Mechanisms underpinning flourishing at the interface of humans and other natural entities: an umbrella review

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Ecological-collective-flourishing (e-co-flourishing) describes the interconnected flourishing of human and non-human natural entities. Despite existing conceptual frameworks, translation into practice remains inadequate owing to insufficient synthesis of empirically tested mechanisms driving change across human and ecological systems. We conducted an umbrella review of systematic reviews examining mechanisms at the e-co-flourishing interface. Searches of seven databases and four grey literature sources identified nine eligible reviews. Evidence supported several cross-domain mechanisms, including psychological (eg, attention restoration and reduced stress), social (eg, cohesion and contact), physical (eg, activity), and environmental pathways (eg, reduced stressors and enhanced environmental quality). Psychological mechanisms showed the most consistent support, whereas evidence for other mechanism domains was mixed. Evidence for causality was weak and largely derived from cross-sectional and qualitative studies, and no reviews examined reciprocal mechanisms influencing both human and non-human flourishing. Future research should prioritise rigorous designs, theory-driven testing, and replication to strengthen evidence for equitable and sustainable e-co-flourishing pathways.

Introduction

In the decade preceding the COVID-19 pandemic, global indicators of human progress—including income, life expectancy, and life satisfaction—showed notable improvement.[1,2] These gains were abruptly halted or reversed by the pandemic and the subsequent cost-of-living crisis. Although headline indicators now suggest some recovery, closer scrutiny reveals that progress is neither uniform nor equitable. Looking beyond human society to the broader natural world and planet, negative environmental trends—including increased ocean acidification, water scarcity, land degradation, and biodiversity loss—are rising, largely driven by unsustainable human practices and technological advancements. These environmental challenges not only threaten natural ecosystems but also exacerbate human inequalities, disproportionately affecting vulnerable populations that depend on natural resources for their livelihoods, food security, and overall wellbeing.[3,4] To help address these concurrent crises, research and policy must adopt more inclusive, comprehensive, and interdisciplinary approaches that aim to promote progress across human and non-human entities and their forms of collectives.[3,5,6]

Existing integrative health frameworks, such as One Health,[7] EcoHealth,[8] and planetary health,[9] rightly emphasise the interdependence of human, ecological, and planetary systems. However, these frameworks have largely been operationalised to mitigate environmental threats to human health rather than to promote shared progress across species and systems. Moreover, their focus on health, understood primarily as functional capacity, addresses necessary but insufficient conditions for living well. Flourishing extends beyond the maintenance of health to encompass the pursuit of having, being, and doing what constitutes a life well lived. It involves dynamic and evolving processes across multiple areas of life, including psychological (eg, mental health and positive affect), social (eg, close and positive relationships and social connectedness), physical (eg, energy and vitality), values (eg, meaning, purpose, mastery, virtue, and knowledge), and environmental (eg, safety, financial security, and access to health care and education). Unlike health, flourishing is not defined by the absence of any given dimension (eg, disease or disorder) but by the pursuit of meeting or exceeding thresholds across these dimensions (psychological, social, physical, values-related, and environmental), which are likely to shift across individuals, collectives, time, and contexts. Rather than seeking optimisation across these dimensions, flourishing reflects the pursuit of a net-positive gain across one's life as a whole and over their entire lifespan.[10]

Ecological-collective-flourishing (e-co-flourishing) is a unifying concept, defined as the practice of pursuing one's own human flourishing alongside the flourishing of natural ecosystems and their collective and individual members.[11] E-co-flourishing involves engaging in modes of flourishing that aim to promote and enhance, rather than hinder, the flourishing of other natural entities and collectives[10,11] (panel 1). In line with a previous work on human wellbeing,[12] need fulfilment is understood as an important but not necessarily sufficient condition for flourishing; e-co-flourishing explicitly focuses on the dynamic processes that shape net-positive gains across both human and ecological systems, which are context-dependent and ultimately shaped by wider social, ecological, and structural systems.

To help translate this concept into real-world applications, the e-co-flourishing framework[10] was developed, which outlines key theoretical components of a programme theory, a core concept in the Medical Research Council framework for developing and evaluating complex interventions.[27] An abductive methodological approach was undertaken, whereby interdisciplinary engagement with existing theoretical understanding was combined with a

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Panel 1: **Key conceptual terms and definitions**

Collective
A group or assembly of individual entities. A collective can vary in size and composition, ranging from small groups to large organisations or communities. The two collectives we are interested in include populations and organisations. Populations are simple sets of members, the properties (including flourishing) of which are simple aggregations or averages of the corresponding properties of their members. Organisations are systems comprising members and their interactions, which have emergent properties (including flourishing) that are not straightforwardly reducible to the individual properties of their members.[13,14]

Ecosystem
The biological community together with the abiotic environment in which it is set (ie, non-living factors and processes within an ecosystem).[14]

Ecosystem flourishing
The state in which natural ecosystems show resilience, species diversity, and self-regulating ecological processes. It reflects the ability of ecosystems to sustain themselves over time while providing essential services and resources to support life and maintain biodiversity.[15]

E-co-flourishing
The practice of pursuing one's own human flourishing along with the flourishing of natural ecosystems and their collective and individual members. It involves engaging in modes of flourishing that aim to promote and enhance, rather than hinder, the flourishing of other natural entities and collectives.[11]

Human flourishing
Having, being, and doing what constitutes living well—realised through dynamic and evolving processes that encompass multiple areas of life including psychological (eg, mental health and positive affect), social (eg, close and positive relationships and social connectedness), physical (eg, energy and vitality), values-related (eg, meaning and purpose), and environmental (eg, safety, security, and access to health care and education).[16,17] This multifaceted conception integrates both subjective and objective components and occurs at both individual and collective levels.

Human health
A state of complete physical, mental, and social wellbeing and not merely the absence of disease or infirmity.[18]

Human wellbeing
Subjective evaluations of psychological, physical, social, and environmental domains. Psychological wellbeing refers to the capacity to express one's feelings in a helpful and productive way and acknowledge one's worth; physical wellbeing refers to maintaining habits and routines that allow one to take care of one's body (eg, through nutrition and adequate sleep); social wellbeing refers to maintaining healthy relationships with others; and environmental wellbeing refers to the ability to consider one's community and surroundings in relation to personal wellbeing.[19–22]

Life satisfaction
The degree to which an individual judges the overall quality of their life as a whole favourably.[23–26]

Non-human
Entities, beings, or objects that are not human. For the purposes of our research, we have elected a narrower definition—a living entity or being, or a group of living entities or beings, of any species other than *Homo sapiens*.[11]

patient and public involvement, engagement, and participation (PPIEP) approach with key stakeholders. Key theoretical components of the programme theory include key intervention characteristics; theorised mechanisms through which the intervention produces change; targeted outcomes (human flourishing and ecosystem flourishing; panel 1); and theorised contextual factors or moderators across individual, microsystem, mesosystem, and macrosystem levels.[10] Economic systems are treated as part of the macrosystem context, encompassing shaping access to resources, inequalities, and environmental exposures that influence flourishing across time and place. To advance this work into the next key phases of research, an evidence synthesis is needed to summarise leading mechanistic targets that might drive change in key outcomes. By deepening understanding of these mechanisms, more precise and effective strategies can be developed to strengthen the effect of e-co-flourishing interventions.

There is an overwhelming body of evidence linking the effects of nature and human health.[28–33] However, a more comprehensive understanding of the entire mechanistic pathway—from contact with nature and long-term outcomes—is needed.[29] With empirical research being undertaken on mechanisms of change,[34,35] there is an opportunity to summarise the leading empirically validated mechanistic targets and to expand the focus beyond human health to e-co-flourishing outcomes (panel 1). To the best of our knowledge, there is no comprehensive review that examines empirically evaluated mechanisms

underpinning the flourishing interface considering both humans and other natural entities. Moreover, evaluation of the quality of mediation analyses or mechanism findings remains scarce. Given the breadth of the topic, particularly in addressing simultaneous flourishing for humans and other natural entities, we adopted an umbrella review approach to identify the top-level evidence. In this Review, we aim to address the aforementioned limitations. The primary objective is to summarise existing systematic review evidence on mechanisms that address the flourishing interface of humans and other natural entities, guided by the e-co-flourishing framework. The secondary objective is to evaluate both the methodological and mediation quality.[36–40]

Methods

Search strategy and selection criteria

An umbrella review methodology was chosen because the evidence base examining mechanisms of flourishing at the human–non-human interface is conceptually broad, methodologically heterogeneous, and distributed across multiple disciplines, necessitating a higher-order synthesis of existing systematic reviews. This umbrella review followed the PRISMA 2020 guidelines,[41] with regard to the checklist, flow diagram, development, conduct, and reporting. The Cochrane Handbook for Systematic Reviews of Interventions (Chapter V: Overview of Reviews) was also consulted regarding the proposed methods, such as preparing the table of primary study overlap.[42] This systematic umbrella review was preregistered with PROSPERO (CRD42024580361) before screening.

Seven bibliographic databases (Web of Science, Philosopher's Index, PubMed, GreenFILE [via EBSCOhost], Scopus, ProQuest Social Science Premium, and PsycINFO) were systematically searched on Aug 17, 2024, with no restrictions on publication date and language. Web of Science (All Collections) included Web of Science Core Collection, BIOSIS Citation Index, Current Contents Connect, Data Citation Index, KCI-Korean Journal Database, MEDLINE, Preprint Citation Index, ProQuest Dissertations & Theses Global, SciELO Citation Index, and Zoological Record. Within these bibliographic databases, there are sources of grey literature, including Preprint Citation Index and ProQuest Dissertations & Theses Global. Additional sources of grey literature were also searched (eg, OpenGrey and connectedpapers.com). 24 content experts (eg, academics and librarians) across a wide range of disciplines (eg, philosophy, medical sciences, psychology, geography, plant sciences, sociology, public health, and anthropology) were consulted to crosscheck the choice of databases and search strategy and to help identify additional relevant reviews. All eligible reviews were examined using forward and backward citation searching, and corresponding authors were contacted if further clarification was needed to establish eligibility.

The core search strategy (panel 2) was organised according to key features of the primary research question. The search strategy included terms related to flourishing outcomes (eg, flourish*, well-being, balance, and sustainability), mechanisms (eg, mechanis*, mediat*, and "indirect effect"), and systematic reviews (eg, "systematic review" and "meta-analysis"). Population terms were subdivided by human (eg, human, individual, participant, male, and female) and non-human (eg, non-human, ecosystem, natur*, fauna, and flora) terms. In an effort to mirror the e-co-flourishing theoretical framework,[10] we also used terms reflecting key contextual levels—individual (eg, "human" and "non-human"); microsystem (eg, "neighbourhood" and "green space"); mesosystem, and macrosystem (eg, "ecosystem", "population", and "planet").

The inclusion criteria comprised systematic reviews that empirically examined mechanisms underpinning flourishing at the interface of human and non-human entities. The interface included the effects of non-human entities on human flourishing, the effects of humans on the flourishing of non-human entities, and bidirectional effects in which simultaneous flourishing was considered. To reflect the definition of e-co-flourishing,[11] the human population of interest included the general population or public, which considers individuals across the full flourishing spectrum (low to high) and across the lifespan. Therefore, no restrictions were applied regarding age, gender, psychiatric history, or medication use.

The non-human entities considered in this Review included living, non-human organisms and systems (eg, plants, animals, and ecosystems). Specifically, entities across the five biological kingdoms—animals, plants, fungi, protists, and monerans—were considered. However, the primary scope of this Review was to highlight interventions involving humans, flora, and fauna, domains in which psychosocial, conservation-oriented, and relational wellbeing interventions are most actively developed and evaluated. Therefore, three key biological kingdoms were prioritised (ie, animals, plants, and fungi), and only mechanisms that can be modified or acted upon by humans were considered.

In this Review, a mechanism is defined as the process or pathway through which an independent variable (eg, intervention or exposure) exerts its effect on an outcome.[37] We focused on mechanisms that were empirically evaluated, that is, supported by data rather than purely conceptual or theoretical propositions. To meet this criterion, the constituent studies within the eligible reviews needed to apply empirical methods to evaluate the proposed mechanism. These methods included quantitative approaches (eg, statistical mediation analyses showing indirect effects) and qualitative approaches (eg, interview studies indicating temporal precedence or experiential accounts of causal processes). We recognise that not all studies used formal mediation testing; however, this approach aimed to prioritise mechanisms with some empirical grounding, even if methodological rigour varied across studies. This balance was chosen to capture mechanisms with the greatest potential for translational

Panel 2: Search terms

Population (human): human OR people OR participant OR subject OR individual OR respondent OR observer OR cohort OR adult* OR student* OR pupil* OR schoolgirl OR schoolboy OR adolesc* OR youth* OR child* OR infan* OR female OR male OR babies OR baby OR boy* OR girl* OR juvenile* OR kid* OR kindergarten* OR minor* OR neonat* OR neo-nat* OR newborn* OR new-born* OR paediatric* OR peadiatric* OR pediatric* OR perinat* OR preschool* OR pre-school* OR puber* OR pubescen* OR school* OR stepchild* OR teen* OR toddler* OR underage* OR young* OR youngster* OR senior OR "elderly person" OR "mature adult" OR "senior citizen" OR "aging adult" OR "older individual" OR "older adult" OR retiree OR geriatric OR popul* OR communit* OR famil* OR collect* OR culture* OR heritage OR partnership* OR friend* OR neighbor* OR neighbour* OR club* OR city OR cities OR nation* OR business* OR non-profit* OR corporation* OR organisation* OR company OR companies OR society OR societies OR workplace

Population (non-human): earth OR planet* OR ecology* OR ecosystem* OR "living world" OR biome OR biosphere OR "more than human" OR "more-than-human" OR "non-human" OR species OR "multi-species" OR "cross-species" OR "cross-kingdom" OR "trophic level" OR fractal OR sentient OR creature* OR natur* OR "natural environment" OR outback OR outdoor* OR wilderness OR wildlife OR animal* OR fauna OR flora OR green-space* OR greenness OR grassland OR wetland OR woodland OR vegetation OR plant* OR flower* OR insect* OR mushroom* OR fung* OR mycorrhiza OR tree* OR vertebrate* OR mammal* OR pet* OR "domestic animal" OR bird* OR reptile* OR amphibian* OR fish* OR invertebrates OR garden* OR park OR "green environment" OR "natural environment" OR recreational OR forest* OR wood* OR jungle OR arboretum OR farm* OR land* OR botan* OR ocean* OR lake* OR river* OR pond* OR bluespace* OR sea OR marine OR reservoir OR stream OR loch OR fjord OR desert* OR savannah OR climate OR ozone OR country OR flock* OR herd* OR "food web" OR "trophic chain"

Outcome: flourish* OR function* OR happiness OR wellbeing OR "well-being" OR health* OR mood OR anxiety OR depress* OR "strengths and difficulties" OR "quality of life" OR "meaning and purpose" OR "meaning making" OR purpose OR eco* OR "life expectancy" OR satisfaction OR "good life" OR "self-improvement" OR self-actuali* OR self-determin* OR "self-esteem" OR pleasure OR eudaimonia OR hedonia OR resilien* OR "full potential" OR "highest good" OR "ultimate end" OR develop* OR grow* OR advance* OR thriv* OR triumph OR prosper* OR progress* OR excel* OR succeed OR "faring well" OR "doing well" OR "well-functioning" OR adapt* OR attainment OR agency OR strength OR autonomy OR security OR safe* OR welfare OR virtue* OR interest OR value* OR "prudential value" OR "prudential good" OR "personal value" OR "personal good" OR "living well" OR "financial security" OR "financial stability" OR "material stability" OR flower* OR blossom* OR bloom* OR reproduct* OR mutualism OR sustain* OR symbio* OR diversity OR biodiversity OR "species richness" OR conserve* OR "commensalism" OR relation* OR balance OR harmony OR reciprocity OR interdependence OR responsibility OR ethic* OR moral* OR respect OR kinship OR altruism OR "source of life" OR knowledge OR wisdom OR holistic OR "cultural continuity" OR "equifinality" OR "social cohesion" OR trait* OR ethno* OR telos OR connect* OR energy* OR vitality OR affect OR education* OR regulat*

Mechanism: mechanis* OR mediat* OR "indirect effect" OR dismant* OR "active ingredient"

Review: "systematic review" OR meta-analysis

"NOT": microbiome OR microbial OR gut OR bacteria OR virus OR parasite OR mitochondria* OR cancer OR tumor OR tumour OR melanoma OR "non-living" OR protist* OR algae OR alge OR moneran* OR archaea OR neoplasm

relevance while maintaining a standard of evidentiary support.

For a systematic review to be eligible, at least two primary studies need to examine mechanisms empirically, thereby aligning with the review-level perspective and reinforcing the objective of the current synthesis. Reviews were not restricted according to the study designs of included primary studies (eg, experimental or cross-sectional) or general methodological approaches (eg, quantitative or qualitative), provided the methods were empirically grounded. The outcomes of interest for this umbrella review related to the flourishing of both human and non-human entities.

The key exclusion criteria concerned the types of non-human entities considered. Reviews focusing on non-living non-human entities (eg, rocks) or on living non-human entities within the protists and monerans categories (eg, bacteria, microbes, viruses, and parasites) were not included at this stage. Studies focusing exclusively on indicators of disease or ill health—such as mental health disorders in humans or extinction rates among non-human natural entities—were also excluded. However, studies exploring flourishing outcomes within populations or ecosystems affected by disease or ill health were eligible, provided they aligned with the broader conceptualisation of flourishing adopted in this Review. This distinction reflects our focus on relative improvements in positive states and processes rather than solely the absence of pathology.

Data analysis

After deduplication, two authors (SM and TH) independently screened all titles and abstracts. Four authors (SM, TH, HZ, and BM) divided the full texts evenly, and at least two authors (SM, TH, HZ, or BM) independently screened

each full text. Any disagreements at the title and abstract or full text screening stage were resolved by a third author. Data extraction was first piloted and then completed by four authors (SM, TH, HZ, and BM), with each eligible record being independently extracted by one author. A second author (SM) crosschecked 20% of the total eligible records, with a third author (TH or HZ) resolving any conflicts. Corresponding authors were contacted when the eligibility of a record was unclear during data extraction.

Data management tools (eg, EndNote, Covidence, and Microsoft Excel) were used to remove duplicates and track included and excluded records. The following information was extracted from each eligible record: name of author(s) of the eligible review; total number of eligible studies included in the review (including total sample, if available); type of flourishing interface (as outlined earlier); characteristics of the human population sample(s); characteristics of the non-human sample(s); independent variable(s) (eg, exposure and intervention) and level of intervention (eg, individual, microsystem, mesosystem, or macrosystem); mechanism(s); dependent variable or outcome(s) (ie, flourishing outcomes); and summary of main mechanism findings.

Eligible reviews were appraised based on whether they included a quality assessment of study methodology and mechanism findings at the study level, and, when available, this information was extracted. The overall methodological quality of each eligible review was then appraised using the AMSTAR2 tool,[40] which considers 16 domains (eg, protocol registration, study design inclusion, risk of bias assessment, and appropriate statistical methods). The quality of the mechanism analyses for each eligible review was appraised using the AGReMA-SF framework,[39] which specifically addresses transparency and reporting of mediation analyses. One author (SM) conducted the quality assessments, and a second author (TH or HZ) crosschecked 20% of the results, with a third author resolving any discrepancies.

A narrative qualitative synthesis was conducted in which the main findings for mechanisms were summarised and categorised according to the overarching e-co-flourishing theoretical framework.[10] For instance, outcomes were categorised across key outcome domains (human flourishing and ecosystem flourishing), and mechanisms were categorised across key subdomains of human flourishing (psychological, social, physical, environmental, and values-related) and key subdomains of ecosystem flourishing (eg, biodiversity, sustainability, interconnectedness, safeguarding evolutionary processes, and ecological vibrancy and energetics). Given that the included systematic reviews applied heterogeneous study designs and analytical strategies, a comprehensive meta-analysis was not appropriate. No subgroup or subset analyses were planned. Minor deviations from the protocol included extracting additional information on the primary methodology used (quantitative or qualitative) and the hierarchy of evidence (randomised control trials [level 1], quasi-experimental [level 2], cross-sectional or prospective cohort [level 3], and qualitative studies [level 4]).

Results

The initial search identified 2089 records, of which 171 were duplicates, leaving 1918 records for title and abstract screening for relevance. Of these records, 1806 were excluded, leaving 112 reviews for full text screening. Of these 112 reviews, 106 were excluded because they did not meet the inclusion criteria (the reasons for each exclusion are detailed in figure 1), leaving six eligible systematic reviews identified through database searching. Three additional systematic reviews were identified through expert consultation, grey literature, or citation checking. Nine systematic reviews were included in the final narrative qualitative synthesis.

The earliest record[43] was published in 2015, with the majority published in 2020 or later. For this umbrella review, we were interested in systematic reviews that explored mechanisms at the flourishing interface of human and non-human entities. All eligible reviews evaluated the effects of non-human entities on human flourishing, and therefore, only human flourishing outcomes were considered. Six of the included reviews used quantitative methods, one used qualitative methods, and two used both. Only one eligible review[44] clearly stated the examination of mechanisms or mediators as the primary aim of the review; one stated this as the secondary aim; and the remaining seven reviews did not clearly state this as an aim or objective but did include mechanism findings. The mechanism findings reported in each eligible systematic review represent a subsample of the included studies. Across all eligible reviews, the total participant sample size was more than 143 072, with two included reviews without clear reporting of sample size. Across the nine eligible reviews, there were 45 unique primary studies. Three primary studies were shared across two eligible reviews, and therefore, overlap was minimal (appendix pp 2–6).

See Online for appendix

All included reviews examined both human and non-human entities, although the characteristics varied. Four reviews primarily focused on adolescent or young populations; two primarily focused on adult populations (eg, workplace employees or the general adult population); and the remaining three reviews included a wide range of participant samples across the lifespan (eg, adolescents, older adults, and children). Regarding non-human entities, six eligible reviews primarily focused on green space, whereas the remaining three reviews included either a combination of green space and blue space or other natural settings. The types of independent variables were heterogeneous, differing in the level of contact or interaction with non-human entities. For instance, some eligible reviews focused on interventions or activities (eg, nature-based interventions and conservation activities), whereas others examined the availability or access to non-human entities (eg, green space and blue space), and other forms were more indirect contact (eg, technological or nature views

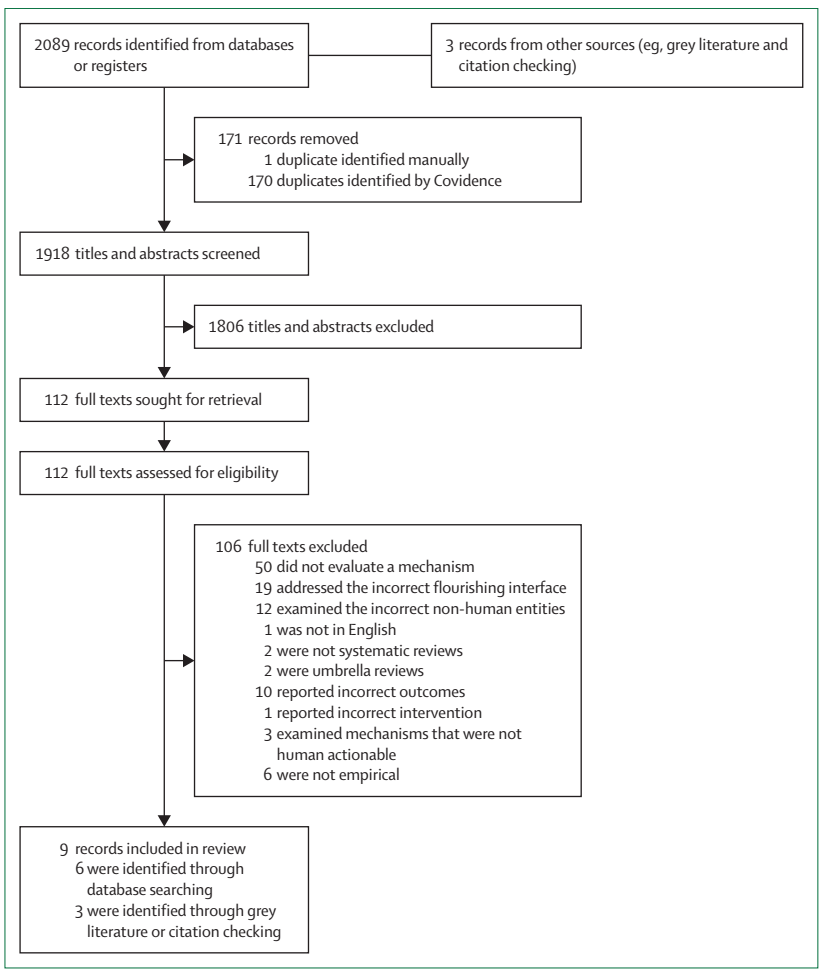


Figure 1: **Study selection**

from indoors). All eligible reviews considered human flourishing outcomes at the individual level. However, two eligible reviews included mechanisms operating at the microsystem level (eg, group membership and social identity) (appendix pp 7–13). The appendix provides a full summary of mechanism findings (appendix pp 7–13) and references (appendix p 14) to all eligible systematic reviews.

The parent paper of this umbrella review[10] identified two key outcome domains of e-co-flourishing—human flourishing and ecosystem flourishing (panel 1). For the current umbrella review, only human flourishing outcomes were considered; therefore, the five key subdomains of human flourishing (psychological, social, physical, environmental, and values-related) were treated as key categories for outcomes and mechanisms. All five subdomains were considered for mechanisms, whereas three subdomains (psychological, social, and physical) were considered in outcomes. Examples of mechanisms included psychological (eg, psychological restorative quality [attention restoration], mindfulness, lower rumination, resilience to or reduced stress, enjoyment, self-efficacy, personal achievement, sense of identity, mental health, perceived crowdedness, reduced disengagement, personal experiences, and development of skills or learning); social (eg, social cohesion, social functioning, social contacts, group membership, social connectedness, interpersonal skills, and mentorship); physical (eg, reduced sleep disturbance; increased physical activity; and lower rates of obesity, high blood pressure, and asthma); environmental (eg, reduced noise and air pollution and environmental annoyance; level of engagement with or time spent in green space and blue space, perceived improvement or naturalness of the environment, benefit of place, and being away from home); and values-related (eg, spirituality). Examples of outcomes included psychological (eg, mental health, stress, self-satisfaction, concentration, reduced fatigue, reduced depression, and emotional beliefs); social (eg, prosocial behaviour); and physical (physical functioning). An additional overall category was considered (eg, health, wellbeing, and quality of life) in which more than one subdomain was evaluated simultaneously. The types of independent variables included amount of green space and blue space, perceived green space, green versus lean office condition, park walks, natural environment exposure, objective green space, subjective greenness, distance to urban parks, residential landscape characteristics, natural residential or agricultural areas, and waterfront landscape characteristics.

Evidence stratified by mechanism type and outcome domain showed the following patterns. For psychological outcomes, there were 15 positive and one negative finding for psychological mechanisms, eight positive and four negative findings for social mechanisms, nine positive and five negative findings for physical mechanisms, 15 positive and ten negative findings for environmental mechanisms, and no findings for values-related mechanisms. For social outcomes, there was one positive finding for psychological mechanisms and no findings for social, physical, environmental, and values-related mechanisms. For physical outcomes, there was one positive finding for psychological mechanisms, one positive finding for social mechanisms, two negative findings for physical mechanisms, one negative finding for environmental mechanisms, and no findings for values-related mechanisms. No evidence was found for environmental and values-related outcomes. For the overall outcome category, there were 46 positive findings for psychological mechanisms, 18 positive findings for social mechanisms, 12 positive findings for physical mechanisms, 14 positive findings for environmental mechanisms, and five positive findings for values-related mechanisms (figure 2).

Stratified by mechanism type and evidence strength, level 1 evidence showed two positive findings for psychological mechanisms and no findings for social, physical, environmental, and values-related mechanisms. Level 2 evidence showed one positive finding for psychological mechanisms, no findings for social and physical mechanisms, five positive findings for environmental mechanisms, and no findings for values-related mechanisms. Level 3 evidence

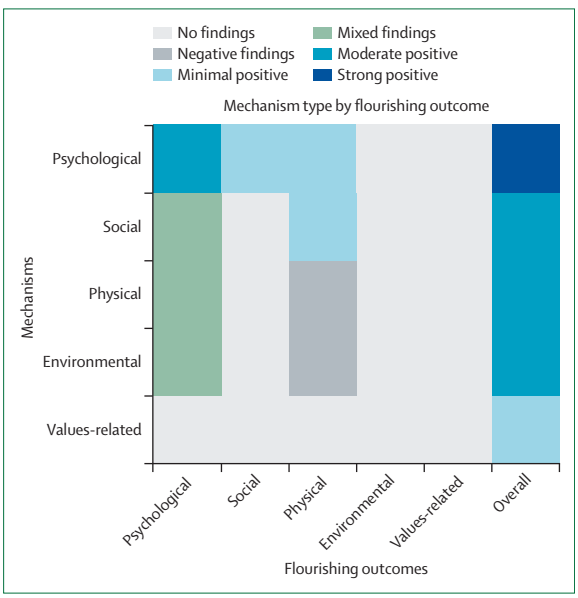


Figure 2: **Mechanism type by flourishing outcome**

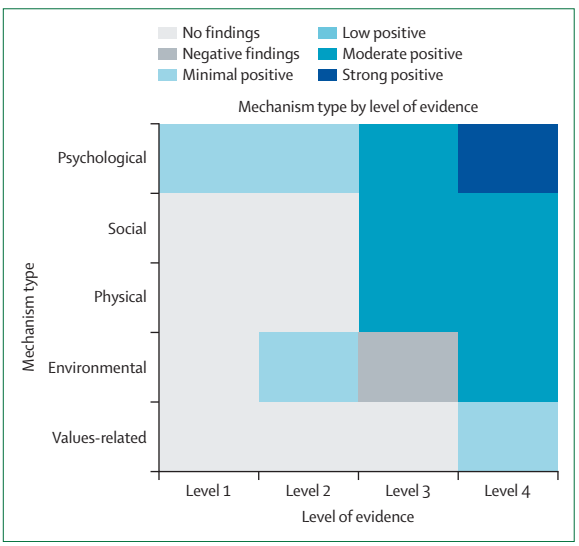


Figure 3: **Mechanism type by level of evidence**

indicated 16 positive and one negative finding for psychological mechanisms, ten positive and four negative findings for social mechanisms, 15 positive and seven negative findings for physical mechanisms, eight positive and ten negative findings for environmental mechanisms, and no findings for values-related mechanisms. Level 4 evidence showed 44 positive findings for psychological mechanisms, 17 positive findings for social mechanisms, 11 positive findings for physical mechanisms, 13 positive findings for environmental mechanisms, and five positive findings for values-related mechanisms (figure 3).

For this umbrella review, quality was appraised in terms of both methodological and mechanism quality (appendix pp 15–18). First, the extent to which methodological and mechanism quality at the study level was appraised in each eligible review was examined, and then overall quality at the review level was reported. Of the nine eligible reviews, eight appraised methodological quality, but none formally appraised mediation or mechanism quality. The frameworks used to determine methodological quality varied across eligible reviews, but the most consistently used framework for quantitative studies was the Effective Public Health Practice Project tool.[45] Among the eligible reviews that clearly reported the overall methodological quality of the included studies (n=8), the results were mixed—approximately half (n=4) reported medium to high quality, whereas the remainder (n=4) reported poor to low quality or a high risk of bias (appendix pp 15–16).

The quality assessments at the review level (appendix pp 17–18) generally indicated low confidence in methodological quality and highlighted several weaknesses in the reporting and transparency of mediation or mechanism findings (eg, specifying participant sample size for mediation tests, reporting indirect and direct effects of interest, fully describing the causal model ideally with a graphical representation, and detailing the statistical techniques).

Discussion

The main objective of this umbrella review was to collate the available empirical systematic review evidence on mechanisms underpinning the flourishing interface for human and non-human entities. Our secondary objective was to appraise the quality of the available evidence in terms of methodological and mechanism quality. Across reviews, evidence supported several cross-domain mechanisms linking non-human entities to human flourishing, including psychological, social, physical, and environmental pathways. Psychological mechanisms were the most consistently supported, with mixed and outcome-specific findings for social, physical, and environmental mechanisms. All mechanism categories were supported for the overall outcome domain (eg, health, wellbeing, and quality of life); however, causality remains weak with evidence predominantly derived from cross-sectional and qualitative studies. Values-related mechanisms and non-psychological outcome domains were notably underexamined (figure 2). Quality appraisal further indicates that confidence in the causal interpretation of mechanisms is constrained by mixed methodological quality and pervasive weaknesses in mechanism and mediation reporting, underscoring the need for more rigorous, theory-driven, and well-reported mechanistic research (appendix p 18). Overall, these findings provide preliminary support for cross-domain mechanisms while highlighting key evidence gaps that should guide future research rather than be interpreted as evidence of absence.

Importantly, the eligible systematic reviews exclusively examined unidirectional effects of non-human entities (eg, nature exposure and environmental interventions) on human flourishing outcomes, with no consideration of

bidirectional or reciprocal relationships in which changes in human and ecosystem flourishing are assessed concurrently. Advancing the e-co-flourishing agenda, therefore, requires future research to incorporate outcomes for both human and ecosystem flourishing (panel 1) and to explicitly test mechanisms that drive simultaneous changes across these domains. The cross-domain mechanisms identified in this umbrella review, together with evidence synthesised in its theoretical foundation,[10] provide a basis for the next phase of research. Ongoing work, including a systematic review of measures of collective human flourishing, will further support this agenda by identifying robust and scalable outcome measures to advance empirical research in this field.[46]

The parent work,[10] outlining theoretical foundations, proposes key cross-domain mechanisms supported in this umbrella review—psychological (eg, attention restoration and stress reduction), social (eg, social cohesion), physical (eg, physical activity), and environmental (eg, reduced environmental stressors, enhanced environmental quality). Additional pathways were also proposed—psychological (eg, mindfulness, awareness, compassion, a sense of awe or gratitude, self-care, emotional regulation, and achievement or mastery), social (eg, connection to self, others, and nature; pro-environmental behaviours; and a sense of belonging), physical (eg, strength and flexibility), values-related (eg, purpose and agency and insight or knowledge), and environmental (eg, perceived safety). However, these mechanisms were identified based on preliminary evidence from related reviews,[29,32,47–51] conceptual frameworks and texts,[52–55] and PPIEP with key stakeholders and therefore require further empirical evaluation.

It is important to note that many records were excluded after title and abstract screening because they did not address the flourishing interface of human and non-human entities (figure 1). For instance, many records included either human or non-human entities but not both simultaneously. Even among those that did include both, many solely examined outcomes and associations[30,50,56–59] rather than examining entire mediation or mechanism pathways or included scarce evidence with only one eligible primary study.[60–62] Highly integrative assessments drawing on mixed review methodologies and normative synthesis (eg, Intergovernmental Platform on Biodiversity and Ecosystem Services values assessments[63]) were not eligible for inclusion unless they explicitly evaluated empirical mechanisms linking human–non-human interactions to flourishing outcomes. Many records might have implied mechanisms by examining associations with proximal outcomes, which might partly reflect pragmatic approaches to behavioural change. However, it is important for the field to fully examine pathways that include all key components—independent variable, mechanism, and dependent variable (outcome)—to better understand interim processes and longer-term effects.[37] Moreover, some papers[32,48,64–67] inferred potential mechanisms underpinning the flourishing interface between humans and non-human entities, yet these papers were theoretical or conceptual rather than empirical. Moving beyond associations (outcomes) and theoretical models will be important in terms of advancing understanding of key processes that explain change and identifying parsimonious pathways for promoting e-co-flourishing, clarifying relationships between independent variables and specific outcomes, and identifying the active ingredients that determine which intervention components are responsible for change.[37] Several exposures examined in the included reviews (eg, access to green space and leisure time for nature-based activities) are likely shaped by broader socioeconomic and structural conditions rather than representing uniformly accessible intervention pathways. Explicit consideration of access, distribution, and equity will therefore be essential for the development and evaluation of e-co-flourishing interventions that are both effective and socially just.

One strength of this Review is its engagement with diverse disciplinary perspectives, which enabled a more holistic appreciation of the flourishing interface and informed the rigorous development of the review search strategy. However, several limitations should be acknowledged. First, the umbrella review focused exclusively on systematic reviews and, therefore, several primary studies[68–70] that have replicated mechanism findings (eg, emotional regulation, connection to nature, agency, and compassion) have yet to be synthesised in systematic reviews. As an umbrella review, our synthesis is also limited by the scope, quality, and conceptual framing of existing systematic reviews, potentially carrying forward earlier limitations in definitions and analytical approaches. Although this approach was appropriate given the early stage of the field, the breadth of the e-co-flourishing concept, and heterogeneity in how mechanisms are evaluated, it prioritises high-level synthesis over detailed examination of primary study design and context. Moreover, the focus on systematic reviews meant that other review methodologies (eg, rapid, scoping, and narrative) were excluded. Although this approach prioritised more rigorous evidence syntheses, it might have led to the omission of emerging or conceptually important developments in the field. To help address this issue, findings from relevant conceptual reviews[29,71,72] were integrated into the programme theory model of e-co-flourishing.

Second, despite efforts to incorporate a wide range of search terms, it is possible that relevant studies might have been inadvertently omitted due to variability in terminology across disciplines. The inclusion of non-western conceptualisations of flourishing, such as balance, kinship, and harmony, represented an important step towards addressing this issue, but further work is needed to integrate diverse epistemologies into future research and investigate values that emerge from specific human-nature relationships.[73] Moreover, although need satisfaction was not used as a standalone search term, foundational needs such as safety, autonomy, and social connection were conceptually

embedded within the included domains. Excluding generic need-based terminology might nonetheless have limited the identification of some relevant mechanisms, warranting further targeted synthesis in future work.

Third, we found that the overall quality of the mediation or mechanism findings in terms of transparency and reporting was poor, suggesting that the field remains at an early stage of development. There is also potential bias because mechanisms were not the primary objective of most eligible reviews, and reported findings might therefore have favoured positive results. Moreover, the operationalisation of mechanisms might have resulted in a bias towards quantitative studies, underscoring the need for frameworks that support rigorous evaluation of potential mechanisms in early stage qualitative research. It was not always clear whether mechanisms were empirically evaluated, and, therefore, some reviews might have been missed due to incomplete reporting. To address these limitations, future studies should prioritise transparent data replication using more robust mediation and methodological approaches (eg, randomised controlled trials and indirect effects). The AGReMA-SF framework,[39] used to evaluate the quality of mediation or mechanism findings, addresses transparency and reporting; however, future work should also consider additional quality criteria (eg, methodological and statistical rigour[36,38]) to strengthen the evidence base for potential mechanisms of change.

To bridge theory and real-world application, future research must move beyond associative evidence to rigorously test candidate mechanistic targets for e-co-flourishing interventions, using robust, theory-driven study designs grounded in conceptual clarity (panel 1), explicit programme theory, and meaningful stakeholder involvement (eg, PPIEP). Future research on e-co-flourishing would benefit from multilevel experimental or quasi-experimental designs that explicitly test sequential causal chains, in which proximal outcomes (eg, attention restoration or social cohesion) function as mechanisms and intermediate inputs for downstream flourishing outcomes. Such studies should incorporate appropriate comparators and test moderation by structural factors, including socioeconomic status, to determine for whom, under what conditions, and at which levels exposures or interventions contribute to e-co-flourishing.

It should be noted that complete or absolute flourishing across all entities, collectives, and systems is neither feasible nor ethically neutral, as interventions occur within complex, value-laden, and resource-constrained contexts. The e-co-flourishing approach therefore prioritises context-sensitive net-positive gains, transparency around inevitable trade-offs, and respect for community sovereignty—including the adaptation or abandonment of interventions in which risks of harm or inequity are identified. E-co-flourishing does not assume an individualised or growth-dependent model of wellbeing and remains open to plural epistemologies, including capabilities-based and post-growth perspectives.[74,75] In doing so, it signals a necessary shift in planetary health from mitigating harm and ill health towards cultivating net-positive improvements in flourishing across species and systems.

Contributors

SM, VH, JM-M, WK, and IS conceptualised the review paper methodology and research question; SM, TH, BM, and HZ conducted the formal screening process and data analysis, which were also reviewed by WK and JM-M. All remaining authors (AMvdV, JM, KW, TL, MGR, EA, JB, WF, LT, MB, CT, GS, and YM), including those listed earlier, contributed to aspects of the methodology (eg, refining search strategy) and provided edits on the original draft and subsequent drafts of the manuscript. SM and WK prepared the original draft and consolidated feedback from all coauthors to produce subsequent versions and the final manuscript. All authors reviewed the final manuscript and had final responsibility for the decision to submit for publication.

Declaration of interests

We declare no competing interests.

Data sharing

The data extracted from the included studies are included in the paper, and other relevant materials used for the Review are available in the appendix and, therefore, publicly available.

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