Imagining Eco-Wellness: A Scoping Review of Interventions Aimed at Changing Individual Behaviors to Promote Personal Health and Environmental Sustainability

Brandon R. Kim, MD, MPH; Maggie L. Grabow, PhD, MPH; Sarah Walters, BS; Sabrina Rateike, BS; Mary Hitchcock, MA, MLS; Bruce Barrett, MD, PhD

ABSTRACT

Introduction: Climate change poses enormous threats to humanity and much of life on earth. Many of the behavioral patterns that drive climate change also contribute to the epidemics of obesity, diabetes, and cardiovascular disease.

Objectives: The primary objective of this study was to compile and categorize the literature on interventions aimed at modifying individual behaviors to promote both personal health and environmental sustainability. Secondary objectives were to help define the emerging field of behavioral eco-wellness and to discuss future directions, including the need for assessment tools and analytic strategies.

Methods: A scoping review was conducted to locate, categorize, and interpret current scientific studies of interventions aimed at changing individual behaviors to promote both personal health and environmental sustainability.

Results: Other than a pilot study that this team previously conducted, nothing was found that strictly fit the inclusion criteria. However, we did find 16 relevant studies that fit neatly within 4 broad topical areas: dietary intake, active transportation, indoor air quality, and green space immersion.

Discussion: While this systematic scoping review found little meeting original criteria, we did find that 4 separate fields of study are converging on a scientific area that we are calling behavioral eco-wellness, defined as the simultaneous pursuit of both personal health and environmental sustainability. The emerging field could provide a conceptual framework and methodological toolkit for those seeking to enhance sustainability while supporting health behaviors, including dietary intake. This, in turn, could help to inform and motivate the urgent action needed to confront both climate change and the epidemics of obesity, diabetes, metabolic syndrome, and cardiovascular disease.

• • •

Author Affiliations: University of Wisconsin School of Medicine and Public Health (UWSMPH), Madison, Wisconsin (Kim); Department of Family Medicine and Community Health, UW SMPH, Madison, Wis (Grabow, Barrett); UW-Madison, Madison, Wis (Walters, Rateike); Ebling Library, UW-Madison, Madison, Wis (Hitchcock).

Corresponding Author: Bruce Barrett, MD, PhD, School of Medicine and Public Health, Department of Family Medicine and Community Health, 1100 Delaplaine Court, Madison, WI 53715; email bruce.barrett@fammed.wisc.edu; ORCID ID 0000-0002-3952-4718

INTRODUCTION

Agencies, governments, organizations, and experts across the world have highlighted the potential devastation of climate instability and the urgency of actions needed.[1] Many individuals and groups are engaged in researching policies, technologies, and interventions to reduce greenhouse gas emissions to mitigate the magnitude of and destructive effects of climate change. Most climate action recommendations are rooted in science from studies analyzing the large-scale impact of technologies, policies, or lifestyle changes. However, little is known about interventions designed to help individuals modify their behaviors to reduce their carbon footprint.

While the climate crisis has been declared the largest single threat to global health in the foreseeable future,[2-4] the epidemics of obesity, diabetes, metabolic syndrome, and cardiovascular disease also are jeopardizing the health of countless people across the globe. A number of authors have noted that many of the same behaviors that reduce carbon footprint also help ameliorate these disease burdens.[5-7] For example, walking, running, or bicycling rather than driving an automobile provide "co-benefits" of better health and a lower carbon footprint.[8-10] Similarly, replacing meat and dairy with plant-derived foods, such as whole grains, nuts, legumes, and vegetables, will lead to both a lowered carbon footprint and improved health.[11-13] Moreover, it is possible that health and sustainability motivations may be mutually reinforcing. Individuals may be more apt to consider taking action for

our climate when educated on the positive health benefits of said actions.[14] Or, knowing that they will be contributing to sustainability, people may be more likely to adopt recommended health practices.[15] Interventions aimed at eco-wellness, defined as the simultaneous pursuit of both personal health and environmental sustainability, may be more effective than those aimed at only one of these targets.

The concept of eco-wellness is particularly apt for the field of nutrition. Because of positive effects for both physiological health and environmental sustainability, the reduction of meat and dairy in the diet has been widely discussed in the literature.[7,11,12,16-18] It is well known that animal-based foods disproportionally contribute to land and water use, air and water pollution, and carbon footprint. Globally, at least 26% and perhaps as much as 35% of anthropogenic greenhouse gases come from food production.[19,20] A recent comprehensive life cycle analysis found that worldwide meat production leads to twice the total greenhouse gas emissions as plant foods, despite the fact that meat represents less than 10% of global calories.[19] One systematic review found that for some affluent areas, reduction in greenhouse gas emissions of 50% or more could be achieved by dietary changes alone.[21]

At the same time, due to high calories and unfavorable fat profiles, animal-based foods are contributors to the global epidemics of obesity, dyslipidemia, and cardiovascular disease, substantively contributing to morbidity and mortality.[22,23] Supporting this conclusion, recent studies have found linear dose-response relationships between red meat consumption and premature death, with an estimated 10% increase in mortality associated with an increase of 100 g of daily meat consumption.[24-26] Nevertheless, despite the well-known health and environmental benefits of transitioning away from meat and dairy and towards a plant-based diet, very few interventions have been developed and tested towards these ends.

Over the past few years, our team developed and piloted the Mindful Climate Action behavioral change program, a mindfulness-based approach aimed at the simultaneous pursuit of both personal health and environmental sustainability.[27-29] Outcomes assessed in our pilot studies include miles and minutes spent walking, bicycling, and driving; household consumption of gas, electricity, and water; and proportion of diet from animal-based versus plant-based sources, assessed using the Automated Self-Administered 24-hour Dietary Assessment Tool (ASA24). Our team also developed a new dietary intake environmental impact calculator to help support this work. The Multi-factor Dietary Impact on the Environment Tool (miDIET) takes self-report data from the ASA24 and then applies environmental impact factors to produce individual-level sustainability metrics, including carbon footprint.[30] This pilot work also included data from validated self-report instruments assessing mental and physical health, self-efficacy, perceived stress, depressive symptoms, presenteeism at work, and happiness.

Experience with this previous work prompted us to look for other studies examining interventions aimed at influencing eco-wellness behaviors. The basis of our definition of intervention was influenced by the National Institutes of Health definition. We sought to find prospective studies involving the manipulation of a human subject's environment to evaluate the effect of the intervention on the study participants' health (either health-related biomedical or behavioral outcome) and on some form of sustainability. Examples of strategies to change health and sustainability-related behaviors include cognitive therapy, motivational interviewing, diet, exercise, or development of new habits.[31]

An initial literature search found no previously published systematic or scoping reviews of individual-level interventions aimed at behavioral eco-wellness. Therefore, our group launched such a review, reported here.

The primary objective of this study was to compile and categorize the literature on interventions aimed at modifying individual behaviors to promote both personal health and environmental sustainability. Secondary objectives were to help define the emerging field of behavioral eco-wellness and to discuss future directions, including the need for fit-for-purpose methods, including assessment tools and analytic strategies for evaluating the efficacy and effectiveness of these interventions for both individual and environmental health.

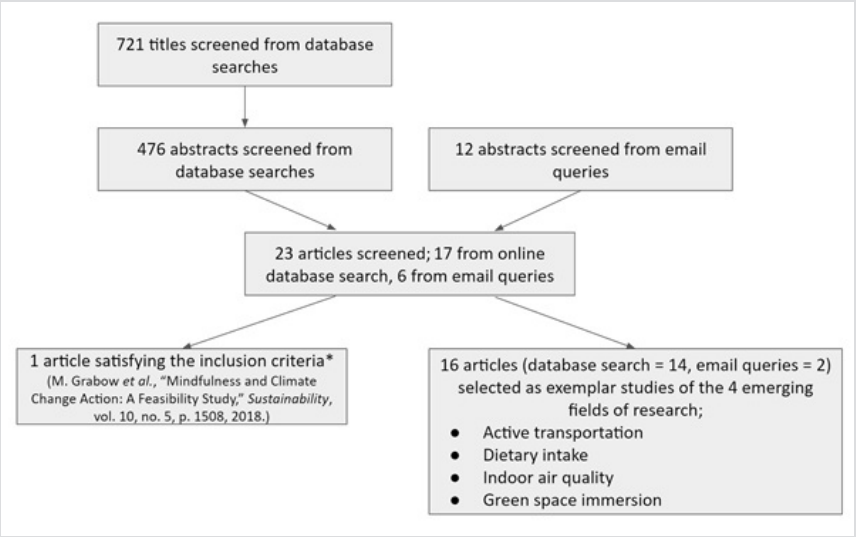
METHODS

To meet the primary objective, we first sought published empirical studies that: (1) conducted an intervention aimed at changing behaviors, (2) were delivered at the individual or group level, with pre- and post-intervention assessments including (3) at least 1 measure assessing a mental or physical health attribute, and (4) at least 1 measure directly related to environmental sustainability (eg, reduced waste, energy use, or carbon footprint; improvement of air or water quality). Our search strategy was limited to English language publications that included terminology regarding both sustainability (environment, climate) AND health (physical, mental, well-being, health behavior). We relied heavily on the term "co-benefit," as this encompasses the intersection of human health and the environment. See supplemental material for specific search terms and strategy.

The scoping review process was guided by the PRISMA Scoping Review guidelines[32] and is summarized in the Figure. The search strategy was developed with health sciences academic librarians, including coauthor MH. We used 3 databases—PubMed, Agricultural and Environmental Science Collection, and Scopus—aiming to identify articles that fulfilled our search criteria. There were no publication date restrictions. The original search was completed by MH on March 6, 2020, then repeated on July 27. The final search was done on January 15, 2021, with the condition that the publication date was limited to the year 2020.

Results were compiled, and duplicate items were removed

Figure. Flow Diagram Showing Review Strategy



*Inclusion criteria were empiric studies that: (1) conducted an intervention aimed at changing behaviors, (2) were delivered at the individual or group level, followed by post-intervention assessments including (3) at least 1 measure assessing a mental or physical health attribute, and (4) at least 1 measure directly related to environmental sustainability.

using Endnote X9, resulting in 572 article titles from the original search, a number that increased to 721 titles after the January 2021 search was completed (see Figure). Team members SR and SW screened all titles for inclusion criteria, resulting in a total of 476 abstracts being reviewed (431 abstracts from the original search). Abstracts were read initially by team members SR and SW, who selected 111 abstracts for indepth review by the full team. The titles and abstracts rejected at the first 2 stages did not describe empirical studies of small group or individual-level interventions aimed at behavior change. The 111 resulting abstracts were read by team members BB, BK, and SW, applying the entire set of inclusion criteria. In case of discrepancy, team member MG reviewed the abstract. Group consensus was achieved by discussion. Database searches resulted in 17 publications that were read in full by at least 2 team members.

To complement the online database search, senior author BB sent email queries to 41 published experts asking for studies that matched our inclusion criteria. The list of experts queried was based on having published relevant literature. This resulted in 12 additional abstracts, which were then reviewed by at least 2 team members (BB, BK, and/or SW), resulting in 6 publications recommended by experts being read in full.

These 2 search processes resulted in 23 papers (17 from the first online database search, none from the second and third online database search, and 6 from authors contacted by email), which were read in full by at least 2 team members (BB, BK, MG, and/or SW) and analyzed for eligibility based on the inclusion criteria described above.

RESULTS

After full-text reviews, we found no studies that strictly fit the inclusion criteria, with the exception of our own Mindful Climate Action pilot study.[27] Reasons for exclusion varied. Many papers were based on theory or models and did not include empirical outcome data from a prospective study design. A number of papers did not include at least 1 health and 1 sustainability outcome measure. Some did not describe discrete interventions, and some were not aimed at addressing individual behaviors. Other than our own work, not a single paper described an empirical study describing an intervention aimed at changing individual behaviors to impact health and sustainability co-benefits.

Nevertheless, despite this null finding, we did identify 4 broad categories of literature relevant to the goal of assessing and influencing both personal health and environmental sustainability: (1) dietary intake, (2) active transportation, (3) indoor air quality, and (4) green space immersion. The emergence of these 4 categories occurred after reading the 23 papers but was strongly informed by reviewing the 721 titles and 476 abstracts. Of the 23 papers, 16 fit within these categories and serve here as exemplars of the potential of behavioral eco-wellness as a burgeoning field. (See Tables 1-4.) The 16 papers included 3 papers involving dietary change, 3 papers focusing on active transportation, 7 papers investigating indoor air quality, and 3 papers looking at green space immersion. All of these were published after 2010. Thirteen of the 16 studies were published after 2015. While this paper highlights research on dietary intake for health and sustainability co-benefits, we also summarize what we found in the other 3 areas.

Dietary Intake

This scoping review did not find any reports of empirical testing of behavioral interventions aimed at changing individual diets to achieve both health and environmental benefits. However, we did discover an emerging stream of literature pointing in this direction. There were large-scale analyses of potential co-benefits of dietary change.[11,21] There were several regional studies looking at health and sustainability correlates of dietary intake patterns.[33-35] There were discussions and analyses of how people might be persuaded to modify their diets towards health and sustainability.[16,36,37] Nevertheless, as far we could find, there were no empirical studies testing interventions aimed at changing dietary intake that included outcome measures relating to both personal health and environmental sustainability.

Table 1. Dietary Intake: Analysis of Major Criteria and Sample Size of Final Review Studies Within the Dietary Intake Category

Studies	Presence of Inclusion Criteria	Study Design	Population	Sample Size	Type of Intervention	Mental/Physical Health Outcome	Environmental Sustainability Outcome
Aston et al, 2012[38]	C, D	Modelling	British general public	N_I=1724	None (consumption of red and processed meat	Risk of coronary heart disease, diabetes, colorectal cancer	Greenhouse gas emissions from dietary intake
Behrens et al, 2017[39]	D	Modelling	NA	NA	None (Nation-specific nationally recommended diets)	None	Impact of diets on greenhouse gases, eutrophiction, land use
Bharucha et al, 2020[40]	C	Cross-sectional study	Participants of local food initiatives in the United Kingdom	Local food initiatives (N_I = 302), general population (N_I = 157)	None (local food project participants)	Psychological need satisfaction, diet, nature-connectedness, physical activity	None

Inclusion criteria were empiric studies that: (A) conducted an intervention aimed at changing behaviors, 9B) were delivered at the individual or small group level, followed by post-intervention assessments including (C) at least 1 measure assessing a mental or physical health attribute, and (D) at least 1 measure directly related to environmental sustainability.

N_I indicates the number of individual participants.

Table 2. Active Transportation: Analysis of Major Criteria and Sample Size of Final Review Studies Within the Active Transportation Category

Studies	Presence of Inclusion Criteria	Study Design	Population	Sample Size	Type of Intervention	Mental/Physical Health Outcome	Environmental Sustainability Outcome
Chapman et al, 2018[43]	A, C, D	Prospective cohort	Community households in 4 New Zealand cities	Interventional (N_H = 1120) control (N_H = 1020)	Incorporation of walking, cycling programs	Disability adjusted life years	Transport-related carbon emissions
Frank et al, 2010[45]	C, D	Cross-sectional study	Participants >16 years old in Atlanta, Georgia region	N_I = 10,148	None (Built environment's impact on transportation)	Kilocalories burned from walking	Kilocalories burned from motorized transport (ie, CO_2 emissions)
Keall et al, 2015[44]	A	Prospective cohort	Community households in New Zealand cities	Interventional (N_H = 1120), control (N_H = 1020)	Incorporation of walking and cycling programs	Rates of active travel[a]	Rates of active travel[a]

Inclusion criteria were empiric studies that: (A) conducted an intervention aimed at changing behaviors, (B) were delivered at the individual or small group level, followed by post-intervention assessments including (C) at least 1 measure assessing a mental or physical health attribute, and (D) at least 1 measure directly related to environmental sustainability.

N_H indicates the number of households, and N_I indicates the number of individual participants.

[a]Indicates outcome measurement not adequate to meet inclusion criteria.

The 3 studies that we chose to include as exemplars are shown in Table 1.[38-40] Two of these utilized a modeling method, while the third conducted a cross-sectional study. Two papers studied populations in the United Kingdom, while the other looked at diets from a global perspective. Studies variously focused on reduced meat consumption, the environmental impact of nationally recommended diets, and the impact of local food initiatives. Two studies estimated greenhouse gas emissions as an environmental outcome, with one also including eutrophication and land use. One study measured health outcomes (coronary artery disease, diabetes, and colorectal cancer), and another assessed psychological need satisfaction, fruit and vegetable intake, nature connectedness, and physical activity.

Active Transportation

Modifying transportation infrastructure and supporting active transportation has been discussed at length in the literature as a major potential source of health and sustainability co-benefits.[6,41,42] Nevertheless, very few empirical studies aimed at supporting active transportation have been conducted. The majority of the papers

Table 3. Indoor Air Quality Analysis of Major Criteria and Sample Size of Final Review Studies Within the Indoor Air Quality Category

Studies	Presence of Inclusion Criteria	Study Design	Population	Sample Size	Type of Intervention	Mental/Physical Health Outcome	Environmental Sustainability Outcome
Anderman et al, 2015[49]	C	Cohort	Households in southern India	NH=199	None (Biogas cook stove vs traditional stove)	Dietary diversity	Subjective firewood utilization[a]
Aung et al, 2018[50]	A, B, C	Randomized control trial	Women >25 years in India	Control N_I=111 and intervention N_I=111	Rocket cook stove vs traditional stove	Systolic/diastolic blood pressure, self-reported eye symptoms	Fine particle (PM 2.5) mass and absorbance around cooking area[a]
Barn et al, 2018[54]	A, B, C	Randomized control trial	Nonsmoking pregant women in Mongolia	Control N_I=253 and intervention N_I=259	HEPA filter air cleaners vs no air cleaners	Blood cadmium and hair nicotine from second-hand smoke exposure	Indoor and outdoor PM 2.5[a]
Champion and Grieshop, 2019[51]	A, B, C	Cohort	Households in Rwanda	Pellet stove (N_H=14), (N_H=4), and charcoal stove (N_H=4)	Pellet cook stove vs wood/charcoal wood stove	Carbon monoxide exposure stoves	Estimated tons of CO_2 equivalent per year of cook stove use and indoor PM 2.5[a]
Patange et al, 2015[52]	C	Cross-sectional study	Households in India	Forced draft stove N_H=10 stove N_H=12	None (forced-draft cook stove vs and traditional	Black carbon exposure traditional stove)	Black carbon around cooking area[a]
Wathore et al, 2017[53]	C	Cross-sectional study	Households in Malawi	Households N_H=22	None (Alternative cook stoves [ceramic forced-draft, institutional models] vs traditional cook stoves)	Carbon monoxide exposure	Indoor PM 2.5[a]
Zhou et al, 2014[55]	A, B, C	Cohort	Participants >40 years in southern China	N_I=996	Household biogas digester for clean fuel usage and kitchen ventilation	FEV1 and risk of COPD	Indoor SO_2, CO, CO_2, NO_2, and PM <10

Abbreviations: PM, particulate matter; FEV1, forced expiratory volume in 1 second; COPD, chronic obstructive pulmonary disease; SO_2, sulfur dioxide; CO_2, carbon dioxide; CO, carbon monoxide; NO_2, nitrogen dioxide.

Inclusion criteria were empiric studies that: (A) conducted an intervention aimed at changing behaviors, (B) were delivered at the individual or small group level, followed by post-intervention assessments including (C) at least 1 measure assessing a mental or physical health attribute, and (D) at least 1 measure directly related to environmental sustainability.

N_H indicates the number of households, and N_I indicates the number of individual participants.

[a]Indicates outcome measurement not adequate to meet inclusion criteria.

we found described modeling studies. Here we will mention 3 empirical studies, 2 studies using a prospective cohort design in New Zealand, and the other using a cross-sectional design in the United States (Table 2).[43-45] All of these studies looked at the impacts of the built environment and socioeconomic factors on active transportation. The environmental outcome measurement was related to motorized vehicle emissions in 2 of the 3 studies. The health outcomes measure varied, including disability-adjusted life years in one study and kilocalories burned during active transportation in another. One of the studies looked generally at rates of active travel and the likely impact on health and environmental outcomes.

Indoor Air Quality

Our scoping review yielded dozens of studies assessing the use of new or upgraded cook stoves and other technological approaches to improve indoor air quality. This is unsurprising given the well-known effects of air pollution—especially fine particulates—on human health.[46-48] Nevertheless, while some studies assessed both health and environmental outcomes, none of these were aimed at changing individual behaviors. Of the 7 exemplar studies, 3 studies used randomized controlled trial methods, 2 studies utilized a cross-sectional design, and 2 studies used a prospective cohort design (Table 3).[49-55] Five studies were conducted in Asia (3 in India, 1 in Mongolia, 1 in China), and 2 studies were conducted in Africa (Rwanda and Malawi). Six studies investigated "cleaner" cooking stoves, and 1 study researched HEPA air filters. Four studies measured indoor fine particulate matter (PM2.5) as an environmental outcome. Other studies measured black carbon

Table 4. Green Space Immersion: Analysis of Major Criteria and Sample Size of Final Review Studies Within the Green Space Immersion Category

Studies	Presence of Inclusion Criteria	Study Design	Population	Sample Size	Type of Intervention	Mental/Physical Health Outcome	Environmental Sustainability Outcome
Coventry et al, 2019[61]	C, D	Cross-sectional study	Conservation volunteers in the UK	N_I=45	None (guided walks, practical conservation or citizen science in urban or semi-urban green spaced)	Mood and stress	Engagement in conservation and sustainable urban development
Raymond et al, 2019[62]	C, D	Semistructured qualitative interviews	Home gardeners in Winnipeg, Canada	N_I=50	None (gardening for biodiversity)	Subjective psychological, physiological, cognitive, and social benefits	Subjective environmental benefits of conservation of native habitat
Reeves et al, 2019[63]	B, C	Self-controlled case series	Healthy participants in London, England	N_I=36	Exposure to urban green spaces	EEG measurements and self-reportedd stress, anxiety, depression	None

Abbreviations: EEG. electroencephalogram.

Inclusion criteria were empiric studies that: (A) conducted an intervention aimed at changing behaviors, (B) were delivered at the individual or small group level, followed by post-intervention assessments including (C) at least 1 measure assessing a mental or physical health attribute, and (D) at least 1 measure directly related to environmental sustainability.

N_I indicates the number of individual participants.

[a]Indicates outcome measurement not adequate to meet inclusion criteria.

concentration, fuel use, and other indoor air pollutants, including CO_2. The studies investigated health outcomes, including blood pressure, eye symptoms, cardiopulmonary and cardiovascular disease mortality, hair nicotine and blood cadmium levels, lung function, incidence of chronic obstructive pulmonary disease, and carbon monoxide exposure. One nonrandomized study from India (n = 199 households) found that households using clean biogas cook stoves reported greater dietary diversity than comparison households.[36]

Green Space Immersion

Experiencing nature (ie, green space immersion, forest bathing, shinrin-yoku, nature immersion, etc) has emerged as a potential avenue toward better mental and physical health and also as a way to foster ecological values.[56-60] Included here as 3 exemplars, 2 green space immersion studies implemented a qualitative approach, while a third study utilized a cross-sectional design (Table 4).[61-63] The studies included short-term exposure to urban green spaces, guided walks/practical conservation tasks/citizen science in urban and semi-urban green spaces, and home gardening for biodiversity. All 3 studies assessed general indicators of physical and psychosocial wellness; one also included measures of stress response, self-reported mood, and heart rate. We did not find green space immersion studies that specifically looked at potential relationships with food production or dietary intake.

DISCUSSION

Although we found no investigations other than our pilot study that matched the specific inclusion criteria, we did find emerging literatures regarding 2 sets of eco-wellness behaviors with well-known health and sustainability co-benefits (active transportation and food choice), as well as research in 2 areas where co-benefits from behavior change have received less attention (indoor air quality and green space immersion). The findings of this scoping review provided new insights into the emerging field we call "behavioral eco-wellness," with 4 streams of literature converging on a new transdisciplinary science concerned with both personal health and environmental sustainability. The exemplar studies in Tables 1-4 highlight the 4 areas and attest to the rapidly rising importance of this emerging field, with the majority of studies published within the last 5 years.

To our knowledge, no previous reviews have attempted to systematically locate and contextualize published studies of interventions aimed at influencing individual behaviors that impact both personal health and environmental sustainability. While our research team uses the term "eco-wellness" to describe this emerging field, it should be noted that the word "ecowellness" has been used previously by Reese et al, who described it as "a sense of appreciation, respect for, and awe of nature that results in feelings of connectedness with the natural environment and the enhancement of holistic wellness."[64-66] We consider Reese's work to be very much in line with the literature on green space immersion that we identified. We build on Reese's ecowellness work by looking more broadly at scientific studies of behaviors and interventions that influence both human health and environmental sustainability rather than only those aimed at the health benefits of experiencing nature.

The emergent field of eco-wellness research seeks to investi-

gate pathways influencing both sustainability and health. Defining the field of behavioral eco-wellness as the study of how individual behaviors impact personal health and environmental sustainability will allow for a wide variety of research topics to be brought together into a unified yet multidisciplinary field of research, in order to contribute substantively towards both climate change mitigation and the epidemics of obesity, diabetes, and cardiovascular disease. Reaching towards these goals will require new conceptual structures, as well as new assessment tools. Development and validation of new tools for measuring eco-wellness outcomes should be guided by theory and supported by both hypothesis-testing and conceptual restructuring and synthesis.

We would be remiss to not mention the importance of equity embedded within the topic of behavioral eco-wellness. Our search criteria were already so specific in nature by combining health and sustainability that adding a health equity component might have rendered us incapable of producing any useful results. As the field of eco-wellness develops and co-benefit strategies evolve, diversity, equity, and inclusion must remain a top priority. In fact, our colleagues at the University of Wisconsin–Madison recently published a scoping review of active transportation interventions and their effects on health equity, finding that significant gaps exist in our understanding of how health inequities could be mitigated through modifying the active transportation environment because it is understudied and underevaluated.[67]

To expand the field of behavioral eco-wellness, measurement of personal health and environmental sustainability outcomes should become more accessible, standardized, precise, reliable, and easy-to-implement in diverse study designs. For example, improved measurement of physical activities, such as active transportation, will be needed and will likely include global positioning system (GPS)-enabled smartphone applications and other wearable technologies. Our research group has used Moves, Move X, and Arc, which are smartphone apps that map personal movement on streets, walking paths, and bike lanes, yielding estimates of minutes and miles of walking, bicycling, and driving that, in turn, can be used by the researchers to estimate both carbon footprint and personal health benefits.[27,28] These movement-measuring tools were developed to assess personal movement metrics but do not assess other eco-wellness behaviors, such as using stairs rather than elevators or choosing to drive an electric car, a fossil-fueled vehicle, a hybrid car or use public transportation.[68] Currently available tools for estimating the carbon footprint of an individual's transportation behaviors require make, model, and year of vehicle; an assessment of "miles driven;" and application of weighting factors, a process that is effort-intensive. Computer programs and smartphone-based apps to reduce the effort should be developed and tested. Better methods for assessing the health and environmental impacts of public transport also are needed. The creation of a comprehensive smartphone application or wearable technology that accurately tracks active and fossil-fueled transportation with the ability to internally calculate the carbon footprint of an individual's movement could improve the accuracy and accessibility of eco-wellness research.

There are currently no properly validated systems to assess dietary intake for both health and sustainability outcome assessment. Various diet measurement tools, such as food frequency questionnaires, 24-hour recalls, and prospective logs, can estimate dietary intake but are known to be inaccurate as well as time-consuming.[69] A goal of dietary eco-wellness assessment is to identify the quantity of specific foods ingested, then link that information to data from studies looking at health outcomes and sustainability impacts of those foods in terms of carbon footprint.[30] Future directions may include mobile technologies and computerized analysis of photos of meals taken by research participants on their smartphones, such as the Technology Assisted Dietary Assessment (TADA) system developed by researchers at Purdue University.[70-72] Researchers in Australia are adapting the TADA system with the aim of measuring both the health and sustainability impacts of individual diets.[73] As another example, smartphone applications have been used in Denmark grocery outlets in an attempt to provide nutritional and environmental information to supermarket shoppers.[74] While some nutritional information is typically available for many foods, assessment and labeling of different foods' carbon footprints and other environmental impacts will need to be improved for the advancement of eco-wellness research related to food production and consumption.

Although several indoor air quality studies were found in this scoping review, there is an inherent difficulty in measuring sustainability outcomes of improved cook stoves and other air quality technologies. We also know this has links to nutrition as cooking and cooking methods may also affect the nutritional content and nutrient availability of food. Understanding the interplay between the energy we use for cooking and its impact on sustainability metrics is a complicated process. Creating a standardized formula to determine the environmental impacts of cook stoves could propel this area of research forward in the field of eco-wellness. Modeling of clean cook stove interventions does show promise of widespread health and environmental benefits, specifically in low- and middle-income countries.[75] But many indoor air pollution projects fail to address how individuals would realistically utilize these interventions.[76] To advance in this field, improving the design of the interventions and their implementation will be necessary to utilize funding effectively and to improve stakeholder livelihood.[77,78] Assessment of the interactions between new stove use, food choice, and nutritional intake also will be needed. If indoor air quality research does not address realistic practicality in study design and sustainability measurement tools, the adaptation within the eco-wellness framework will continue to be limited.

In addition to improving the toolkits available for measuring the co-benefits of active transportation and dietary intake, better methods are needed to assess potential health and sustainability

outcomes attributable to experiencing the natural environment. During the past few years, a growing body of literature has begun to describe health benefits from spending time in nature.[79-81] Nevertheless, studies to date are almost entirely observational rather than experimental, with interventions and outcomes either poorly described or not yet validated. A few studies in this emergent scientific area have attempted to assess health outcomes, but little attention has been paid to the potential feedback loop toward improvement of environmental preservation and sustainability behaviors. Quite plausibly, nature immersion could lead to improved personal sustainability behaviors and improved health, or even perhaps environmental advocacy or sustainability-directed political activism. Undoubtedly, there is also potential overlap with the domains of active transportation and nature immersion as well as mindful eating and nature immersion, as experiencing nature may change how one is motivated to move and eat more in accordance with sustainability principles. However, without proper testing, such potential co-benefits remain hypothetical rather than empirically tested.

Improvements in study design will be essential in furthering the field of eco-wellness. Many studies found in this field utilize observational methods without any sort of intervention or pre-/post-assessment. This likely is due to multiple reasons, notably the financial feasibility of conducting an intervention, assessing control conditions, and completing baseline and follow-up assessments. Modeling studies are quite popular, especially in the active transportation area of research. These methods allow researchers to illuminate the potential impact of large-scale interventions but do not empirically assess intervention effects. This review found several studies employing observational data and modelling methods but almost no experimental studies assessing the results of interventions. Considering the rapid progression of climate instability and the increasing obesity epidemic worldwide, we conclude that there is an urgent need to develop and test promising behavioral interventions. Moving toward experimental study design methods will be essential for eco-wellness research to take the next steps towards rigorous and generalizable information that can be used to improve human health and environmental sustainability.

We were impressed by the fact that the 4 identified domains not only overlapped but were characterized by potential interactions and perhaps synergy. For example, while we selected Bharucha et al as a dietary study exemplar, that paper also discussed the psychological benefits of interacting with local green spaces and initiatives and so could have instead been categorized under green space immersion.[40] Similarly, many of the indoor air quality studies were based on the development and testing of cook stoves, which has obvious yet largely unexplored implications for healthy and sustainable dietary intake. Less obvious but nonetheless important may be the impacts on active transportation; procurement of fuel and foodstuffs requires movement and transportation, which is likely to be influenced by type of stove, fuel, and cookware used. Another example would be the interactions between transport, green space, and types of food consumed. In both urban and rural communities, choice of foodstuff and considerations such as packaging and shelf life may affect whether walking or bicycling are possible or whether fossil-fueled transportation is needed. Food delivery systems might affect people's physical activity patterns. Developing and protecting greenspace might influence personal transportation choices, both related and unrelated to dietary intake. While fully comprehensive studies may not be possible, the incipient field of behavioral eco-wellness should strive to be holistic and comprehensive enough to take into account as many relevant outcome domains as possible, so as to maximize useful knowledge and perhaps avoid undesirable unintended consequences.

These considerations further highlight the importance of defining search terms, keywords, sub-fields, and domains of study for the field of behavioral eco-wellness to move forward. We used the term co-benefit as part of our search criteria, which may have limited the extent of our findings since it may not be an umbrella term used worldwide. While we did include expert inquiries to help identify potential blind spots in our scoping review's methodology, it is likely that individual studies or even whole fields of relevant research may have slipped past our review. As with all systematic or scoping reviews, papers published in journals not encompassed by the search strategy (nonindexed journals, gray literature) likely will have been missed. With the understanding that the study of eco-wellness is only now emerging (the majority of our exemplars were conducted in the last 5 years), this scoping review does not claim to have exhaustively found all studies in the 4 research domains identified and does not assert that the study of eco-wellness is limited to these 4 areas. It is possible that we missed a study that would have met our strict inclusion criteria. However, even if that were the case, we do not believe that would substantively change our findings, conclusions, or interpretation. In the future, it will be important for research within the field of eco-wellness to be published using consistent terms and for scientists to communicate and work together to consolidate and develop this field.

Given the enormous challenges posed by climate change and the epidemics of obesity, diabetes, and cardiovascular disease, it is incumbent upon us to grow and strengthen these areas of research as swiftly and comprehensively as possible.

Financial Disclosures: None declared.

Funding/Support: When this work was begun, Maggie Grabow was supported by research training grants from the Health Resources and Services Administration (Grant No. T32HP10010) and the National Center for Complementary and Integrative Health, National Institutes of Health, training award (Grant No. T32AT006956).

Acknowledgments: The authors wish to acknowledge the many scientists and authors who produced the material that this scoping review covers and especially the many experts who responded to Dr Barrett's email inquiries.

They would like to thank medical librarian Leslie Christensen for the help with the online database bibliographic search, administrative assistant Nathaniel Javid for assistance with final formatting and submission, and Barbara Sorkin, PhD, and Cathy Middlecamp, PhD, for valuable ideas and assistance with editing.

REFERENCES

1. Climate change widespread, rapid, and intensifying. News release. International Panel on Climate Change; August 9, 2021. Accessed September 6, 2021. https://www.ipcc.ch/site/assets/uploads/2021/08/IPCC_WGI-AR6-Press-Release_en.pdf

2. Solomon CG, LaRocque RC. Climate change - a health emergency. *N Engl J Med.* 2019;380(3):209-211. doi:10.1056/NEJMp1817067

3. Hobbhahn N, Fears R, Haines A, Ter Meulen V. Urgent action is needed to protect human health from the increasing effects of climate change. *Lancet Planet Health.* 2019;3(8):e333-e335. doi:10.1016/S2542-5196(19)30114-7

4. Patz JA. Solving the global climate crisis: the greatest health opportunity of our times?. *Public Health Rev.* 2016;37:30. doi:10.1186/s40985-016-0047-y

5. Chang KM, Hess JJ, Balbus JM, et al. Ancillary health effects of climate mitigation scenarios as drivers of policy uptake: a review of air quality, transportation and diet co-benefits modeling studies. *Environ Res Lett.* 2017;12(11):113001. doi:10.1088/1748-9326/aa8f7b

6. Quam VGM, Rocklöv J, Quam MBM, Lucas RAI. Assessing greenhouse gas emissions and health co-benefits: a structured review of lifestyle-related climate change mitigation strategies. *Int J Environ Res Public Health*. 2017;14(5):468. doi:10.3390/ijerph14050468

7. Willett W, Rockström J, Loken B, et al. Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. *Lancet*. 2019;393(10170):447-492. doi:10.1016/S0140-6736(18)31788-4

8. Grabow ML, Spak SN, Holloway T, Stone B, Mednick AC, Patz JA. Air quality and exercise-related health benefits from reduced car travel in the midwestern United States. *Environ Health Perspect*. 2012;120(1):68-76. doi:10.1289/ehp.1103440

9. Maizlish N, Woodcock J, Co S, Ostro B, Fanai A, Fairley D. Health cobenefits and transportation-related reductions in greenhouse gas emissions in the San Francisco Bay area. *Am J Public Health*. 2013;103(4):703-709. doi:10.2105/AJPH.2012.300939

10. Frank LD, Greenwald MJ, Winkelman S, Chapman J, Kavage S. Carbonless footprints: promoting health and climate stabilization through active transportation. *Prev Med.* 2010;50 Suppl 1:S99-S105. doi:10.1016/j.ypmed.2009.09.025

11. Springmann M, Godfray HC, Rayner M, Scarborough P. Analysis and valuation of the health and climate change cobenefits of dietary change. *Proc Natl Acad Sci USA.* 2016;113(15):4146-4151. doi:10.1073/pnas.1523119113

12. Cobiac LJ, Scarborough P. Modelling the health co-benefits of sustainable diets in the UK, France, Finland, Italy and Sweden. *Eur J Clin Nutr.* 2019;73(4):624-633. doi:10.1038/s41430-019-0401-5

13. Berners-Lee M, Hoolohan C, Cammack H, et al. The relative greenhouse gas impacts of realistic dietary choices. *Energy Policy.* 2012;43:184-190. doi:10.1016/j.enpol.2011.12.054

14. Amelung D, Fischer H, Herrmann A, et al. Human health as a motivator for climate change mitigation: results from four European high-income countries. *Glob Environ Change*. 2019;57:101918. doi:10.1016/j.gloenvcha.2019.05.002

15. Werner A, Spiller A, Meyerding SGH. The yoga of sustainable diets: exploring consumers mind and spirit. *J Clean Prod*. 2020;243:118473. doi:10.1016/j.jclepro.2019.118473

16. Bozeman JF, Bozeman R, Theis TL. Overcoming climate change adaptation barriers: a study on food–energy–water impacts of the average American diet by demographic group. *J Ind Ecol*. 2020:24(2):383–399. doi:10.1111/jiec.12859

17. Heller MC, Willits-Smith A, Meyer R, Keoleian GA, Rose D. Greenhouse gas emissions and energy use associated with production of individual self-selected US diets. *Environ Res Lett*. 2018;13(4):044004. doi:10.1088/1748-9326/aab0ac

18. Rice P, O'Brien D, Shalloo L, Holden NM. Evaluation of allocation methods for calculation of carbon footprint of grass-based dairy production. *J Environ Manage.* 2017;202(Pt 1):311-319. doi:10.1016/j.jenvman.2017.06.071

19. Xu X, Sharma P, Shu S, et al. Global greenhouse gas emissions from animal-based foods are twice those of plant-based foods. *Nat Food*. 2021;2(9):724-732. doi:10.1038/s43016-021-00358-x

20. Poore J, Nemecek T. Reducing food's environmental impacts through producers and consumers. *Science*. 2018;360(6392):987-992. doi:10.1126/science.aaq0216

21. Hallström E, Carlsson-Kanyama A, Börjesson P. Environmental impact of dietary change: a systematic review. *J Clean Prod*. 2015:91:1–11. doi:10.1016/j.jclepro.2014.12.008

22. Wang DD, Li Y, Afshin A, et al. Global improvement in dietary quality could lead to substantial reduction in premature death. *J Nutr.* 2019;149(6):1065-1074. doi:10.1093/jn/nxz010

23. GBD 2017 Diet Collaborators. Health effects of dietary risks in 195 countries, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*. 2019;393(10184):1958-1972. doi:10.1016/S0140-6736(19)30041-8

24. Papier K, Fensom GK, Knuppel A, et al. Meat consumption and risk of 25 common conditions: outcome-wide analyses in 475,000 men and women in the UK Biobank study. *BMC Med*. 2021;19(1):53. doi:10.1186/s12916-021-01922-9

25. Zheng Y, Li Y, Satija A, et al. Association of changes in red meat consumption with total and cause specific mortality among US women and men: two prospective cohort studies. *BMJ*. 2019;365:l2110. doi:10.1136/bmj.l2110

26. Schwingshackl L, Schwedhelm C, Hoffmann G, et al. Food groups and risk of all-cause mortality: a systematic review and meta-analysis of prospective studies. *Am J Clin Nutr.* 2017;105(6):1462-1473. doi:10.3945/ajcn.117.153148

27. Grabow M, Bryan T, Checovich M, et al. Mindfulness and climate change action: a feasibility study. *Sustainability*. 2018;10(5):1508. doi:10.3390/su10051508

28. Barrett B, Grabow M, Middlecamp C, et al. Mindful climate action: health and environmental co-benefits from mindfulness-based behavioral training. *Sustainability*. 2016;8(10):1040. doi:10.3390/su8101040

29. University of Wisconsin Department of Family Medicine and Community Health. Mindful Climate Action (MCA). Accessed March 16, 2021. https://www.fammed.wisc.edu/mca/

30. Bryan T, Hicks A, Barrett B, Middlecamp C. An environmental impact calculator for 24-h diet recalls. *Sustainability*. 2019:11(23):6866. doi:10.3390/su11236866

31. National Institute on Deafness and Other Communication Disorders. NIH clinical trials definition. Updated January 11, 2018. Accessed October 3, 2022. https://www.nidcd.nih.gov/research/clinical-studies/researchers-professionals/clinical-trials-definition

32. Tricco AC, Lillie E, Zarin W, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med*. 2018;169(7):467-473. doi:10.7326/M18-0850

33. Farchi S, De Sario M, Lapucci E, Davoli M, Michelozzi P. Meat consumption reduction in Italian regions: health co-benefits and decreases in GHG emissions. *PLoS One*. 2017;12(8):e0182960. doi:10.1371/journal.pone.0182960

34. Lehikoinen E, Salonen AO. Food preferences in Finland: sustainable diets and their differences between groups. *Sustainability*. 2019;11(5):1259. doi:10.3390/su11051259

35. Rao ND, Min J, DeFries R, Ghosh-Jerath S, Valin H, Fanzo J. Healthy, affordable and climate-friendly diets in India. *Glob Environ Change*. 2018;49:154–165. doi: 10.1016/j.gloenvcha.2018.02.013

36. Reisch LA, Sunstein CR, Andor MA, Doebbe FC, Meier J, Haddaway NR. Mitigating climate change via food consumption and food waste: a systematic map of behavioral interventions. *J Clean Prod*. 2021;279:123717. doi:10.1016/j.jclepro.2020.123717

37. Ridoutt BG, Hendrie GA, Noakes M. Dietary strategies to reduce environmental impact: a critical review of the evidence base. *Adv Nutr.* 2017;8(6):933-946. doi:10.3945/an.117.016691

38. Aston LM, Smith JN, Powles JW. Impact of a reduced red and processed meat dietary pattern on disease risks and greenhouse gas emissions in the UK: a modelling study. *BMJ Open*. 2012;2(5):e001072. doi:10.1136/bmjopen-2012-001072

39. Behrens P, Kiefte-de Jong JC, Bosker T, Rodrigues JFD, de Koning A, Tukker A. Evaluating the environmental impacts of dietary recommendations. *Proc Natl Acad Sci USA*. 2017;114(51):13412-13417. doi:10.1073/pnas.1711889114

40. Bharucha ZP, Weinstein N, Watson D, Böhm S. Participation in local food projects is associated with better psychological well-being: evidence from the East of England. *J Public Health (Oxf)*. 2020;42(2):e187-e197. doi:10.1093/pubmed/fdz057

41. Frank LD, Greenwald MJ, Winkelman S, Chapman J, Kavage S. Carbonless footprints: promoting health and climate stabilization through active transportation. *Prev Med*. 2010;50 Suppl 1:S99-S105. doi:10.1016/j.ypmed.2009.09.025

42. Avila-Palencia I, Int Panis L, Dons E, et al. The effects of transport mode use on self-perceived health, mental health, and social contact measures: a cross-sectional and longitudinal study. *Environ Int*. 2018;120:199-206. doi:10.1016/j.envint.2018.08.002

43. Chapman R, Keall M, Howden-Chapman P, et al. A cost benefit analysis of an active travel intervention with health and carbon emission reduction benefits. *Int J Environ Res Public Health.* 2018;15(5):962. doi:10.3390/ijerph15050962

44. Keall M, Chapman R, Howden-Chapman P, Witten K, Abrahamse W, Woodward A. Increasing active travel: results of a quasi-experimental study of an intervention to encourage walking and cycling. *J Epidemiol Community Health*. 2015;69(12):1184-1190. doi:10.1136/jech-2015-205466

45. Frank LD, Greenwald MJ, Winkelman S, Chapman J, Kavage S. Carbonless footprints: promoting health and climate stabilization through active transportation. *Prev Med*. 2010;50 Suppl 1:S99-S105. doi:10.1016/j.ypmed.2009.09.025

46. Xie W, Li G, Zhao D, et al. Relationship between fine particulate air pollution and ischaemic heart disease morbidity and mortality. *Heart*. 2015;101(4):257-263. doi:10.1136/heartjnl-2014-306165

47. Miri M, Alahabadi A, Ehrampush MH, et al. Mortality and morbidity due to exposure to ambient particulate matter. *Ecotoxicol Environ Saf*. 2018;165:307-313. doi:10.1016/j.ecoenv.2018.09.012

48. Cromar KR, Gladson LA, Ewart G. Trends in excess morbidity and mortality associated with air pollution above American Thoracic Society-recommended standards, 2008-2017. *Ann Am Thorac Soc*. 2019;16(7):836-845. doi:10.1513/AnnalsATS.201812-914OC

49. Anderman TL, DeFries RS, Wood SA, Remans R, Ahuja R, Ulla SE. Biogas cook stoves for healthy and sustainable diets? A case study in Southern India. *Front Nutr.* 2015;2:28. doi:10.3389/fnut.2015.00028

50. Aung TW, Baumgartner J, Jain G, et al. Effect on blood pressure and eye health symptoms in a climate-financed randomized cookstove intervention study in rural India. *Environ Res*. 2018;166:658-667. doi:10.1016/j.envres.2018.06.044

51. Champion WM, Grieshop AP. Pellet-fed gasifier stoves approach gas-stove like performance during in-home use in Rwanda. *Environ Sci Technol.* 2019;53(11):6570-6579. doi:10.1021/acs.est.9b00009

52. Patange OS, Ramanathan N, Rehman IH, et al. Reductions in indoor black carbon concentrations from improved biomass stoves in rural India. *Environ Sci Technol.* 2015;49(7):4749-4756. doi:10.1021/es506208x

53. Wathore R, Mortimer K, Grieshop AP. In-use emissions and estimated impacts of traditional, natural- and forced-draft cookstoves in rural Malawi. *Environ Sci Technol.* 2017;51(3):1929-1938. doi:10.1021/acs.est.6b05557

54. Barn P, Gombojav E, Ochir C, et al. The effect of portable HEPA filter air cleaners on indoor PM2.5 concentrations and second hand tobacco smoke exposure among pregnant women in Ulaanbaatar, Mongolia: The UGAAR randomized controlled trial. *Sci Total Environ.* 2018;615:1379-1389. doi:10.1016/j.scitotenv.2017.09.291

55. Zhou Y, Zou Y, Li X, et al. Lung function and incidence of chronic obstructive pulmonary disease after improved cooking fuels and kitchen ventilation: a 9-year prospective cohort study. *PLoS Med*. 2014;11(3):e1001621. doi:10.1371/journal.pmed.1001621

56. White MP, Alcock I, Grellier J, et al. Spending at least 120 minutes a week in nature is associated with good health and wellbeing. *Sci Rep.* 2019;9(1):7730. doi:10.1038/s41598-019-44097-3

57. Twohig-Bennett C, Jones A. The health benefits of the great outdoors: a systematic review and meta-analysis of greenspace exposure and health outcomes. *Environ Res.* 2018;166:628-637. doi:10.1016/j.envres.2018.06.030

58. Beyer KM, Kaltenbach A, Szabo A, Bogar S, Nieto FJ, Malecki KM. Exposure to neighborhood green space and mental health: evidence from the survey of the health of Wisconsin. *Int J Environ Res Public Health.* 2014;11(3):3453-3472. doi:10.3390/ijerph110303453

59. Passmore HA, Holder MD. Noticing nature: individual and social benefits of a two-week intervention. *J Posit Psychol*. 2017;12(6):537–546. doi:10.1080/17439760.2016.1221126

60. Capaldi CA, Passmore HA, Nisbet EK, Zelenski JM, Dopko RL. Flourishing in nature: a review of the benefits of connecting with nature and its application as a wellbeing intervention. *Int J Wellbeing*. 2015;5(4):1-16. doi:10.5502/ijw.v5i4.449

61. Coventry PA, Neale C, Dyke A, Pateman R, Cinderby S. The mental health benefits of purposeful activities in public green spaces in urban and semi-urban neighbourhoods: a mixed-methods pilot and proof of concept study. *Int J Environ Res Public Health*. 2019;16(15):2712. doi:10.3390/ijerph16152712

62. Raymond CM, Diduck AP, Buijs A, Boerchers M, Moquin R. Exploring the co-benefits (and costs) of home gardening for biodiversity conservation. *Local Environ.* 2019;24(3):258–273. doi:10.1080/13549839.2018.1561657

63. Reeves JP, Knight AT, Strong EA, et al. The application of wearable technology to quantify health and wellbeing co-benefits from urban wetlands. *Front Psychol.* 2019;10:1840. doi:10.3389/fpsyg.2019.01840

64. EcoWellness: contextualizing nature connection in traditional clinical and educational settings to foster positive childhood outcomes. *Ecopsychology*. 2018;10(4):289–300. doi.org/10.1089/eco.2018.0031

65. Reese RF, Lewis TF. Greening counseling: examining multivariate relationships between ecowellness and holistic wellness. *J Humanist Couns*. 2019;58(1):53-67. doi:10.1002/johc.12089

66. Reese RF, Myers JE. EcoWellness: the missing factor in holistic wellness models. *J Couns Dev*. 2012;90(4):400-406. doi:10.1002/j.1556-6676.2012.00050.x

67. Hansmann KJ, Grabow M, McAndrews C. Health equity and active transportation: a scoping review of active transportation interventions and their impacts on health equity. *J Transp Health*. 2022;25:101346. doi: 10.1016/j.jth.2022.101346

68. Kooiman TJ, Dontje ML, Sprenger SR, Krijnen WP, van der Schans CP, de Groot M. Reliability and validity of ten consumer activity trackers. *BMC Sports Sci Med Rehabil.* 2015;7:24. doi:10.1186/s13102-015-0018-5

69. Freedman LS, Commins JM, Moler JE, et al. Pooled results from 5 validation studies of dietary self-report instruments using recovery biomarkers for energy and protein intake. *Am J Epidemiol*. 2014;180(2):172-188. doi:10.1093/aje/kwu116

70. Boushey CJ, Spoden M, Zhu FM, Delp EJ, Kerr DA. New mobile methods for dietary assessment: review of image-assisted and image-based dietary assessment methods. *Proc Nutr Soc*. 2017;76(3):283-294. doi:10.1017/S0029665116002913

71. Amoutzopoulos B, Steer T, Roberts C, et al. Traditional methods v. new technologies - dilemmas for dietary assessment in large-scale nutrition surveys and studies: a report following an international panel discussion at the 9th International Conference on Diet and Activity Methods (ICDAM9), Brisbane, 3 September 2015. *J Nutr Sci*. 2018;7:e11. doi:10.1017/jns.2018.4

72. Shoneye CL, Dhaliwal SS, Pollard CM, et al. Image-based dietary assessment and tailored feedback using mobile technology: mediating behavior change in young adults. *Nutrients*. 2019;11(2):435. doi:10.3390/nu11020435

73. Harray AJ, Boushey CJ, Pollard CM, et al. A novel dietary assessment method to measure a healthy and sustainable diet using the mobile food record: protocol and methodology. *Nutrients*. 2015;7(7):5375-5395. doi:10.3390/nu7075226

74. Withers A. Checking in on the climate as you check out: a major supermarket chain in Denmark lets customers know the carbon footprint of their groceries. *Washington Post*. September 20, 2020. Accessed December 6, 2020. https://www.washingtonpost.com/climate-solutions/2020/09/30/carbon-footprint-supermarkets/

75. Rosenthal J, Quinn A, Grieshop AP, Pillarisetti A, Glass RI. Clean cooking and the SDGs: Integrated analytical approaches to guide energy interventions for health and environment goals. *Energy Sustain Dev*. 2018;42:152-159. doi:10.1016/j.esd.2017.11.003

76. Ezzati M, Baumgartner JC. Household energy and health: where next for research and practice?. *Lancet*. 2017;389(10065):130-132. doi:10.1016/S0140-6736(16)32506-5

77. Baumgartner J, Arku RE, Dickinson KL. Household energy solutions in low and middle income countries. In: *Encyclopedia of Environmental Health.* 2nd ed. Elsevier; 2019:494-509. Accessed May 23, 2023. https://www.sciencedirect.com/science/article/abs/pii/B9780124095489117841?via%3Dihub

78. Rosenthal J, Arku RE, Baumgartner J, et al. Systems science approaches for global environmental health research: enhancing intervention design and implementation for household air pollution (HAP) and water, sanitation, and hygiene (WASH) Programs. *Environ Health Perspect.* 2020;128(10):105001. doi:10.1289/EHP7010

79. Hansen MM, Jones R, Tocchini K. Shinrin-yoku (forest bathing) and nature therapy: a state-of-the-art review. *Int J Environ Res Public Health*. 2017;14(8):851. doi:10.3390/ijerph14080851

80. Chen HT, Yu CP, and Lee HY. The effects of forest bathing on stress recovery: evidence from middle-aged females of Taiwan. *Forests*. 2018;9(7):403. doi;10.3390/f9070403

81. Panno A, Carrus G, Lafortezza R, Mariani L, Sanesi G. Nature-based solutions to promote human resilience and wellbeing in cities during increasingly hot summers. *Environ Res*. 2017;159:249-256. doi:10.1016/j.envres.2017.08.016

advancing the art & science of medicine in the midwest

WMJ

WMJ (ISSN 1098-1861) is published through a collaboration between The Medical College of Wisconsin and The University of Wisconsin School of Medicine and Public Health. The mission of *WMJ* is to provide an opportunity to publish original research, case reports, review articles, and essays about current medical and public health issues.

Visit www.wmjonline.org to learn more.