

Article

Evaluating Nature-Based Versus Generic Physical Activity Programs to Address Chronic Health Conditions: Lessons from an Oregon (USA) Pilot Study

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Abstract: Evidence appears to be building that direct exposure to natural landscapes characterized by significant green cover, such as forests, can help to reduce chronic health conditions such as obesity, stress, hypertension, chronic cardiovascular conditions, depression, anxiety, cancer, and diabetes. One way to encourage greater exposure to nature may be through the use of nature prescriptions, whereby clinicians formally recommend (or prescribe) time in nature to their patients. Based on self-reported data, we describe the implementation and lessons learned from a pilot field experiment examining the clinical use of nature-based versus conventional exercise recommendations in rural Oregon. We discuss the potential benefits of such recommendations, as well as identify several challenges and opportunities associated with field experiments seeking to evaluate whether nature prescriptions, offered as one part of patients' overall treatment plans, meaningfully improve human health outcomes in clinical settings. We conclude with several recommendations for practitioners and researchers interested in implementing and evaluating nature-based exercise programs to improve public health.

Keywords: nature prescriptions; public health and policy; forest and park management; natural landscapes; primary care and preventative medicine



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1. Introduction

The relationship between environmental exposure and human health has gained significant attention in recent years, especially concerning treating chronic illness and improving overall well-being (e.g., see [1–3]). Almost 130 million people in the US have at least one major chronic disease (e.g., heart disease, cancer, and diabetes), and half of all deaths are linked to these preventable and treatable diseases [4]. At the same time, health care professionals are recognizing the potential public health benefits of exposure to nature [5,6], and some clinicians (physicians and nurses) are even prescribing time in nature as a form of preventive and therapeutic care [6–8]. Such therapeutics have garnered the attention of researchers, resulting in a growing body of evidence highlighting the benefits of nature exposure on mental and physical health [2,9–13], potentially mediated by increased physical activity [14], which is the focus of this paper.

The concept of so-called “nature prescriptions” or “park prescriptions” involves clinician-focused recommendations that encourage patients to utilize trails, parks, and open spaces for recreation and exercise to help manage conditions such as anxiety, depression, obesity, cardiovascular disease, and hypertension [8,15] and encourage behaviors that improve health outcomes [16]. If effective, nature prescriptions could potentially be useful aspects of patients’ treatment plans [7,17,18]. There is also a growing interest among both public health officials and natural resource policymakers and managers in promoting and ensuring access to natural areas. The nonprofit organization ParksRx America, in partnership with the USDA Forest Service and National Park Service, serves as a clearinghouse for information on park prescriptions (<https://www.parkrx.org/>, accessed on 20 April 2025) and <https://parkrxamerica.org/>, accessed on 20 April 2025) (The mission of the USDA Forest Service is to connect people to the outdoors [19]. This mission includes ensuring that residents have adequate access to forests and their potential health benefits by, among other things, promoting access to recreation and outdoor experiences [20].

Despite growing research and programmatic and policy interest, uncertainties remain concerning the potential for nature prescriptions to improve human health. Although there have been several systematic reviews and meta-analyses of the effects of physical activity in nature, sample sizes in existing studies generally have been small and results mixed [21–23]. Responding to the need for additional research, in this paper we describe our efforts to conduct a pilot research project examining the potential efficacy of general exercise recommendations versus exercise in nature for the treatment of chronic illness. Specifically, we sought to (1) create a replicable process for engaging with medical clinics and patients and (2) identify key issues and limitations for evaluating nature prescription field experiments.

Our pilot study participants were patients diagnosed as having at least one chronic condition for which exercise was part of the standard of care. In particular, we tested recruitment and data collection strategies to gain insights regarding opportunities and challenges that researchers can face when conducting similar studies. In this paper, we present results related to these objectives, including our experiences with and lessons from implementing the pilot field experiment in two health clinics in rural Oregon. We also discuss the challenges we encountered and suggest ways to address those issues.

2. Chronic Diseases and Potential Effects of Time in Nature

Public health officials in the US have long expressed concern about the prevalence of chronic diseases. Two out of five people in the US have two or more chronic illnesses, and 12% experience at least five chronic illnesses [4]. About 40% of school-age children in the US had at least one chronic condition that limited their activities [24], and the same portion of adults over 20 years old are affected by obesity [25]. In 2022, heart disease, stroke, and diabetes were the leading chronic diseases, affecting approximately 25% of adults [26]. More than 20 million adults experience at least one episode of depression annually [27].

Managing the costs associated with chronic diseases is crucial. In the US, 90% of the 4.5 trillion USD spent annually on healthcare goes to the treatment of chronic conditions [26]. The financial effects of chronic diseases often fall disproportionately on low-income individuals and disadvantaged groups, who face less access to healthcare resources and potentially greater out-of-pocket expenditures [28].

In this context, treatments that include nature-based components have emerged as a promising complement to traditional medicine. Obesity is a medical condition characterized by excessive fat accumulation in the body, potentially leading to adverse effects on well-being [29]. The prevalence of obesity among children in the US aged 2 to 5 exceeds 8%, with a rate of 15% for children from low-income backgrounds [30]. The presence

of easily accessible and appealing natural surroundings, such as parks and forests, may enhance the enjoyment of physical exercise [20], potentially promoting physical activity and addressing obesity.

Several studies suggest that contact with parks, trees, and natural greenness may be associated with reduced obesity (Appendix A Table A1), among other outcomes [31,32]. Research suggests that increased physical activity may be a mediating factor, and research also found that programs promoting contact with nature were important [33,34]. In some cases, greenness in residential areas was itself associated with reduced obesity and smaller waist circumference [32].

Cardiovascular illness is responsible for more deaths than any other cause, and the World Health Organization anticipates that this will be the case through at least 2030 [35,36]. Coronary heart disease and stroke, potentially related to hypertension, are the primary contributors to cardiovascular mortality, combined representing around 18–20% of the overall disease burden in both Australia and the United States [35]. Hypertension affects an estimated 1.3 billion adults between the ages of 30 and 79 worldwide [37] and represents the foremost risk factor for a range of cardiovascular conditions, including coronary heart disease, stroke, chronic kidney disease, heart failure, and arrhythmia [38].

There have been several studies linking contact with nature with reduced cardiovascular disease [39], some of which are summarized in Appendix A Table A2. Spending time in forest environments in particular, sometimes called “forest bathing”, may significantly reduce blood pressure, perhaps through improved autonomic nervous system function [40,41] and reduced resting pulse rate [42], heart rate variability [43], and stress-related biomarkers [44]. Ref. [45] found that increased urban forest biodiversity was linked to a 13% reduction in heart disease mortality and a 16% reduction in stroke mortality. While not a replacement for standard medical care, time and especially physical activity in nature potentially offer a complementary set of treatments [3,13].

The body of research on the mental health effects of time in nature is especially advanced (Appendix A Table A3), and numerous studies suggest that forest walks can improve mood, reduce anxiety, and increase memory function. There is also some evidence of positive effects on depression and stress. Importantly, this body of research is international, suggesting that the potential effects of nature on mental health are not confined to specific countries or cultures.

Depression includes several conditions, including major, persistent and seasonal affective disorders. In the United States, 8.3% of adults experienced at least one major depressive episode during the previous year [27]. About 12% of US adults regularly experience feelings of nervousness, worry or anxiety [46]. Walking in nature was found to improve both cognition and mood, particularly for individuals with major depressive disorder [47]. One study found that short forest bathing episodes significantly reduced depression and tension in middle-aged and elderly people [42]. Ref. [48] found that a ninety-minute walk in nature reduced self-reported worry and neural activity associated with behavioral withdrawal, while walks in urban environments had no such effects. Research also suggests that exercise in parks and forests enhances peoples’ enjoyment of physical activity while concurrently mitigating stress and anxiety levels [21,49–51].

Discussion of the mechanisms by which nature may improve human health is beyond the scope of this paper, but [52] does offer some possible explanations. Chief among these is improved immune function, which may exist as a “central pathway” linking nature to human health. Another possibility is exposure to sunlight when spending time outdoors, which can improve sleep and aid in blood pressure regulation [53]. Relaxation techniques may also be more effective in natural settings, resulting in improved mental health and blood pressure regulation [54].

Although research so far is suggestive, ref. [7] notes an absence of clear evidence regarding the efficacy of nature prescriptions on patients with chronic diseases. Randomized control trials (RCT) are an important method for convincingly estimating impacts of programs, such as nature prescriptions, while eliminating potential confounders, yet few recent papers apply RCT methodologies to nature prescriptions (Appendix A Tables A1–A3). To help fill this gap, we therefore conducted a pilot RCT in Oregon and report on our lessons learned from its implementation.

3. Materials and Methods

Chronic diseases are a significant problem in Oregon (Table 1). More than half of all Oregonians have one or more chronic illness, with arthritis and depression being the most important. Especially in Klamath County, where one of our two clinics is located, the incidence of chronic disease is indeed significantly greater than the state average, due in part to higher incidence among women. With existing literature suggesting that many chronic conditions can be improved via time—and especially exercise—in nature, evaluating the efficacy of nature prescriptions in improving chronic health conditions in Oregon may be especially appropriate. Notably, all of the chronic health issues in Table 1 are mitigated by exercise.

Table 1. Adult Prevalence of Chronic Diseases in Oregon and the Counties Where the Two Clinics Studied are Located.

Chronic Condition	Oregon (Overall)	Klamath County			Wallowa County		
		Female	Male	Overall	Female	Male	Overall
One or more	52.8%	64.6%	49.4%	58.8%	53.7%	48.1%	52.7%
Any Heart Disease	6.8%	6.6%	11.2%	8.4%	5.9%	5.3%	5.8%
Chronic Heart Disease	3.1%	2.9%	4.2%	3.4%	n/a	n/a	n/a
Heart Attack	3.3%	3.9%	5.3%	4.4%	n/a	n/a	2.7%
Stroke	2.6%	2.3%	6.2%	3.8%	4.6%	n/a	3.5%
COPD	5.7%	9.3%	5.3%	7.8%	n/a	n/a	n/a
Cancer	8.1%	11.3%	8.6%	10.6%	10.8%	10.7%	10.2%
Depressive Disorder	25.5%	36.0%	15.4%	27.9%	15.6%	13.5%	14.8%
Diabetes	8.5%	12.2%	12.0%	12.1%	n/a	9.4%	8.6%
Arthritis	23.2%	35.6%	24.4%	31.2%	26.6%	31.2%	28.7%

Source: [55,56]. n/a indicates data are not available.

Our data collection involved enrolling study participants throughout the 2024 summer season and monitoring their physical activities for eight weeks via daily activity reports. Four undergraduate student research assistants received four hours of training in the data collection instruments included in Appendix A and were instructed on how to interact with patients. A senior student researcher was responsible for managing the research assistants and overall data collection process and also served as the first line of inquiry when study participants or any of the three student research assistants had questions. All student researchers were instructed that they should positively engage and encourage study participants to regularly report data.

Data collection began in July 2024 and ended in October 2024, when Oregon weather typically becomes significantly cooler, potentially making outdoor exercise in natural areas less appealing and potentially unsafe for some participants. Our research procedure included clinic recruitment, population identification and sampling, patient recruitment, randomization to treatment, and data collection, with each of these steps summarized as follows. The research study received human subject Institutional Review Board (IRB) approval from both Portland State University and Oregon Health Sciences University.

Two rural clinics participated in the study (Figure 1). The first was in Enterprise, Oregon, located in the northeastern part of the state. The second clinic was located in Klamath Falls, Oregon, which is in the south-central part of the state. Both clinics participated in kickoff meetings with study leads who presented the rationale for nature prescriptions, the study protocols, and specific wording for the nature prescription recommendations used for recruitment to the clinic staff members, nurses, and physicians who would directly engage with patients during participant recruitment. Throughout the study, researchers conducted periodic check-ins with clinics to provide workflow support and sent weekly enrollment updates to ensure clinics were aware of progress on recruitment targets.

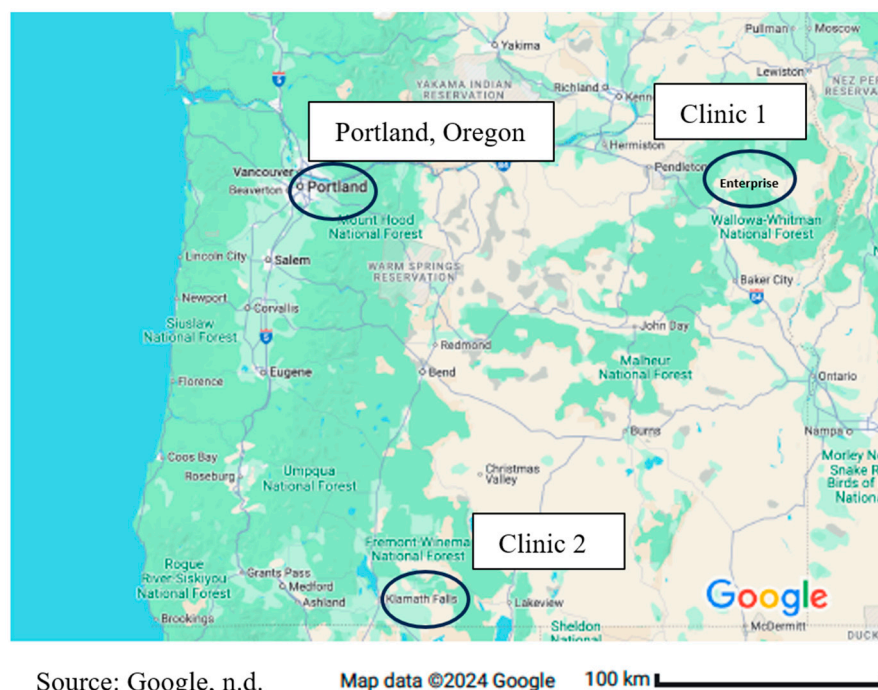


Figure 1. Location of the two clinics participating in the pilot evaluation [57].

Our sample population was made up of participants with at least one of the chronic conditions listed in Table 1, who were referred to the project by health care clinicians. The sample included only those patients who agreed to participate in the study. This opt-in approach was unavoidable, as we found that busy health care clinicians were unable to randomly sample patients using a protocol provided by the project. There was also no therapeutic reason to not offer all patients the chance to participate in the study.

All study participants received recommendations from their clinicians to exercise an average of 150 min per week, which is the US Centers for Disease Control and Prevention recommendation. Patients who opted into the sample were randomized into treatment and control groups by study personnel. Following their enrollment in the study, participants had several behavioral decisions they could make regarding their actual physical activity, reporting of activity, and activity locations (Figure 2). We acknowledge that the self-selection of study participants potentially creates analytical challenges that we and all researchers need to address statistically (e.g., using quasi-experimental methods) in order to evaluate the health effects of nature prescriptions.

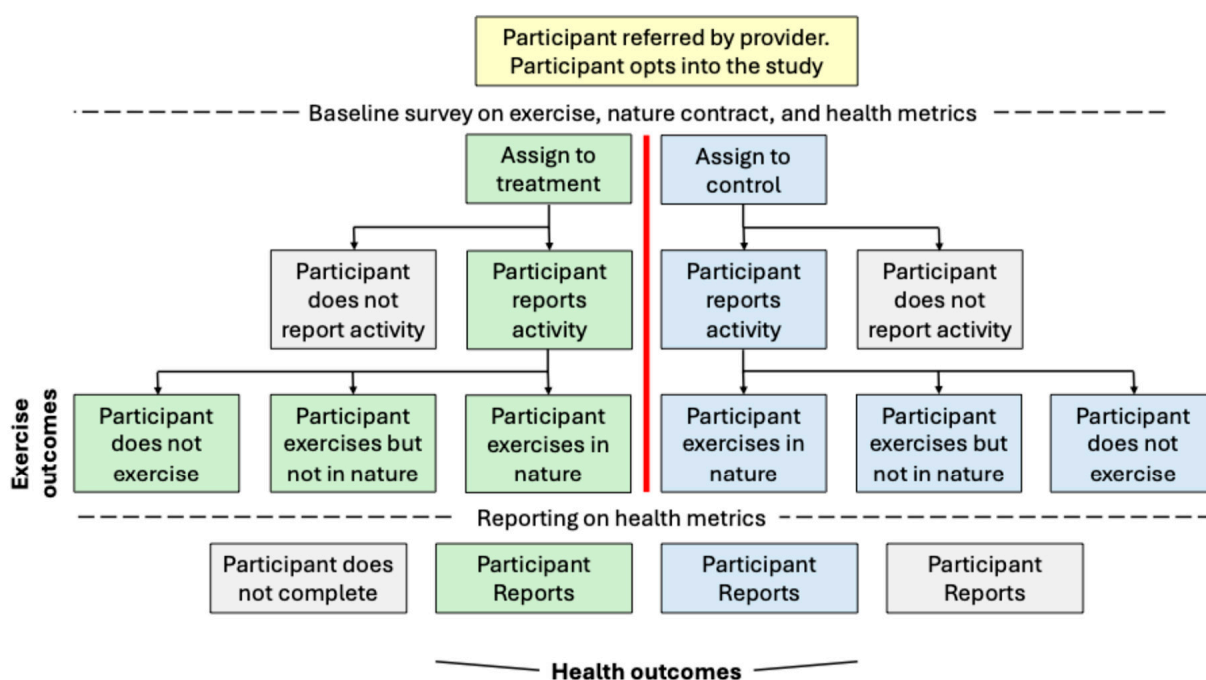


Figure 2. Decisions by self-selected study participants.

Study personnel advised clinics to use one of two approaches for participant recruitment: active or hybrid. Active recruitment involved clinics identifying patients diagnosed with at least one chronic condition prior to appointments. During the appointment, a health care provider introduced the study and asked if their patient was interested in participating. If the patient agreed, then the provider would write a prescription recommending 30 min of exercise five times per week. Patients were then asked to take the prescription to the reception staff who provided patient contact information to the research team. The senior student researcher contacted patients to welcome them as participants in the study and obtain their formal verbal consent.

Hybrid recruitment followed the same process for identifying potential participants as active recruitment, but if a patient expressed interest, then the provider gave them a recruitment postcard and suggested that they reach out independently to the study team to learn more and enroll in the study. The recruitment postcard included a QR code for patients to sign up for the study and agree to be contacted by the study team, who would then contact them to seek their consent. Patients could also sign up via email or telephone.

Clinicians in Clinic 1 chose active recruitment and an R_x pad (Figure 3) to prescribe that patients with one or more chronic conditions perform an average of at least 30 min of exercise per day. Providers also noted that they were partnering with university researchers on a project that was evaluating exercise behaviors over 8 weeks during the summer and that all study participants would receive a 100 USD electronic or physical gift card. Providers gave the nature prescriptions to patients who then could decide whether or not to fill them. If patients wanted to participate, then clinic staff forwarded patients' contact information to research staff.

Clinic 2 used hybrid recruitment. Health care clinicians encouraged their patients to exercise and invited patients to participate in the study by giving them a small flyer/postcard with information on how to enroll in the study. They also noted that all study participants would receive a 100 USD electronic or physical gift card. Participants responding affirmatively to the study flyer/postcard contacted the senior student researcher.

R_x Nature

Name.....

Date.....

Recommended Dosage

☐ Average of 30 minutes of exercise per day
5 days a week (total 2.5 hours/week)

MD

Figure 3. Anonymized Clinic 1 Nature Rx prescription pad.

All clinicians (comprising both nurses and physicians) made the opportunity to participate in the study available to their patients, but did not pressure them. We gave clinics a script (Appendix A) to serve as a guide. Patients who were interested in the study contacted the senior student researcher. The senior student researcher then used the script in the appendix to explain the project and discuss the compensation and participants' obligations. If the patient agreed to participate, then the student sent the participant an informed consent form by email or post and obtained oral consent by telephone or email, depending on participant preference. Each participant received a 100 USD gift card of their choosing and, in accord with institutional review board requirements; this thank you gift was theirs to keep even if they decided to leave the study. Patients who agreed to participate received their standard program of care, including the recommendation to exercise, with the only difference between treatment and control groups being the addition of a nature prescription.

Randomized Treatment—Nature prescription based on recommendation to engage in standard of care exercise outdoors in natural areas.

Randomized Control—Current standard of care involving exercise, but no prescribed nature contact.

The senior student researcher randomized patients who agreed to participate, assigning half into the treatment group and half into the control group using even-odd randomization. The student informed patients to which study arm they were assigned (nature prescription or general exercise) and gave them the appropriate instructions (Appendix A). Patients did not know about the other arm of the study and were free to exercise (or not) wherever they chose throughout the eight-week monitoring period.

Participants assigned to the treatment group were provided with a brochure that included a list of suggested parks and other natural areas with trails where they were encouraged to exercise. To the extent possible, participants were also given directions to parks/natural areas and information on key characteristics (e.g., places to sit, bathrooms, trail surface), though a key issue in Enterprise, Oregon, given its highly rural location, was a lack of formalized natural recreational areas. The brochure for participants from Klamath County is shown in Figure 4.

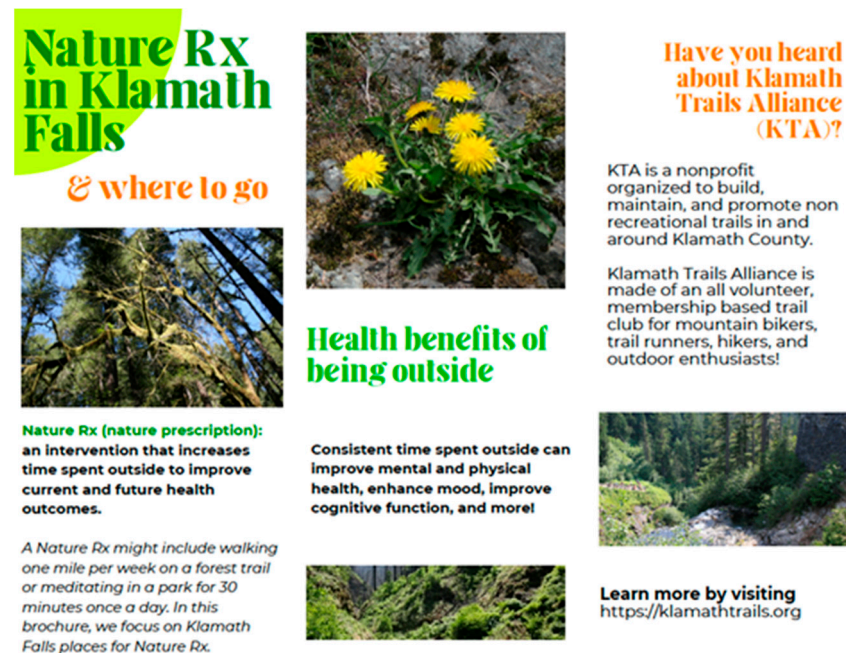


Figure 4. Klamath County treatment group brochure.

The study did not directly access or rely on participant medical information and all data were self-reported, including information on exercise behavior, general health status, and socio-economics. The baseline survey instrument and the daily log form for one of the eight weeks are included in the appendix. The main outcome metrics collected were self-reported wellness, exercise frequency, exercise duration, and exercise location. To record their exercise, patients received weekly logs, either in paper or electronic forms, in which they were asked to record each date and time they started and stopped their exercise (if any), the location of their exercise and notes on their experiences.

Most participants provided their data online via a secure Google Form, but some reported by telephone. Student research assistants in any case telephoned participants each week (a minimum of 8 times/patient during the full study period) to either collect these data or simply to check in and remain connected. Participants were contacted by telephone or via the internet at baseline for a short survey focused primarily on patient wellness. Figure 5 presents a summary of the data collection workflow.

1. Provider recommends exercise to a patient and asks if they would like to learn more about the study.
2. Provider either writes a nature Rx or gives patients a small study flyer/post-card.
3. The patient contacts the student researcher.
4. The senior student researcher presents the project and asks if they would like to participate.
5. If the patient agrees to participate, then the senior student researcher discusses how the patient would like to receive the informed consent document and 100 USD gift card. The student sends the consent document and receives informed consent by email or phone. After receiving informed consent, the gift is sent.
6. The senior student researcher assigns the participant an ID number (1, 2, 3, 4, 5, etc.) and randomizes them into treatment or control groups using even-odd number randomization. The student reads the treatment or control script in the appendix to the participant as appropriate and sends treatment group participants information on natural recreation areas, including the brochure.
7. The senior student researcher sends one of three student research assistants the participant information, including participant ID number and whether the participant is in the treatment or control group. They also tell the student research assistant how the participant wants to provide information, which can be via Google Form, email or phone).
8. The student research assistant calls the participant to confirm the mode of data collection and starts data collection with the baseline survey. Baseline survey data are entered directly into a Google form, using the participant ID number, with no identifying information. The student research assistant also sends the patient the Week 1 Exercise, Sleep and Health Log Form.
9. The student research assistant assigned to each participant sends the participant a new Exercise, Sleep and Health Log Form every week for 8 weeks (Google Form link, email or mail) to be sure they have it.
10. The student research assistant calls participants weekly to check in, collect data (and enter it into the Google Form) or thank the participant for filling out the log Form. They ask participants to complete the form, if they have not yet done it. Student researchers also inquire how the exercise is going.
11. After 8 weeks, the data collection ends.

Figure 5. Summary of data collection workflow.

4. Results

We enrolled a total of 34 participants who provided multiple observations over the course of the study, out of 68 people who contacted our senior student researcher to sign up. The other 34 either informed study personnel that they did not want to participate or did not respond to outreach. Because of our even-odd randomization procedure, participants were virtually equally divided between treatment and control groups. To be sure we consider participants who genuinely participate, in our discussion of results we only include those who submitted at least 10, but not more than 69 daily log forms. We therefore report

information on 25 participants, for a total of 771 observations. Considering only the number of data groupings, our sample size is in line with the recommendations for pilot studies of [58] (12 observations in each arm) and [59] (9% of envisioned full trial sample size).

The key data collected for our study came from the daily log forms participants mainly submitted online as Google Forms. Our unit of analysis is therefore the person-day, with full participation implying 56 log forms from each participant. The average participant submitted 29 forms, with the median lower at 19.5, but 40% submitted 34 log forms or more, which represented a significant, though imperfect, commitment to the project. Only 12% of participants submitted 50 daily log forms or more over the course of 8 weeks.

A number of features of our sample stood out. First, sample descriptive statistics were largely consistent with the counties from which they were drawn, with the exceptions of participants who were employed and female. Twenty-four percent of participants were retired, and only 36% reported being employed, which is well below US Census-reported figures for both counties (Table 2). Fifty-six percent of participants reported pre-tax household income of less than 50,000 USD, which is in line with Census data.

Only 25% of participants were men while 75% self-identified as women, which is a significant response gap. Although our questionnaire included the option, no participants specified non-binary genders. The research literature on gender gaps in study participation is surprisingly limited, but based on the available evidence, it seems that women typically participate more than men. A gender gap is therefore not surprising, but the difference was significantly higher than is typically observed, for example, for one-off surveys [60]. The fact that our study required a more intensive and prolonged commitment of time and effort than completing a simple survey instrument, may have contributed to our gender-based participation gap.

We did not ask participants for their ages, but about two-thirds of the sample indicated that they were over 45 years old, and 25% of participants were over 65 years old—slightly above the county averages. Twenty-three percent of respondents were 35 years old or younger. Twenty-eight percent reported having a bachelor’s degree or higher, which is roughly in line with county averages and below the Oregon statewide average of 38%.

Table 2. Key Descriptive Statistics from the Sample and Select Census Data from Oregon and the Counties Where the Two Clinics Were Located.

	Sample Data	US Census Data		
		Oregon	Klamath County	Wallowa County
% of People > 65 Years	24%	20%	22%	29%
% of People with a Bachelor’s Degree or More Education	28%	38%	21%	32%
Employment Rate	36%	60%	46.7%	53.7%
Retired	24%	n/a	n/a	n/a
Median Household Income	n/a	80,160 USD	52,547 USD	62,238 USD
Poverty Rate	16% *	12.2%	21%	9%
Female	75%	50%	50%	51%
Randomly Assigned to Treatment	48%	n/a	n/a	n/a

Source: author analysis [61]. * based on household income < 25,000 USD. n/a—not available or not applicable.

Second, all except two participants were from Clinic 2 which used the hybrid recruitment process. Participants from this clinic were given a small flyer/postcard and invited by their providers to self-enroll in the study. We suspect that hybrid recruitment shifted

some of the burden of signing up from the clinic to respondents, thus easing the participant recruitment task for clinic staff. We might have expected recruitment to be lower under hybrid recruitment, but we found that more patients enrolled (We thank an anonymous reviewer for raising this point. We note that the active recruitment approach potentially could have encouraged patients to exercise in natural areas, but we found that it was substantially less effective at recruiting participants into the study. We emphasize that we do not know the reasons for this difference. Given that we only had two clinics in this study, we cannot generalize or compare recruitment methods and conclusively say one approach is better than another). Another benefit of hybrid recruitment was we were more easily able to track patient recruitment efforts, because we provided the recruitment flyers/postcards used by the clinic during the study. In total the project made available 200 postcards.

Participant engagement varied significantly during the study. Some individuals demonstrated high levels of adherence by consistently and regularly completing their daily exercise logs. Many of these participants also maintained steady communication, frequently reaching out via email or text with questions and updates. Student researchers reported that responsiveness and commitment appeared to stem from self-motivation and a genuine interest in improving their health and maintaining a fitness routine.

Other participants were less consistent and logged their exercise activities three to four days a week. Maintaining regular contact with less consistent participants required multiple follow-ups via email, text, and phone calls. Some of these participants were difficult to contact, primarily due to work, vacations, and health issues. Some participants requested that weekly log weblinks be sent via text rather than email, finding text messages more convenient and less likely to be missed than emails. Regular weekly check-ins were conducted to actively support participants and address any issues as they arose. These weekly points of contact also encouraged participants to complete their log forms.

Despite the best efforts by study personnel, over time some participants exhibited waning interest or expressed their desire to withdraw from the study. Participants reported withdrawing due to personal stress, family emergencies or significant health issues, which prevented them from exercising. In cases where participants gradually ceased responding to phone calls, texts, and emails, we sent an additional email specifically asking if they wished to continue participating. This email was sent after sending three text messages and/or phone calls. If a participant explicitly confirmed their intention to withdraw or did not respond to this emailed inquiry, then we considered them as having left the study. We then sent a final email thanking them for their participation.

Reactions to the 100 USD gift card were mixed. While some participants appreciated the incentive, others indicated that it was not an important reason to join the study. For some participants, issues with activating and using physical Visa gift cards posed challenges. Difficulties in returning malfunctioning cards and hesitance to ask for help due to privacy concerns or unfamiliarity with technology delayed resolution of compensation-related problems.

We used password-protected spreadsheets to track participant information and progress, noting log form completion rates and any issues encountered. For participants reporting their activity using online forms, we checked their submissions weekly and sent out new exercise forms as needed. For those preferring physical forms, we collected their data via phone calls or emails and manually entered the information into our data system. Seasonal illnesses, age-related physical problems, and unexpected accidents disrupted participants' ability to consistently complete their exercise and weekly log forms. Participants suffered from a variety of illnesses during the study period, making it difficult for them to exercise and complete their daily log forms.

Seasonal and climate-related issues contributed to data submission irregularities. Participants took vacations, which sometimes made it difficult to maintain regular contact. Heat waves and smoke from wildfires, both typical for eastern Oregon during the summer, kept some participants indoors. A minority of participants also experienced difficulties with submitting online daily log forms, which meant students had to send PDF or even physical versions of the exercise log forms, leading to delays in reporting. Though 23% of our daily log data indicated that participants did not exercise, students reported that some participants may have not submitted log forms on days when they did not exercise or were feeling poorly. Finally, although we provided guidance regarding what activities constituted physical exercise (Appendix A), participants in the treatment group sometimes mistook sedentary outdoor activities for exercise, and there were occasions when treatment participants reported simply sitting outside as outdoor exercise.

5. Discussion of Findings and Lessons Learned

Previous research suggests that exposure to nature can help promote and maintain physical and mental well-being. Potentially one of the most significant impacts is nature's capacity to help combat the increasing prevalence of obesity, a serious public health issue. In addition, researchers have sometimes found effects on the prevention of other chronic diseases, such as diabetes, hypertension, and cardiovascular disease. There could be many approaches to encouraging exercise in natural areas, but one important channel may be through health care providers via so-called nature prescriptions. Our study contributes to the nature prescription literature by presenting the experimental process and lessons-learned from a pilot randomized field experiment implemented in two sites in rural Oregon. We found that designing, implementing, and evaluating the results of such studies is feasible and can potentially contribute to evidence-based conclusions about the efficacy of physician-prescribed exercise in nature. We also found that such studies involve several challenges (Table 3).

Significant compromises needed to be made while implementing the study, including being flexible about the notion of nature prescriptions themselves. Health care clinicians reported that it was not feasible for them to randomize and keep track of patients. At neither study site, therefore, did clinicians randomly provide prescriptions to exercise in nature, because the randomization into treatment and control had to take place after rather than coincident with participant recruitment. One clinic utilized active recruitment and formally prescribed exercise using the prescription pad shown in Figure 3. For reasons that are not fully understood, it was not very successful in recruiting patients into the study. Clinic 2, which used hybrid recruitment, was more successful in enrolling patients, but the "prescription" was less formal than in Clinic 1.

Most participants were responsive and regularly completed their daily log forms (average was 29 logs over 8 weeks). Researchers can therefore perhaps expect that most patients who enroll in such studies will be willing to keep track of their activities, report their well-being, and keep in contact with project staff members. Student researchers often reported, though, that the participants who most diligently reported also said they were trying to increase their exercise. Indeed, it may have been the case that some of these participants were using the study as a commitment mechanism to increase their exercise or even to more frequently get out into nature. This finding raises the possibility that the more motivated people may have stuck with the study or specifically wanted to increase their time in nature, creating inference challenges we and others will face going forward. Almost all of the participants in our pilot study self-identified as women, suggesting a particularly visible result of self-selection.

Table 3. Summary of Findings and Lessons Learned.

Our Findings	Key Research Design Implications
Health care clinicians are busy and were not able to randomly identify patients.	Patients self-select and researchers randomize. Need to statistically adjust for self-selection. Consider incentivizing clinics to recruit and randomize.
There is some evidence of participant moral hazard behaviors.	Consider focus groups to pinpoint issues and include screening questions in surveys to statistically adjust for them.
Most participants were women.	Though this finding may not be systematic, researchers may need to oversample men.
Some clinics recruit much more than others.	Researchers may want to consider including several clinics to allow for such differences. Consider incentivizing clinics to recruit and potentially also randomize patients.
Hybrid patient recruitment was most successful.	With only two clinics, we are unable to draw strong lessons from this finding.
Fewer daily logs submitted over the course of the study.	Consider providing incentives payable over time to reduce attrition and encourage continuous engagement.
Some respondents had difficulty with technology.	Researchers may want to consider GPS-enabled health monitoring technologies.
Some respondents appear to have not reported when they did not exercise.	Researchers may want to consider GPS-enabled health monitoring technologies.
Some respondents reported sedentary outdoor activities as exercise.	Researchers may want to consider GPS-enabled health monitoring technologies.

There was some participant attrition during our study. About 20% of study participants formally dropped out or “ghosted” student researchers soon after starting to provide data. Our study’s initial enrollment number was therefore significantly higher than the 34 participants who ended up providing data. In a few cases, it seemed as if participants signed up so they could receive the 100 USD gift card and had little intention of actually participating.

The medical clinics participating in our study were busy, and it was clear that clinicians had priorities beyond our nature prescriptions project. As a result, startup and enrollment were both slower than anticipated. Our experience was that even using hybrid recruitment, over two to three months one clinic can be expected to recruit approximately 25 patients who actively engage in study activities and provide data. Especially if time is of the essence, as is the case during the summer in Oregon, then more clinicians and perhaps more clinics must be simultaneously engaged to meet minimum sample size goals.

About 23% of our daily log observations indicated no exercise, but we believe that no exercise days are under-reported. Research staff members tried to make clear that patients should report every day, but either the message was unclear or the student researchers were unable to convince respondents to follow this protocol. This result may have been due to confusion but could also have been a form of moral hazard.

Our pilot field experiment in rural Oregon offers some important lessons for implementers and evaluators of nature prescriptions programs. First, researchers will probably need to be flexible when working with clinics and may want to consider incentivizing clinics through payments or other support if personnel burdens are likely to be significant. The closer recruitment protocols get to true nature prescriptions, the greater the communication and data management burdens on clinics, and it may therefore make sense to compensate clinics and/or staff members for the increased work.

Even with clinic incentives, our pilot results suggest that it will be challenging for nature prescription studies to reach 100% randomized control trial situations. With perhaps inevitable self-selection into studies, there may be a variety of unobservable drivers of behaviors. Researchers will therefore need to plan to use screening survey questions and quasi-experimental statistical methods to adjust for self-selection. We only started to understand moral hazard within this context, but there appears to be a lot going on. Nature prescription program proponents and researchers need to think about procedures to help reduce participant transaction costs and moral hazard behaviors. For example, rather than utilizing exercise self-reporting, GPS-enabled heart monitors could help researchers know when exercise occurs, how long it lasts, where it takes place, and how intensive it was. Such technologies would avoid a lot of issues, including confusing no data with no exercise and defining sedentary activities as exercise.

Also related to moral hazard behaviors, the one-time incentive payments to patients appear to have created some problems. Future studies may want to consider increasing total payment levels and also spreading payments out over the course of the data collection period to reduce attrition. This approach may help keep participants with a variety of motivations actively and appropriately participating in the studies.

Finally, nature prescription programs and studies are staff-intensive enterprises. More than one project staff meeting per week during the data collection period was needed to effectively coordinate. Student researchers also spent a lot of time communicating with participants, especially when participants did not submit data or encountered issues entering data. Researchers wanting to conduct such studies should plan on an average contact time of 30–60 min per week per participant.

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Appendix A. Scripts to Be Read to Patients

Script for Health Care Clinicians to Offer the Opportunity to Participate in the Research Project

“Based on recommendations from the Centers for Disease Control and other organizations, I am prescribing that you exercise an average of 30 min daily over five days each week (total of 2 h and 30 min per week). Your exercise can include any activity you

enjoy, including walking, hiking, biking, yoga, stretching, games, swimming and strength conditioning. I am giving you this prescription because exercise can provide important physical and mental health benefits.

I am partnering with university and scientists to study the effects of regular exercise in people with chronic conditions. The study will take place between July and October 2024. Participation is completely voluntary and participants will receive a \$100 Visa or comparable gift card for participating. Would you like to learn more about this study and what you would need to do as a participant? **[PLEASE CONTINUE ONLY IF PATIENT WOULD LIKE TO LEARN MORE]** Would it be okay if I shared your telephone number and/or email address with the research team so they can reach out to you?"

Participant Recruitment Script

(To Be Read to Potential Participants by Senior Student Researcher)

"Based on recommendations from the Centers for Disease Control, and other organizations, your health care provider has prescribed that you exercise an average of 30 min daily over five days each week (total of 2 h and 30 min per week). Your provider is giving you this prescription because exercise can provide important physical and mental health benefits.

Your provider is partnering with university and scientists to study the effects of regular exercise in people with chronic conditions. The study will take place between July and October 2024. Participation is voluntary. If you choose to participate in this study, you will be asked to keep a daily log of your exercise activities, which we will provide to you. The log form will either be online or on paper, depending on your preference. It will include information on where you exercised, your sleep habits, your heart rate immediately after exercising, and how you feel physically and mentally. Completing the log form is expected to take about 5 min per day. If you keep your log on paper, once per week for eight weeks, university researchers will call and ask you to report the data from your log form. Each week, they will anonymously record these data on a password-protected data sheet.

You will also be asked to complete short questionnaires at the beginning of the study, after eight weeks, and after six months. These questionnaires will focus on your exercise activities, time spent in nature, and your personal characteristics.

Approximately 84 people will participate in this study. University and we will seek to publish the study's results to increase knowledge about the effects of exercise. No personally identifying information will appear in any publications.

To offset the participation costs and as a small token of appreciation for your time, you will receive cash or a gift card of \$100. Once you receive this gift, it is yours to keep, and even if you decide to leave the study, it does not need to be returned.

Would you be willing to participate in this study? If yes, I will send you a document that answers questions about use of your information, privacy and who to contact during the study. I will then follow up to ask if you have any questions. I will also ask if you voluntarily consent to participate in the study."

Script For Participants Who Have Given Informed Consent and Are Randomized into the Treatment Group (To Be Read to Participants by Senior Student Researcher)

"Thank you for agreeing to participate in this study conducted by university and scientists. As a reminder, the focus of the study is to understand the effects of regular exercise in people with chronic health conditions. The study will take place between July and October 2024."

"Your exercise can consist of any activity you enjoy doing, including walking, hiking, biking, yoga, stretching, games, swimming, and strength conditioning. Your health care provider is prescribing that you conduct exercise as much as possible, in natural areas

within approximately 15 min of your home for an average of 30 min daily over five days each week (total of 2 h and 30 min per week). Your provider is giving you this prescription to exercise to the extent possible in natural areas because exercising in nature—or spending any time in nature – may provide important physical and mental health benefits above-and-beyond any benefits from exercise.

These natural areas should be green and have significant plant coverage. Your provider is making this recommendation, because exposure to green natural areas can especially offer health benefits. Ideally, there should be trees in your places of exercise that cover at least 50% of the sky. When you look up, at least some of the time, tree canopy should cover half the sky. Please think of this recommendation as a prescription about where you might like to do your exercise. Do you have any questions so far?

I will be sending you information about natural areas where you may want to exercise. I can send this information by email or post. Which would be better for you? **[Note to research assistant: please take note of the participant's preferred delivery method and send the information by that method.]** I will also be connecting you with a university undergraduate student who will be working with you throughout the study **[Note to research assistant: If you will be working with this participant yourself, please let them know]** and who will send you daily log forms each week and the first of three surveys. These can be made available via an online Google Form or as a document. If you would like these as documents, the student or I will telephone you weekly at a mutually agreeable time to get your responses. Which method would you prefer? **[Note to research assistant: If using Google Forms, please request the email address to send the link. If by paper, please ask if the participant would like the form emailed or sent by post. Please ask the patient for the relevant addresses].** I will also send your \$100 gift card **[Note to research assistant: Please discuss whether the participant would like a physical or electronic Visa gift card].** Do you have any questions?"

Script For Participants Who Have Given Informed Consent and Are Randomized into the Control Group (To Be Read to Participants by Senior Student Researcher)

"Thank you for agreeing to participate in this study conducted by university and scientists. As a reminder, the focus of the study is to understand the effects of regular exercise in people with chronic health conditions. The study will take place between July and October 2024."

"Your exercise can consist of any activity you enjoy doing, including walking, hiking, biking, yoga, stretching, games, swimming, and strength conditioning. Your health care provider is prescribing that you exercise indoors or outside for an average of 30 min daily over five days each week (total of 2 h and 30 min per week). Your provider is giving you this prescription because exercise can provide important physical and mental health benefits. Do you have any questions so far?

I will be connecting you with a university undergraduate student who will be working with you throughout the study and **[Note to graduate research assistant: If you will be working with this participant yourself, please let them know]** who will be sending you the daily log form and the first of three surveys. These can be made available via an online Google Form or as a document. If you would like these as documents, the student or I will telephone you weekly at a mutually agreeable time to get your responses. Which method would you prefer? **[Note to graduate research assistant: If using Google Forms, please request the email address to send the link. If by paper, please ask if the participant would like the form emailed or sent by post. Please ask the patient for the relevant addresses].** I will also send your \$100 gift card **[Note to research assistant: Please discuss whether the participant would like a physical or electronic Visa gift card].** Do you have any questions?"

Daily Log form

Please complete approximately at the same time each day. At the end of each day, please upload your responses via Google Forms. If you are not using Google Forms, at the end of the week a university researcher will call you to collect this information.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Your Sleep-Please Answer Approximately at the Same Time Each Day							
1	How many hours did you sleep last night?						
	Approximately how many min did it take for you to fall asleep?						
2	How was the quality of your sleep? (poor, okay, good, excellent)						
Your Exercise-Please Answer Approximately at the Same Time Each Day							
3	Did you exercise today?						
	Your first time exercising today (if applicable)						
4	What exercise activity did you do?						
5	What time did you start?						
6	What time did you stop?						
7	Was exercise done outside? (yes, no)						
8	How would you rate the intensity of exercise? (Low, moderate, high)						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
9	What was the location? (place name or home)						
10	What was your heart rate immediately after exercising(beats/minute)						
	Your second time exercising today (if applicable)						
11	What exercise activity did you do?						
12	What time did you start?						
13	What time did you stop?						
14	Was exercise done outside?						
15	How would you rate the intensity of exercise? (Low, moderate, high)						
16	What was the location? (place name or home)						
17	What was your heart rate immediately after exercising(beats/minute)						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Your Physical Health-Please Answer Approximately at the Same Time Each Day							
18	What was your blood pressure?						
19	How was your physical flexibility today? (poor, okay, good, excellent)						
20	How was your physical strength today? (poor, okay, good, excellent)						
Your Mental Health-Please Answer Approximately at the Same Time Each Day							
21	Did you feel down, depressed or hopeless at all? (yes, no, somewhat)						
22	Did you have little interest or pleasure in doing things? (yes, no, somewhat)						
23	Did you feel nervous, anxious or on edge? (yes, no, somewhat)						
24	Were you unable to control worrying? (yes, no, somewhat)						

Table A1. Review of Recent Quantitative Studies on Enhancing Physical Activity and Reducing Obesity.

Literature	Study Area	Data Source	Dependent Variable Examined	Major Findings
[1]-(Ulmer et al., 2016)	Sacramento, California	California Health Interview Survey (CHIS).	General Health is assessed in relation to tree canopy near participants' homes, with mediating factors including obesity, social cohesion, and physical activity.	Higher tree cover was linked to better health, mainly through reduced obesity and enhanced social cohesion.
[33]-(Reuben et al., 2020)	United States	National Survey of Children's Health (NSCH), 2016.	Child Health: focusing on outcomes like physical activity, screen time, sleep, obesity, anxiety, depression, and ADHD in relation to the presence of neighborhood parks.	Children with access to parks showed higher physical activity, better sleep, lower obesity, and reduced ADHD symptoms.
[31]-(Wolch et al., 2011)	Southern California	Southern California Children's Health Study (CHS) (longitudinal study).	BMI index Growth: assessed how access to park space and recreational programs influenced children's BMI levels over time.	Proximity to parks and availability of programs were associated with reduced BMI growth by age 18, with recreation programs showing more substantial impacts than park space.
[32]-(Persson et al., 2018)	Stockholm County, Sweden	Stockholm Diabetes Prevention Program (SDsPP) cohort.	BMI, waist circumference, and weight gain: used to assess adiposity and risks of overweight, obesity, and central obesity with residential greenness.	Greater residential greenness was linked to reduced waist circumference and central obesity in women, not men. Exposure to low greenness, traffic pollution, and noise increased waist circumference in both sexes.
[34]-(Tesler et al., 2022)	Israel	Urban Forest Health Intervention Program Survey.	Physical activity, healthy eating habits, self-efficacy, and life satisfaction (LS).	Participation in the program significantly improved physical activity, healthy eating, self-efficacy, and life satisfaction among at-risk youth.

Table A2. Review of Recent Quantitative Studies on Reducing Heart Disease.

Literature	Study Area	Data Source	Dependent Variable Examined	Major Findings
[45]-(Giacinto et al., 2021)	California	California Department of Public Health covering 2010-2018.	Cardiovascular mortality rates for heart disease and stroke are measured per 100,000 individuals.	Greater urban forest biodiversity was linked to a 13% reduction in heart disease mortality and a 16% reduction in stroke mortality, highlighting the health benefits of a diverse tree population.
[3]-(Lee et al., 2014)	Japan	Observational field experiment: 48 young Japanese adult males were recruited to examine the short-term physiological and psychological effects of forest walking versus urban walking.	Heart rate variability (HRV), heart rate, blood pressure, and mood states.	Forest walking increased parasympathetic activity, reduced sympathetic activity, lowered heart rate, and improved mood, promoting both physiological and psychological relaxation compared to urban walking.
[40]-(Grazuleviciene et al., 2015)	Kaunas, Lithuania	Randomized controlled trial: 20 coronary artery disease (CAD) patients were recruited and randomly assigned to walk 30 min daily for seven consecutive days.	Heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate recovery, and exercise capacity.	Green walking improved heart rate variability, indicating better autonomic function and relaxation, while both green and suburban walking reduced systolic blood pressure without significant differences between environments.
[43]-(Brito et al., 2020)	St-Paul Minneapolis, MN metropolitan area	Crossover trial: 24 middle-aged adults participating in both green and suburban walking conditions. The study, lasting for 9 weeks, included two treatments: green walking on nature trails and suburban walking on residential sidewalks.	Heart rate variability (HRV) and blood Pressure. They were measured before, during, and after walking session.	Greater residential greenness was linked to reduced waist circumference and central obesity in women, not men. Exposure to low greenness, traffic pollution, and noise increased waist circumference in both sexes.
[12]-(Mao et al., 2017)	Zhejiang Province, China	Randomized controlled trial: 45 CHF patients from Hangzhou City, with 36 completing the study.	Cardiovascular biomarkers include BNP and NT-pro BNP, as well as inflammatory cytokines, oxidative stress markers, and cardiovascular disease-related factors like endothelin-1(ET-1) and renin-angiotensin system components.	Forest bathing improved health in elderly heart failure patients, reducing BNP ET-1, inflammatory markers, and oxidative stress while enhancing mood and reducing tension, anxiety, and depression.
[62]-(Seo et al., 2019)	Korea	Korean National Health Insurance Service National Sample Cohort (NHIS-NSC), which includes data from 351,409 participants aged over 20 years from seven Korean metropolitan areas.	Cardiovascular disease (CVD) events include coronary heart disease, acute myocardial infarction, total stroke, ischemic stroke, and hemorrhagic stroke.	Living in areas with higher green space coverage significantly reduced the risk of cardiovascular disease, including coronary heart disease and stroke, especially for individuals aged 40 and older.
[39]-(Paul et al., 2020)	Ontario, Canada	Ontario Population Health and Environment Cohort (ONPHEC), which includes all Canadian-born Ontario residents aged 35–100 who were registered with provincial health insurance.	Risk of dementia and stroke.	Increased urban green space was linked to a 3% reduced risk of dementia and a 4% reduced risk of stroke, indicating its protective effect on neurological health.
[44] (Mao et al., 2012)	Hangzhou, China	Randomized controlled trial: 24 elderly patients with essential hypertension we recruited.	Blood pressure (systolic and diastolic), cardiovascular disease-related biomarkers, pro-inflammatory cytokines, and mood states.	Forest bathing significantly reduced blood pressure and improved cardiovascular health in elderly hypertensive patients, with lower levels of endothelin-1, homocysteine, and pro-inflammatory cytokines.

Table A3. Review of Recent Quantitative Studies on the Mental Health Effects of Nature Therapies.

Literature	Study Area	Data Source	Dependent Variable Examined	Major Findings
[50]-(Koselka et al., 2019)	Greater Chicago, Illinois	Randomized controlled trial (RCT): participants from Northwestern University and nearby communities.	Positive and negative affect, state anxiety, perceived stress, and working memory (visual backward digit span).	Forest walking improved positive affect, reduced anxiety, and lowered perceived stress compared to road sidewalk and daily activities.
[63]-(Razani et al., 2018)	Oakland, California	Randomized controlled trial: Primary Care Clinic (PCC), a federally qualified health center in Oakland, California.	Stress: Using PSS10, other secondary variables include park visits, loneliness, physical activity, physiologic stress (salivary cortisol), and nature affinity.	Park prescription reduced stress in low-income parents, with increased park visits significantly linked to lower stress.
[41]-(Song et al., 2015)	Japan	Twenty Japanese men; participants walked in a coniferous forest and an urban area on consecutive days.	Heart rate variability (HRV) and heart rate, psychological responses (measured by semantic differential and POMS) to assess autonomic nervous system and mood changes.	Forest walking significantly increased parasympathetic activity, lowered heart rate, and improved mood, reducing anxiety and fatigue in middle-aged hypertensive individuals compared to urban walking.
[47]-(Berman et al., 2012)	Ann Arbor, Michigan	Participants with major depressive disorder were recruited and assessed using SCID and PANAS.	Working memory capacity and affective states. These were measured before and after participants took a walk in a natural or urban setting.	Nature walks improved memory and had more positive effects on individuals with depression than urban walks.
[64]-(Sia et al., 2020)	Singapore	Field experimental design: data from 47 elderly participants in Singapore’s senior care centers were measured using various scales (happiness, cognitive function, sleep hygiene), before, during, and after a 24-week therapeutic horticulture program.	Momentary affect, cognitive function (measured by MMSE), functional outcomes, and psychosocial health.	The program improved cognitive function, reduced anxiety, and enhanced positive affect in older adults with sustained benefits up to size months post-intervention.
[42]-(Yu et al., 2017)	Taiwan	One-group pre-test–post-test field experimental design.	Autonomic nervous system activity measured through HRV, pulse rate, and diastolic blood pressure, and psychological states assessed using POMS and STAI.	Forest bathing reduced pulse rate and systolic and diastolic blood pressure, improved mood, and increased positive emotions in middle-aged and elderly participants.
[51]-(Orstad et al., 2020)	New York City	New York City’s Physical Activity and Transit (PAT) survey conducted between 2010 and 2011.	Mental distress and other variables include park proximity and frequency of park use for physical activity.	Park proximity was linked to fewer days of mental distress through increased park-based physical activity.
[49]-Beute & De Kort, 2018)	Eindhoven, Netherlands	Ecological Momentary Assessment (EMA) in an intensive longitudinal design. Fifty-nine participants were recruited for the study from the mental health institutes and a local participant database.	Stress levels as measured by momentary assessment throughout the day. Other variables include mood, psychosomatic complaints, and rumination.	Nature and daylight exposure improved mood and reduced stress, with nature being particularly beneficial for individuals with depressive symptoms, while daylight had consistent positive effects across all participants.
[65]-(Razani et al., 2019)	Oakland, California	Prospective cohort design, observing individuals for three months. Data were collected from the clinical trial at a federally qualified health center.	Child resilience is measured using the Brief Resiliency Scale (BRS), and child stress is measured using the PSQ 8–11 scale.	Park prescriptions increased resilience in low-income children, with more weekly park visits linked to greater improvements.
[66]-(Chun et al., 2017)	Gyenggi-do, Republic of Korea	Cross-sectional study: 59 patients with chronic stroke were recruited from a stroke welfare center in South Korea.	Depression and anxiety in patients with chronic stroke.	Forest therapy significantly reduced depression and anxiety in chronic stroke patients with increased antioxidant capacity.

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