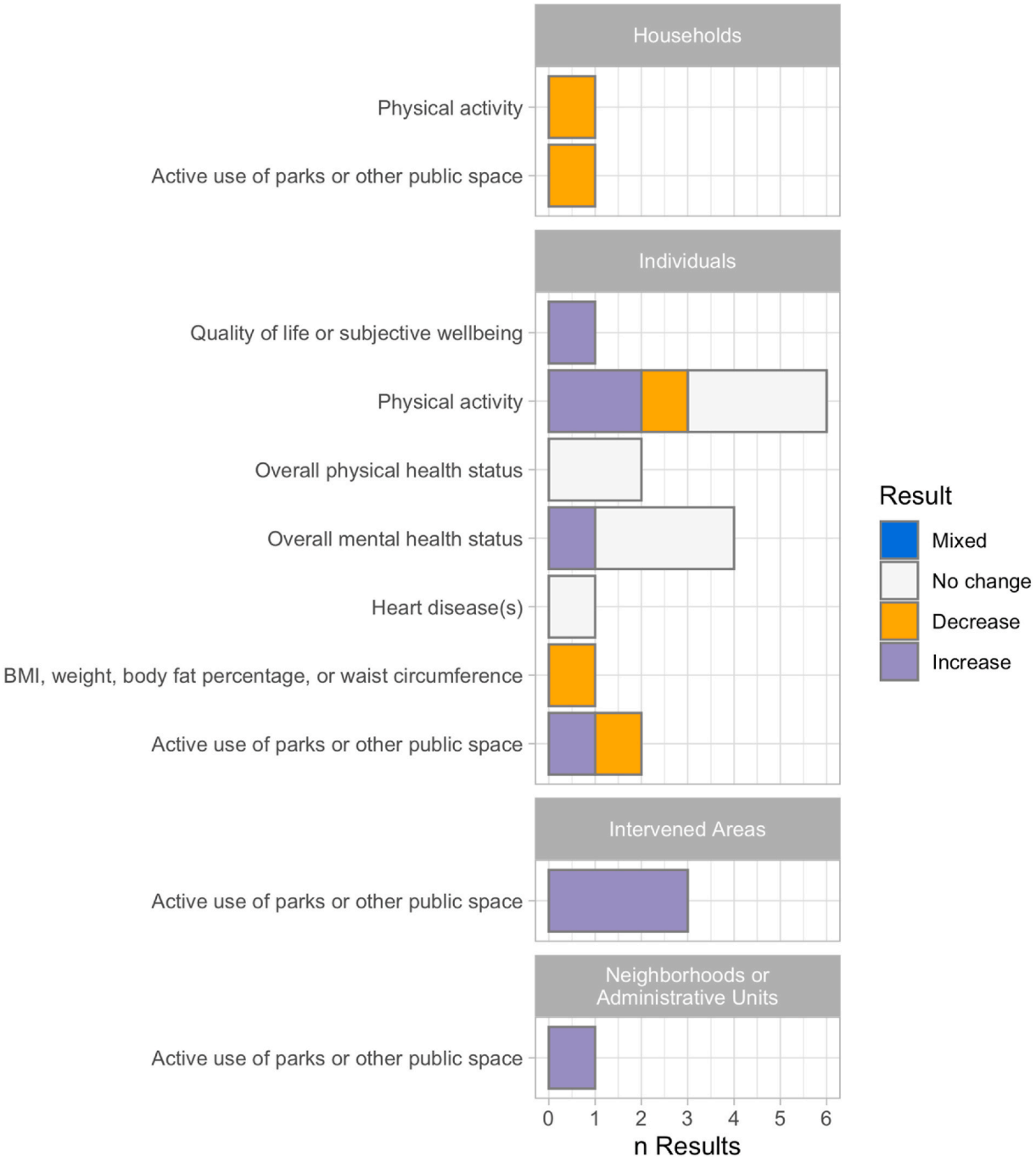

Fig. 5. Results from Trail and Greenway Papers
Summarized results from studies of trail- and greenway-based interventions. Outcomes are listed according to the level of analysis at which they were assessed. Multiple results may be reported from the same manuscript. A result is listed as "decrease" or "increase" for an outcome if statistical significance was reported for that outcome in the manuscript.

quasi-experiments while the remaining three were non-experimental pre-post evaluations. For the quasi-experimental evaluations, intervention and control units were generally constructed based on residential proximity: residents close to the intervention site were defined as the intervention group, and residents living further away as the control group. One study (Vert et al., 2019) (Vert et al., 2019) took advantage of a trail upgrade on one side of a river and defined the other side of the river as the control group, comparing trail use and physical activity levels between the two sides of the river before and after the intervention; another study (Benton et al., 2021) (Benton et al., 2021) defined geographically distinct control areas. Three studies did not define a place-based control group and relied on comparisons of the same area before and after the intervention took place. None of the included studies combine data from interventions on multiple urban trails.

Future work on evaluating trail and greenway projects can assess outcomes other than physical activity, such as mental health or traffic safety, and quantify the extent to which new trails displace or promote physical activity.

3.5. *Vacant lot greening/pocket parks*

Twelve studies focused on vacant lot cleaning-and-greening

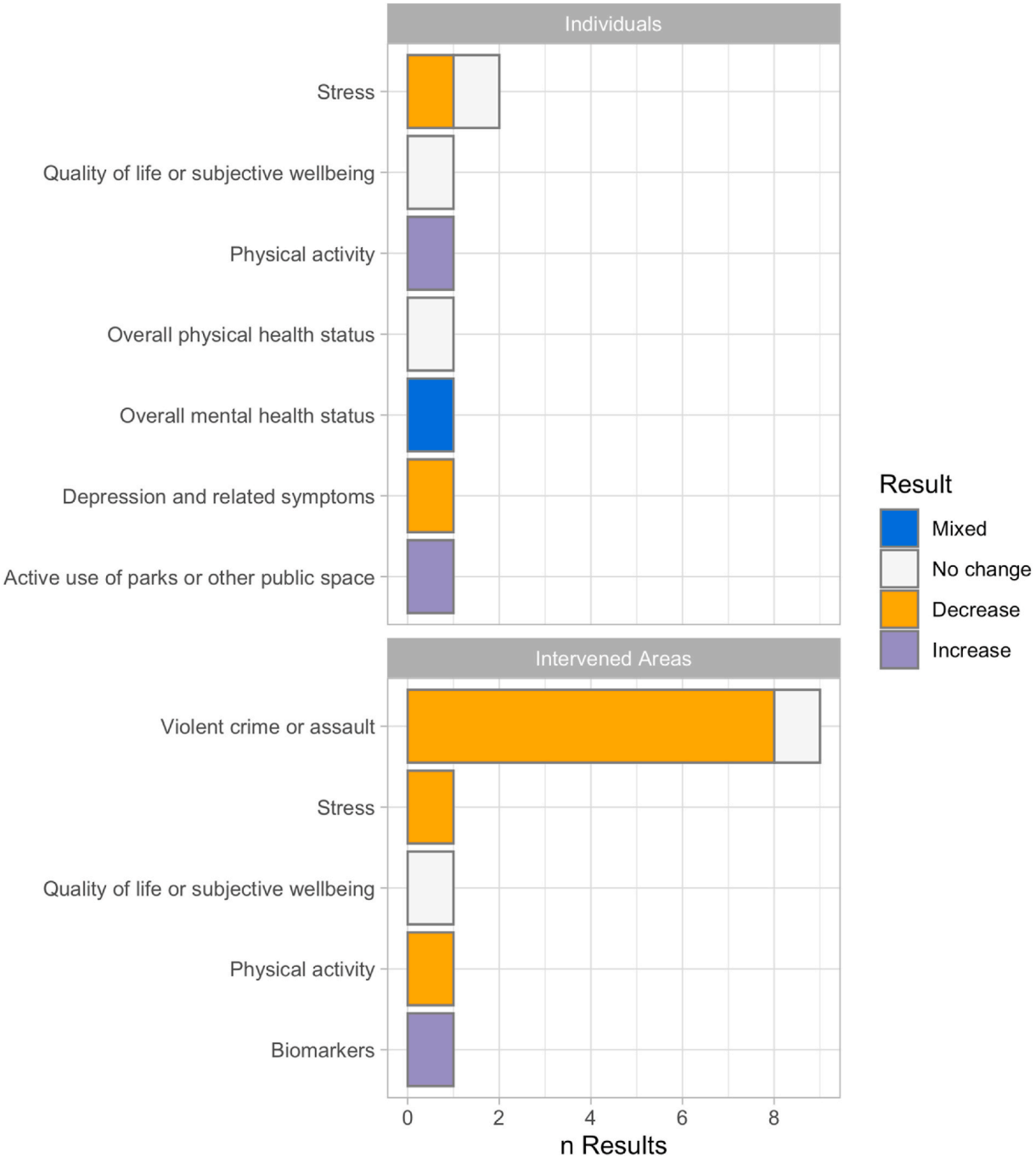

Fig. 6. Results from Vacant Lot Greening and Park Papers
Summarized results from studies of interventions related to vacant lot greening and pocket parks. Outcomes are listed according to the level of analysis at which they were assessed. Multiple results may be reported from the same manuscript. A result is listed as "decrease" or "increase" for an outcome if statistical significance was reported for that outcome in the manuscript.

interventions of various types. In Flint, MI, the intervention was routine maintenance (i.e., mowing, weeding, and gardening) of vacant lots (Heinze et al., 2018) (Heinze et al., 2018); in New Orleans, the intervention included removal of debris and mowing of vegetation (Kondo et al., 2018) (Kondo et al., 2018); and in Philadelphia, PA and Youngstown, OH, vacant lot cleaning-and-greening included removing debris, grading the land and adding topsoil, planting grass and trees, building a wooden fence with entry openings around the perimeter, and maintenance every two weeks (Branas et al., 2011; Branas et al., 2018; Garvin, 2013; Moyer et al., 2019; South, 2018) (Branas et al., 2011, 2018; Garvin et al., 2013; Moyer et al., 2019; South et al., 2018b). There were also community engagement components where residents conducted the cleaning-and-greening in Flint, MI (Heinze et al., 2018) (Heinze et al., 2018), and in Youngstown, OH, residents often constructed gardens on the vacant lots (Kondo et al., 2016) (Kondo et al., 2016). The vacant lot cleaning and greening interventions were generally implemented throughout the city under study, while one study in Los Angeles, CA (Cohen et al., 2014) (Cohen et al., 2014) focused on the construction of three pocket parks on formerly vacant land with a smaller spatial extent.

All of these interventions were implemented in low-income areas, characterized by high rates of vacancy or property foreclosure. Outcomes studied in these settings primarily included violent crime or assault, but also included perceived safety, mental health status, depression, physical activity, stress, heart rate, quality of life or subjective well-being, and active use of parks or other public spaces. One randomized cluster study, the LandCare RCT in Philadelphia, resulted in several papers being published (Branas et al., 2018; Moyer et al., 2019;

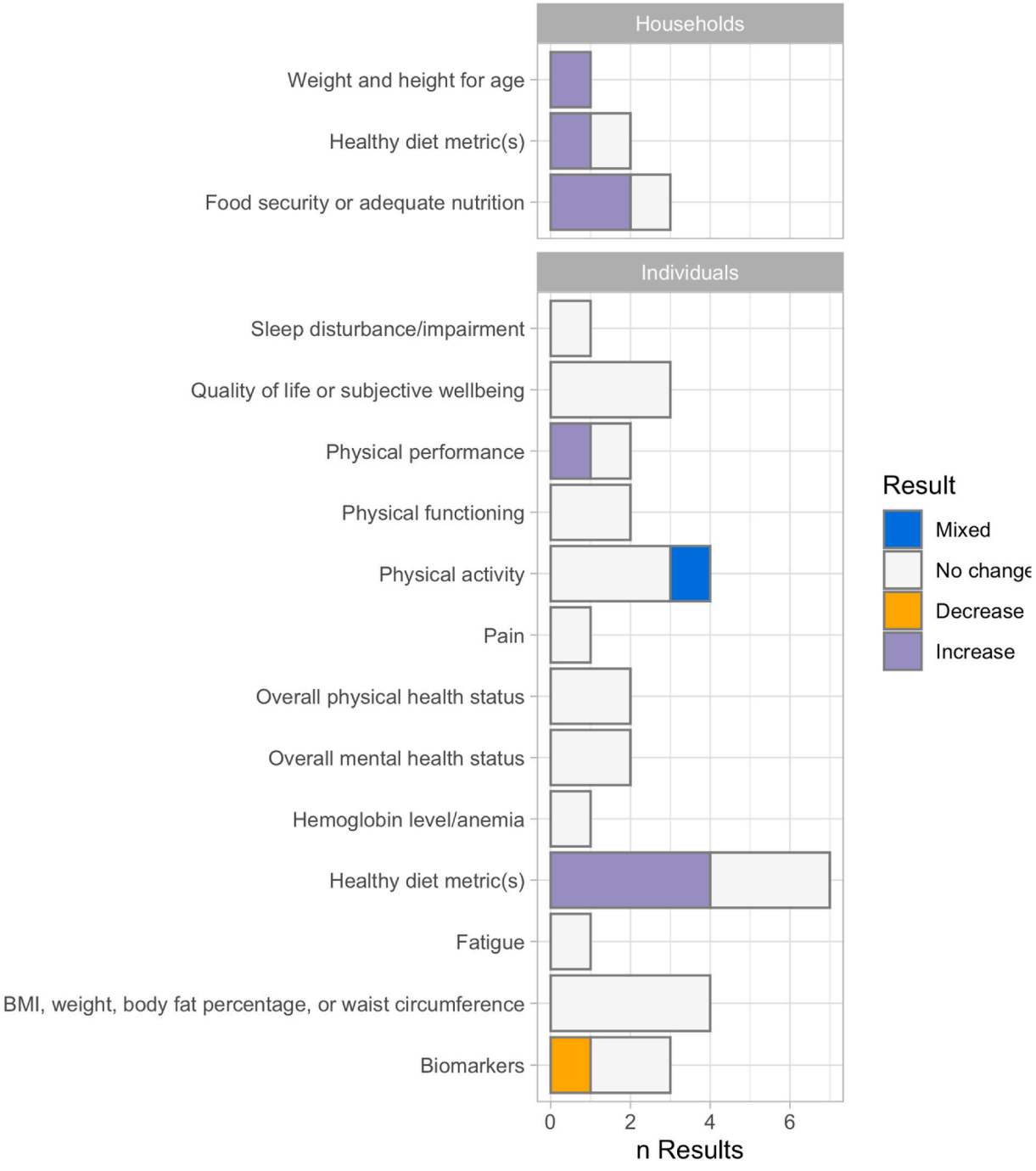

Fig. 7. Results from home garden studies.

South, 2018) (Branas et al., 2018; Moyer et al., 2019; South et al., 2018b), while the remainder were quasi-experimental studies, and one non-experimental pre/post-study design.

Results for vacant lot greening and pocket park papers are presented in Fig. 6. Most vacant lot greening studies found significant reductions in violent crimes surrounding intervened sites (Branas et al., 2011; Branas et al., 2018; Garvin, 2013; Heinze et al., 2018; Kondo et al., 2016; Moyer et al., 2019) (Branas et al., 2011, 2018; Garvin et al., 2013; Heinze et al., 2018; Kondo et al., 2016; Moyer et al., 2019), with more significant effects when community engagement was involved (Kondo et al., 2016) (Kondo et al., 2016).

3.6. Home gardens

Eleven studies focused on home garden interventions, most of which involved vegetable garden cultivation. Four studies provided participants with essential materials such as seeds and soil to facilitate garden creation (Blakstad et al., 2021; Carney et al., 2012; Depenbusch et al., 2021; Marquis et al., 2018) (Blakstad et al., 2021; Carney et al., 2012; Depenbusch et al., 2021; Marquis et al., 2018). Most studies included a social training component: four provided a master gardener for support (Bail et al., 2018; Blair et al., 2013; Demark-Wahnefried et al., 2018; Sharma et al., 2022) (Bail et al., 2018; Blair et al., 2013; Demark--Wahnefried et al., 2018; Sharma et al., 2022), two offered formal gardening training (Cases, 2018; Depenbusch et al., 2021) (Cases, 2018; Depenbusch et al., 2021), three distributed educational materials (Blair et al., 2013; Carney et al., 2012; Marquis et al., 2018) (Blair et al., 2013; Carney et al., 2012; Marquis et al., 2018), and one provided diet and health counseling (Blakstad et al., 2021) (Blakstad et al., 2021).

Home garden interventions frequently targeted patient populations, such as cancer survivors (Bail et al., 2018; Blair et al., 2013; Blair et al., 2021; Cases, 2018; Demark-Wahnefried et al., 2018; Sharma et al., 2022) (Bail et al., 2018; Blair et al., 2013, 2021; Cases, 2018; Demark-Wahnefried et al., 2018; Sharma et al., 2022) or people living with multiple chronic diseases (Budowle, 2022) (Budowle, 2022). Blair et al., 2013 (Blair et al., 2013) paired older cancer survivors with child cancer survivors, while Cases, 2018 and Demark-Wahnefried 2018 (Cases, 2018; Demark-Wahnefried et al., 2018) focused on older cancer survivors.

Outcome measures were primarily individual-level, with four studies utilizing household-level data (Blakstad et al., 2021; Carney et al., 2012; Depenbusch et al., 2021; Marquis et al., 2018) (Blakstad et al., 2021; Carney et al., 2012; Depenbusch et al., 2021; Marquis et al., 2018). Key outcomes included diet (e.g., vegetable consumption, preferences), physical activity, BMI, body fat, physical health, mental health, food security, and sleep disturbances. Most studies showed no significant changes in these outcomes. Seven studies focused on diet, with five reporting increased fruit and vegetable consumption, while physical activity remained unchanged (Blair et al., 2013; Blair et al., 2021; Cases, 2018; Demark-Wahnefried et al., 2018; Sharma et al., 2022) (Blair et al., 2013, 2021; Cases, 2018; Demark-Wahnefried et al., 2018; Sharma et al., 2022). Similarly, physical functioning and performance outcomes, typically paired with physical activity measures, showed no significant results (Bail et al., 2018; Blair et al., 2013; Cases, 2018; Demark-Wahnefried et al., 2018; Sharma et al., 2022) (Bail et al., 2018; Blair et al., 2013; Cases, 2018; Demark-Wahnefried et al., 2018; Sharma et al., 2022). Food security and nutrition were assessed in three studies, with two showing significant improvements (Carney et al., 2012; Marquis et al., 2018) (Carney et al., 2012; Marquis et al., 2018) and one showing no change (Blakstad et al., 2021) (Blakstad et al., 2021).

Study designs varied, with the majority using randomized controlled trials (RCTs). Three employed non-experimental pre-post evaluations (Blair et al., 2021; Carney et al., 2012; Sharma et al., 2022) (Blair et al., 2021; Carney et al., 2012; Sharma et al., 2022), and one was a longitudinal cohort study (Blair et al., 2013) (Blair et al., 2013). Among the RCTs, control groups varied, with three using a waitlist control, two without any intervention, and two using alternative controls, such as participant-chosen programs or standard care. Most studies were conducted in rural settings, with two in agricultural and metropolitan areas.

Results from home garden papers are presented in Fig. 7. Interventions seeking to improve dietary quality among patient populations through installing edible home gardens showed inconsistent results in improving measures of dietary quality. However, these interventions show promise at improving food security in developing countries. Expanding the population under study beyond patient populations may improve the generalizability of these results.

3.7. Community garden interventions

The seven community garden intervention studies were conducted in a wide variety of intervention settings. One study took place in a senior welfare center (Park et al., 2020) (Park et al., 2020); one in Black and Latino churches in Los Angeles (Derose et al., 2019) (Derose et al., 2019); and one in a correctional institution (Lee et al., 2021) (Lee et al., 2021). Studied interventions included direct participant involvement in gardening activities. Four studies were explicitly framed as "horticultural therapy" or "care farming" interventions, which targeted veterans with a history of suicidality (Meore et al., 2021) (Meore et al., 2021), prisoners (Lee et al., 2021) (Lee et al., 2021), mother-child pairs (Lee et al., 2020) (Lee et al., 2020), and dementia patients (Ura et al., 2022) (Ura et al., 2022). Because of this focus, community garden interventions were more likely to assess outcomes relating to mental health and overall wellness than were other study categories. Four studies assessed depression and related symptoms, two assessed cognitive functioning, one assessed physical functioning, and one assessed pain.

Results from community garden papers are presented in Fig. 8. Community garden studies consistently found that interventions were associated with reduced depression symptoms (Lee et al., 2020; Lee et al., 2021; Meore et al., 2021; Ura et al., 2022) (Lee et al., 2020, 2021; Meore et al., 2021; Ura et al., 2022), but none of these four studies employed a control or comparison site, so these findings cannot be taken as causal evidence. Both studies measuring cognitive functioning also identified significant improvements associated with the intervention (Park et al., 2020; Ura et al., 2022) (Park et al., 2020; Ura et al., 2022). Other outcomes were less consistent. One study found that the intervention was associated with an improved diet (Derose et al., 2019) (Derose et al., 2019) while the other study assessing this outcome did not (Lombard et al., 2021) (Lombard et al., 2021).

The quality of community garden intervention studies was hindered by very low sample sizes without relevant controls. Five of the seven studies were pre-post evaluations of one or two intervention sites with no control or comparison sites (Lee et al., 2020; Lee et al., 2021; Lombard et al., 2021; Meore et al., 2021; Ura et al., 2022) (Lee et al., 2020, 2021; Lombard et al., 2021; Meore et al., 2021; Ura et al., 2022). Of the remaining two studies, one does not include a place-based control and relies on differential exposure to the intervention between residents of the same senior welfare center to control for confounding (Park et al., 2020) (Park et al., 2020). The final study was a randomized controlled trial establishing community gardens at a sample of Black and Latino churches; this study found improvements to diet and reductions in body mass index among members of intervened churches relative to controls, but changes to physical activity were not significant (Derose et al., 2019) (Derose et al., 2019).

While early evidence from community garden interventions shows promise in reducing depressive symptoms, future work can improve the strength of evidence by employing place-based randomization or quasi-experimental designs. In addition, included studies only assessed outcomes among garden participants, and the health outcomes of neighborhood residents living near community gardens are understudied.

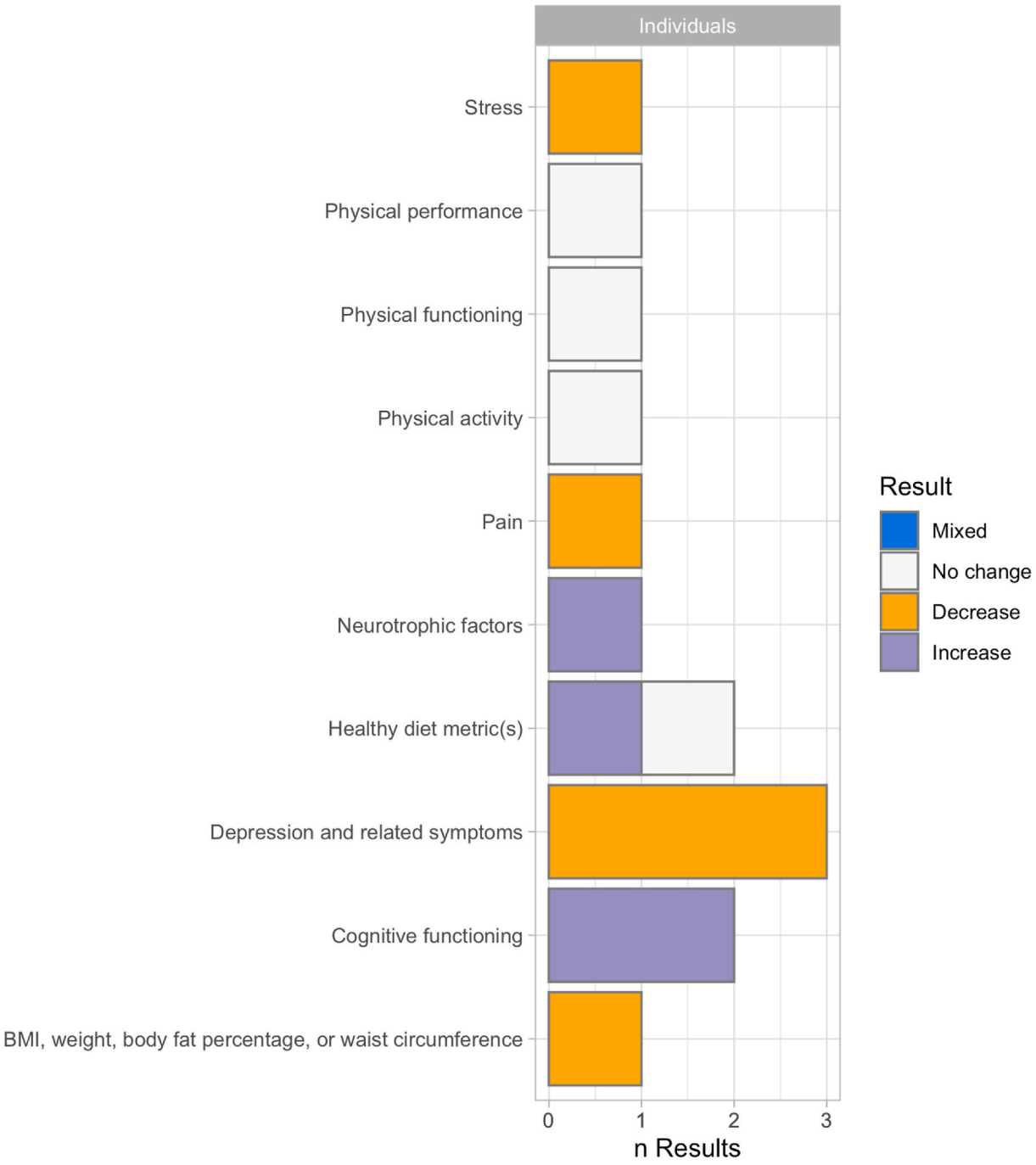

Fig. 8. Results from Community Garden Studies
Summarized results from studies of community garden interventions. All outcomes were assessed at the level of the individual participant. Multiple results may be reported from the same manuscript. A result is listed as "decrease" or "increase" for an outcome if statistical significance was reported for that outcome in the manuscript.

3.8. Tree canopy

We identified only one study that evaluated the health impacts of a place-based intervention increasing the level of tree canopy. Donovan et al., 2022 (Donovan et al., 2022) longitudinally analyzed the impact of a large-scale street tree planting project in Portland, Oregon, finding that neighborhoods with greater levels of tree planting experienced greater reductions in non-accidental mortality rates, with this effect increasing with greater tree age. Sabin et al., 2019 (Sabin et al., 2019) evaluated a community-led environmental restoration project in a watershed in the eastern Congo. This evaluation found that although residents in the intervention watershed reported greater tree planting activities than residents in the control watershed, forest cover did not change between the two areas; nonetheless, households in the intervention watershed reported improved food security relative to controls.

Because of the small number of studies, and the widespread interest in urban tree canopy, we also chose to include three studies that evaluated the inverse intervention: tree canopy loss as a result of the introduction and spread of the emerald ash borer in the United States (Donovan et al., 2013; Donovan et al., 2015; Kondo et al., 2017) (Donovan et al., 2013, 2015; Kondo et al., 2017). These studies found that emerald ash borer presence was associated with higher mortality

levels in affected counties (Donovan et al., 2013) (Donovan et al., 2013); that women living in counties infested with the emerald ash borer experienced an increase in cardiovascular disease (Donovan et al., 2015) (Donovan et al., 2015); and that affected census blocks with greater levels of tree removal experienced greater increases in violent crime (Kondo et al., 2017) (Kondo et al., 2017). Although these studies consistently show public health harm resulting from tree canopy loss, this is not an equivalent intervention to interventions that increase levels of tree canopy. There is a significant lack of evaluation and longitudinal studies assessing the impact of tree-planting projects.

3.9. Other intervention types

Two included studies (Semenza et al., 2007; Ward Thompson et al., 2014) (Semenza et al., 2007; Ward Thompson et al., 2014) reported on interventions that sought to beautify streetscapes and public squares through the installation of street planters and other design elements. Semenza et al., 2007 (Semenza et al., 2007) found that residents living near intervened squares experienced reductions in depression, but this study did not include control sites or comparison areas. Ward Thompson et al., 2014 (Ward Thompson et al., 2014) found that older adults living on intervened streets experienced no statistically significant change in physical activity, quality of life, or overall physical health status relative to older adults living on control streets. Although street and sidewalk planters are commonly implemented in urban environments, the effect of this intervention on public health is understudied.

Cummins et al., 2018 (Cummins et al., 2018) assessed the impact of the intensive urban redevelopment associated with the London Olympics, which included the addition of trees and greenspaces. Although surveyed residents reported that the Olympic Games alleviated stressors in the built and social environment, no significant changes in physical activity, overall mental health status, depression, or anxiety were found relative to boroughs not experiencing Olympics-related urban redevelopment.

Droomers et al., 2016 (Droomers et al., 2016) described the results of a large-scale project to increase the quantity and quality of greenspaces in economically deprived neighborhoods in the Netherlands. Twenty-four neighborhoods were targeted for interventions, including garden redevelopment, vacant lot greening, trail improvement, and playground construction. This study assessed physical activity and physical health status as outcomes and found no statistically significant change in these outcomes among residents of intervened neighborhoods relative to residents of control neighborhoods.

Kondo et al., 2015 (Kondo et al., 2015) reported the effects of green stormwater infrastructure installation in Philadelphia, finding no significant change in stress, violent crime, cholesterol, or blood pressure among residents of intervened neighborhoods relative to control neighborhoods. However, this analysis did find slightly higher rates of homicide at a geographic scale of 1/16th of a mile surrounding green stormwater infrastructure projects.

3.10. Works in progress

We screened seven protocol papers that would qualify for inclusion in this review, but for which we were unable to identify a relevant follow-up paper. Macmillan et al., 2018 (Macmillan et al., 2018) reported the protocol for a community-based streetscape and active travel infrastructure intervention in New Zealand; however, the follow-up paper does not report the planned quantitative health outcomes (Raerino et al., 2021). dos Santos et al., 2020 (dos Santos et al., 2020) reported the protocol for a school-based intervention in Brazil, and Qi et al., 2022 (Qi et al., 2022) for a school-based intervention in China, but full follow-up manuscripts were not available.

We were able to obtain the current project status for four protocols by contacting the authors. For instance, Barenie et al., 2023 (Barenie et al., 2023) reported the protocol of a schoolyard greening project in Little Rock, Arkansas, that was pending completed school renovations. Pearson et al., 2020(Pearson et al., 2020) reported a plan to evaluate the ecological restoration of parks in Detroit; interventions were completed in 2021, and manuscripts are in preparation. Mank et al., 2022 (Mank et al., 2022) described the protocol of a randomized-controlled trial of a home garden intervention; data collection for this project is in progress. Finally, Schmidt et al., 2022 (Schmidt et al., 2022) reported the evaluation plan for a nature-based rehabilitation intervention in a Danish nursing home; this project is also in a data collection stage.

3.11. Study design and reporting quality

The quality of included studies was frequently hampered by poor control for confounding. Twenty-eight studies, 28.5 % of all included, did not use a place-based control unit or comparison area, and 18 studies did not describe any method for controlling for confounding. Seven of the studies with no control or comparison area used multivariable regression, but as all participants received the same intervention in these cases, multivariable regression can highlight differential responses to the treatment between participants but does not isolate an independent treatment effect. Similarly, studies based in limited geographic settings such as schools or elder care centers cannot reasonably prevent spillover of an environmental intervention such as garden installation, so defining participant-level control groups within these settings as in Khan (2019) or Park et al., 2020 (Park et al., 2020; Khan and Bell, 2019) does not help to define the treatment effect of the place-based intervention. Only by incorporating comparison sites that did not receive the intervention under study can evaluation studies both account for time-varying confounding and estimate a treatment effect for place-based interventions.

Across intervention categories, study design and reporting were characterized by a lack of consistency in outcome measurement. Although 34 studies assessed the dietary quality of individual study participants, this was achieved by at least 20 distinct measurement and operationalization strategies. Similarly, at least 14 distinct approaches to classifying the physical activity of individual study participants were applied across 30 studies. Because policy recommendations should be derived from summary evidence across a variety of study settings, standardizing the reporting of outcome domains of interest is essential. Dietary outcomes such as the count of servings of fruits and vegetables consumed per day as in Blair et al., 2013) or Khan 2019 (Khan and Bell, 2019; Blair et al., 2013), and physical activity measurements such as metabolic equivalents as in He et al., 2022) or Thompson et al., 2019 [23, 70], are easier to compare between studies than measures that are more subjective (Derose et al., 2019; Eckerman, 2014) (Derose et al., 2019; Eckermann et al., 2014) or that are reported with reduced information such as by categorizing continuous responses (Droomers et al., 2016; Spears-Lanoix et al., 2015; van den Berg et al., 2020) (Spears-Lanoix et al., 2015; van den Berg et al., 2020; Droomers et al., 2016), and will aid in future evidence summary efforts.

During the screening process, our team's ability to assess study eligibility was hampered by a large number of manuscripts that either did not describe the intervention at all or did so in vague terms. Replicability demands that the nature of the intervention under study be described in detail such that it can be implemented by other groups or compared with other projects of a similar type. We found that visual illustrations of the intervention and its setting were invaluable in our understanding of each project; 26 studies included photographs illustrating the intervention and four studies included diagrams. We wish to particularly note three studies that included especially high-quality intervention descriptions: Cosco et al., 2022, Khan 2019, and King

2015 (Cosco et al., 2022; Khan and Bell, 2019; King et al., 2015). Future work in evaluating greening projects should seek to be as specific and straightforward as possible in describing interventions so that the audiences of these evaluations can replicate elements of interventions that are demonstrated to be successful and revise elements that are less so.

4. Discussion & conclusion

Based on our screening of 18,831 unique citations, we found 98 published studies quantifying the effects of place-based interventions that increased the quantity, quality, or accessibility of outdoor greenspace on a human health outcome or health behavior, with pre/post measurements using randomized experiment, quasi-experiment, or pre-post longitudinal study designs. While there have been multiple prior reviews of "nature-based interventions," ours is the first to focus solely on the evidence for impacts of physical, place-based greening interventions.

Outcomes relating to physical activity, body mass index, and dietary quality were especially common across studies but were not consistently conceptualized or measured, and therefore, meta-analyses were not feasible. Findings indicate that park projects incorporating community engagement may be more likely to enhance physical activity compared to those without such involvement. School garden projects often show improvements in nutritional knowledge and attitudes, although changes in behavior and BMI outcomes are less consistent. Vacant lot greening projects consistently report reductions in violent crime. New trail and greenway constructions do not appear to boost the population's physical activity levels. Home garden projects generally do not improve dietary quality, but they can enhance food security in developing countries. Reflecting growing interest in the socially inequitable distribution of greenspace access in cities, many studies focused on interventions in low-income areas. Fewer studies, however, applied comparable interventions across multiple types of neighborhoods, so it is unclear how the outcomes from greening interventions vary between neighborhoods.

The studies included in the review varied widely in the type and scope of interventions and study design. Few studies applied randomized designs, and many failed to adequately address confounding factors; nearly one in three studies did not employ relevant control units. Additionally, manuscripts often lacked sufficient detail in describing the interventions they reported. These weaknesses significantly limit our ability to make conclusive statements about the effectiveness of interventions or to compare features of interventions that tend to improve or impede success. In addition, while this review provides the state of evidence across a variety of categories of greening interventions, individual interventions within each category varied widely in goals, design, and scope. As a result, our summaries may overlook important nuances between individual interventions, which could help explain why some interventions reported improved health outcomes and others did not. We encourage researchers and public stakeholders to carefully consider the characteristics of individual interventions when planning future projects and evaluation work. This consideration extends both to intervention goals and to study design. While some studies are designed to evaluate changes in individual health, quasi-experimental studies leveraging aggregate health data describe neighborhood effects rather than changes to individual health or health behaviors.

The large number and substantial diversity of studies included in this review indicate a widespread and growing interest in projects aimed at improving public health by enhancing the quantity, quality, and accessibility of greenspace. However, the high risk of bias from confounding variables, lack of standardization in outcome measurements, and insufficient reporting on the intervention descriptions make it challenging to develop actionable recommendations from the current state of evidence. Future evaluations of greenspace interventions would benefit from close collaborations between researchers, practitioners, and community members. Designing interventions with evaluation in mind would lead to more robust study designs that incorporate randomized intervention units and employ high-quality, standardized measures of outcomes and covariates. Further recommendations for research on specific categories of place-based interventions are presented in Table 3.

Table 3
Recommendations for future research, by place-based intervention category.

Intervention Category	Recommendations for future research
School Gardens	Greater standardization of outcome measurement could elucidate mixed results.
Parks	Longitudinal surveys of neighborhood residents living near intervened and control park areas could reveal changes to park perceptions, physical activity levels, and mental health symptoms associated with park improvements.
Trails/Greenways	Broadening outcome categories and quantifying the potential for physical activity displacement could improve understanding of the role of trails and greenways in urban environments.
Vacant Lot Greening/ Pocket Parks	Health outcomes besides violence, as well as pathways of effect, could be explored.
Home Gardens	Conduct research with participants other than patient populations.
Community Gardens	Improve the quality of evidence by incorporating control sites and conducting longitudinal surveys of residents living near newly constructed or renovated community gardens.
Tree Canopy	There is a significant lack of evaluation and longitudinal studies assessing the impact of tree-planting projects. Detailed tree monitoring records, where they exist, could be combined with public health data.

An important methodological recommendation across all study types is the use of outcome measurements that are both standardized and can be compared across different manuscripts. For example, studies that used dietary quality or physical activity as outcomes frequently started with a standardized continuous measure, such as a count of servings of fruits and vegetables per day, or duration of moderate-to-vigorous physical activity. However, these measures were frequently categorized or binarized before reporting, and the categorized cutoffs varied between studies, limiting comparability. For all outcome domains of interest, we recommend the use of measures that are standardized, validated in prior research, and that are reported in a transparent and comparable way. Raw (uncategorized) counts of fruit and vegetable servings for dietary quality, and metabolic equivalents (METs) for physical activity, are examples of this recommendation.

In addition to these recommendations for study design, we also note a lack of relevant mental and emotional health outcomes reported in studies. Although multiple hypotheses for the nature-health relationship suggest impacts on mental wellbeing, these outcomes were rarely assessed in studies of school garden, park, and trail interventions, as school garden evaluations focused on dietary outcomes and both park and trail studies focused on physical activity. Theories of biophilia, attention restoration, and the social forums provided by public parkland would predict improvements to mental and emotional wellbeing from these interventions, but these relationships appear to be understudied in greenspace intervention evaluations. In addition, although studies of physical activity associated with park and trail interventions appear vulnerable to bias due to displacement of physical activity from other settings, this displacement could itself be beneficial for different public health outcomes: for example, a new greenway might displace walking and cycling away from busy roadways, resulting in a reduction in traffic injury risk. To ensure that the outcomes assessed in evaluation studies are useful and relevant, researchers may consider partnering with community members and policymakers prior to the evaluation to understand what health outcomes stakeholders are interested in understanding or that are expected to benefit from the planned intervention.

Community groups, park agencies, and land managers dealing with competing priorities and limited budgets rely on specific, actionable evidence of program effectiveness to guide planning and

implementation. By restricting our focus to longitudinal evaluations of place-based greening interventions and categorizing individual studies based on the nature of the intervention under study, we seek to summarize the state of evidence across multiple types of interventions. Although our summaries may miss important distinctions between individual interventions within categories, we report takeaways for each category that can be used to plan future interventions and to improve the quality of research that evaluates them. While some high-quality and robust findings support the value of place-based greenspace interventions for public health, the general quality of evidence remains low.

CRediT authorship contribution statement

Dustin Fry: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jalayna Antoine:** Writing – original draft, Validation, Methodology, Investigation. **Kylan Simpson:** Writing – original draft, Validation, Methodology, Investigation. **Ava-Clare Steed:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation. **Charles C. Branas:** Writing – review & editing, Methodology. **Mark Nieuwenhuijsen:** Writing – review & editing, Methodology, Conceptualization. **Kristin Mmari:** Writing – review & editing, Resources, Methodology. **Michelle C. Kondo:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.envres.2025.123157.

Data availability

Data attached as supplementary file

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