GeoHealth

REVIEW ARTICLE

10.1029/2024GH001254

Lars Ratjen and Emily Goddard contributed equally to this work.

Key Points:

- The increasing urgency of the environmental and mental health crises warrant for a deeper understanding of their interactions
- Environmental factors play a key role in the etiology of mental health disorders, influencing human well-being on various scales
- Bringing our focus to an integral environmental protection bears the potential to decrease the burden of the mental health crisis

Supporting Information:

Supporting Information may be found in the online version of this article.

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Citation:

Ratjen, L., Goddard, E., Gilcher, E. B., Nguyen, B. K., Kelley, M., Feldman, H. S., et al. (2025). EnvironMental Health: A framework for an emerging field at the intersection of the environment and mental health crises. *GeoHealth*, *9*, e2024GH001254. https://doi.org/10.1029/2024GH001254

Received 2 NOV 2024
Accepted 20 DEC 2024

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EnvironMental Health: A Framework for an Emerging Field at the Intersection of the Environment and Mental Health Crises

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Abstract Understanding how the environment shapes our mental and cognitive health is imperative to support efforts that promote healthy and sustainable living conditions. The etiology of mental health conditions remains often unclear, and social factors have received more scrutiny than natural or built environments. We present a conceptual framework illustrating the emerging intersection between the environment and neuropsychological health, intended to structure and guide research and funding, as well as public health and environmental initiatives. We conducted a scoping review of reviews of existing evidence on the impacts of the environment on mental and cognitive health. We found that an extensive body of work was focused on chemical hazards and the built environment and their associations with neurological and mental health, including attention-deficit/hyperactivity disorder (ADHD), autism, dementia, and mood. We identified emerging areas of research intersecting environmental factors such as air, water, light, and green space with schizophrenia and behavioral health. Our analysis of the intersections between the environment and mental and cognitive health allows for the identification of knowledge clusters and gaps, contextualizing needs and opportunities for future research and funding strategies. These significant connections showcase the importance of understanding the relationships between the environment and mental and cognitive health. With this work, we assert that the protection of the environment and its integration into healthcare can bring cascading benefits and synergies to mental and cognitive health and well-being and address the social and economic burden of the mental health crises.

Plain Language Summary This study emphasizes the importance of understanding how our surroundings and the environment affect mental and cognitive health. While the causes of mental health issues are still largely unclear, research has often focused more on social factors than on how natural or built environments contribute. Historically, the role of the environment in mental health has been overlooked, making research and action in this area necessary but challenging. We conducted a review of existing studies on how the environment impacts mental and cognitive health and found a lot of research linking chemical hazards and built environments to conditions like ADHD, autism, dementia, and mood disorders. We also noticed emerging research exploring how natural factors like air, water, light, and green spaces relate to mental health, including specific conditions like schizophrenia. Our findings and reflections highlight key areas of knowledge and gaps, showing the need for more research. The study emphasizes that protecting the environment and considering it in healthcare can greatly benefit mental and cognitive health, helping to reduce the social and economic costs of the mental health crisis.

1. Introduction

1.1. A Situational Analysis of the Environment and Mental Health

We are a product of our environment, and our environment is shaped by our existence. Environments impact our mental health as much as they impact our physical well-being, and understanding this intersection is imperative to

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develop effective research and promote healthy and sustainable living conditions (Beaglehole et al., 2018; Callaghan et al., 2021; Clifford et al., 2016; Fuller et al., 2022; Gascon et al., 2015; Haines et al., 2020; Lai et al., 2021; Ma et al., 2022; UNEP, 2018). Considering the projected environmental outcomes of climate change in the Anthropocene, it is more important than ever to understand the reciprocal nature of the links between the environment and our mental health. There is certainly some understanding of the potential mental and cognitive risks of environmental factors, such as chemical exposures and extreme weather events, yet the full range of associations is far from being clearly elucidated (Haines, 2016; Tong & Bambrick, 2022). While some areas of environment and mental health research are more evolved, others remain underinvestigated, such that critical environmental harms and benefits to mental and cognitive health are not being studied equally. Nevertheless, contemporary healthcare has begun to recognize the potential for environment-focused treatments, such as greenspace prescriptions and light therapies, to improve mental and cognitive function, yet more work is needed to harness their full potential (Joschko et al., 2023; Pouso et al., 2021). Therefore, we aim to develop a resilient and applicable framework that outlines the impact of the environment on mental and cognitive health, enabling a synthesis of existing high-level scientific evidence to promote a better understanding of the state of the field. A framework-guided analysis allows for the identification of areas of connection, knowledge clusters, promising novel intersections, and research gaps. We envisage this work to provide direction for future research, funding, and efforts, aid in public health and environmental management decision, and facilitate conversations between two extremely important and interconnected yet siloed fields. Mental and cognitive health is foundational to communication, decision-making, relationship-building, and personal well-being, but increasing rates of mental illness and cognitive disorders threaten effective and functional societies (Trautmann et al., 2016; Vos et al., 2020). While an increasing awareness of mental health disorders and a decreased stigmatization play a key role in the increase of incidence, this undoubtedly positive tendency alone can not account for the rapid increase in diagnoses and medicalization (Foulkes & Andrews, 2023). A recent study estimated that mental disorders account for 16% of global disability-adjusted life years (DALYs), and the World Health Organization (WHO) named mental disorders as the leading cause of disability globally (Arias et al., 2022; WHO, 2022c). The 2017 Global Burden of Diseases (GBD) Study identified depressive and anxiety disorders among the 20 most common causes of years lived with disability (YLD), alongside lower back pain, headache, stroke, and diabetes, while the 2019 GBD report found similar trends for DALYs (James et al., 2018; Vos et al., 2020; WHO, 2020). Overall from 1990 to 2019 the occurrence of mental disorders increased by 48% (Vos et al., 2020). A 2023 study found that the use of special education services for autism spectrum disorder (ASD) and attention-deficit/hyperactivity disorder (ADHD) has increased by 242% and 183%, between 2006 and 2021, and suggested that environmental exposures could be directly related to the rapidly increasing prevalences of those neurodevelopmental disorders (Dufault et al., 2023). At the same time, many global populations are aging, increasing the prevalence of neurodegenerative diseases and prompting the need for novel therapies (Andrada et al., 2023). Many mental health stressors have increased since the COVID-19 pandemic, with social isolation and disruptions of everyday routines taking a significant toll on mental health worldwide (Giuntella et al., 2021; WHO, 2022a). Many mental and cognitive disorders still go untreated, often caused by underdiagnosis, lack of integral knowledge, and inadequate resources: the WHO reports that less than one-third of global populations experiencing depression or psychosis receive mental healthcare of any form. Importantly, there are often huge disparities in both risks and access to treatment: the most disadvantaged populations, often those in low and middle-income countries (LIMCs), are at the highest risk of mental ill-health and are also the least likely to access support services (Chan et al., 2023; WHO, 2022c). A better understanding of the relationship between the natural and built environments and mental and cognitive health could encourage and direct more research, funding, and investment in sustainability, climate change mitigation and adaptation, healthy environments and primary care, and subsequently lower burdens of mental illness, or possible concomitant stigmatization.

1.2. A Case for Prioritization of Environment and Mental Health Research

Addressing human-made environmental harms can lead to extremely positive cascading structural change and support preventative health, both physical and mental. The WHO estimates that a quarter of the global burden of disease could be prevented by safeguarding or creating healthier environments (UNEP, 2018; WHO, 2022b). However, investment in environmental protection and healthy living conditions remains low. Many countries have fallen far behind on their progress toward the Paris Agreement goal to "limit temperature increase to 1.5°C above pre-industrial levels" and 43% of the global population is still without a safely managed sanitation service (UN-Habitat, 2021; UNFCCC, 2015). Over the last two centuries, human activities have led to the surpassing of

many planetary boundaries beyond "a safe operating space for humanity" as described by Rockström (Richardson et al., 2023; Rockström et al., 2009). Environmental challenges such as greenhouse gas (GHG) emissions, climate change, urbanization, forest loss, and decreased biodiversity all play a major role in the long-term viability of the planet to support life (Ahmed et al., 2018; Armstrong McKay et al., 2022; Dakos et al., 2019; Pigot et al., 2023). From 2010 to 2030, the global surface temperature is expected to increase by 0.7°C, CO_2 concentrations are predicted to surge by more than 10%, forest area is expected to decrease by approximately 1 million km^2, and biodiversity is estimated to drop by an additional 5%, all of which have wide-reaching implications for planetary and human health (NASA, 2024; OECD, 2012; Seto et al., 2012). The lack of governmental financial investment in environmental and mental health research exemplifies how these fields are deprioritized. In the U.S. as of 2010, the Environmental Protection Agency (EPA) and the National Institute of Health (NIH) had annual budgets of $US 8.8B and $US 30B respectively, representing only about 2% and 8% of the total U.S. government budget (CSBA, 2009). Additionally, only 24%–38% of the EPA budget was mobilized for spending categories directly benefiting environmental conservation (US EPA, 2013). In Europe, the German Federal Ministry for Environment, Nature Conservation, and Nuclear Safety (BMUV) allocated around 20% of its annual budget of € 2.40B to environmental and natural protection in 2024 (BMUV, 2024). Even when funding is allocated to the environment, efforts are not always directed in a way that also benefits mental and cognitive health. Much current research on the environment and health has focused on physical health, as it is often easier to study and less stigmatized (Kohn et al., 2004; Puras & Gooding, 2019; WHO, 2013; Winkler et al., 2017). Mental health research receives only 2.3% of the overall National Institute of Health (NIH) research budget, lower than the spendings on both cancer and infectious diseases, and of a comparable magnitude to aging research (NIH, 2023). Similarly, funding for psychology and related fields represented only 4% of the U.S. National Science Foundation (NSF) budget in 2022, compared to 50% for life sciences in general (NSF, 2022).

Mental health is also long at the heart of public health needs: In the United States alone, the direct spendings on mental and behavioral disorders surmounted $US 280B in 2020 (The White House - CEA, 2022), passing for example, direct expenditures on cancer treatment ($US 201B), and other nations across the globe show very similar trends (Mariotto et al., 2020). Acute and potentially life-threatening medical conditions like cancer, cardiovascular diseases, or infections incur high direct costs associated with diagnostics and treatment. Mental health disorders on the other hand, do not only incur high direct costs through expensive diagnostics, therapies, and medications, but also high indirect costs, which include burden from disability, care-seeking, and lost productivity. In a report from 2016, Trautmann et al. (2016) estimated mental health related direct and indirect costs for 2010 (and 2030), with direct costs at $US 800B ($US 2,000B in 2030) and indirect costs at $US 1,700B ($US 4,100B in 2030) (Trautmann et al., 2016).

Despite recent commitments at COP28 to climate change and health research (UNFCCC-COP28, 2023), the previously stated factors illustrate the ongoing deprioritization, but also a possible path forward for refocusing research and funding priorities, and counteract two of the most marked problems humanity is facing in this moment (see Figure 1).

1.3. The Environment and Neuropsychological Health

The term "Environmental Health" was defined by the WHO in 1989 as "aspects of human health and disease that are determined by factors in the environment"; however, environmental health as a field of study has existed for most of the 20th century (WHO, 2022b). Such research has historically been centered around pollutants and anthropogenic threats and their physical health impacts, such as respiratory illness, infectious diseases, and cancers. Environmental toxicology emerged in the early 1960s in the wake of Rachel Carson's book, *Silent Spring*, and has since formed the basis for many environmental regulations (Carson, 1962). This well-studied research area has explored more specific mechanisms and manifestations, particularly dose-response relationships, and can be seen as a subset of the wider environmental health intersection (Schwartz et al., 2014). In the mental health space, environmental psychology emerged in the 1960s as the study of the complex relationships between human activities and the surrounding environments (Steg et al., 2018). This field has explored both values and harms associated with environmental impact on human behavior and mental health (Russell & Ward, 1982). Groundbreaking work by Wilson (1984) on the "biophilia theory" highlighted the tendency of humans to connect with nature and living organisms and alluded to the beneficial power of nature on our health (Wilson, 1984). Inauen, Osvaldo, and others have gone even further, suggesting that psychologists actively promote human behavior beneficial for environmental and planetary health, coining the term "environmental

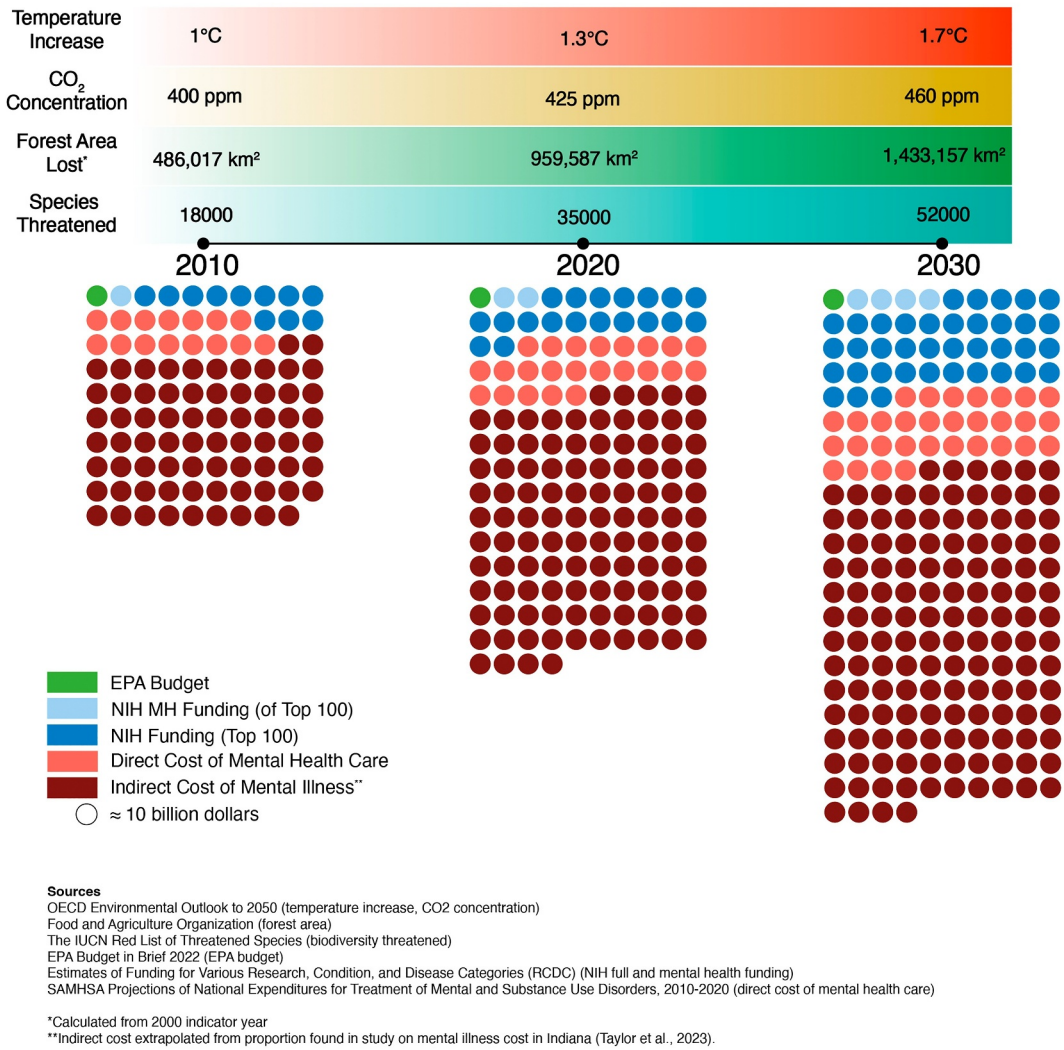

Figure 1. Development of selected environmental indicators (upper part) versus funding priorities/mental health costs (lower part) worldwide. Comparison of available environmental funding, mental and cognitive health research versus overall research funding, and the financial impact of mental health through direct and indirect costs from 2010 to 2030 in the United States.

health psychology" (Inauen et al., 2021; Santos et al., 2021). Complementarily, the field of ecopsychology has focused on emotional bonds and synergies between humans and the Earth, the "human-nature relationship," and their respective benefits, as well as the problems associated with the increasing alienation of humans from nature (Roszak, 1995; Thoma et al., 2021). While these fields have greatly advanced the state of research on the environment and mental health, they fail to fully contextualize their unique relationship—specifically the concrete ways in which environmental phenomena impact neuropsychological health, warranting an intentional framework to bring these understudied impacts to the forefront.

Our environments undeniably shape our health, and only by understanding this relationship can we support environmental conditions that most effectively promote well-being (Kühn & Gallinat, 2024). Mental and cognitive health are essential, yet underestimated components of overall health and well-being, and their relationship with environmental factors is of growing importance. Despite the lack of an organized field, there is a multitude of disparate research connecting a wide variety of mental and cognitive health facets with natural and built environmental phenomena. However, both of these fields—the environment and mental and cognitive health—are broad, complex, and multidisciplinary, making their myriad interconnections complicated to grasp. Many systematic reviews have linked specific environmental elements, such as natural disasters (Fernandez

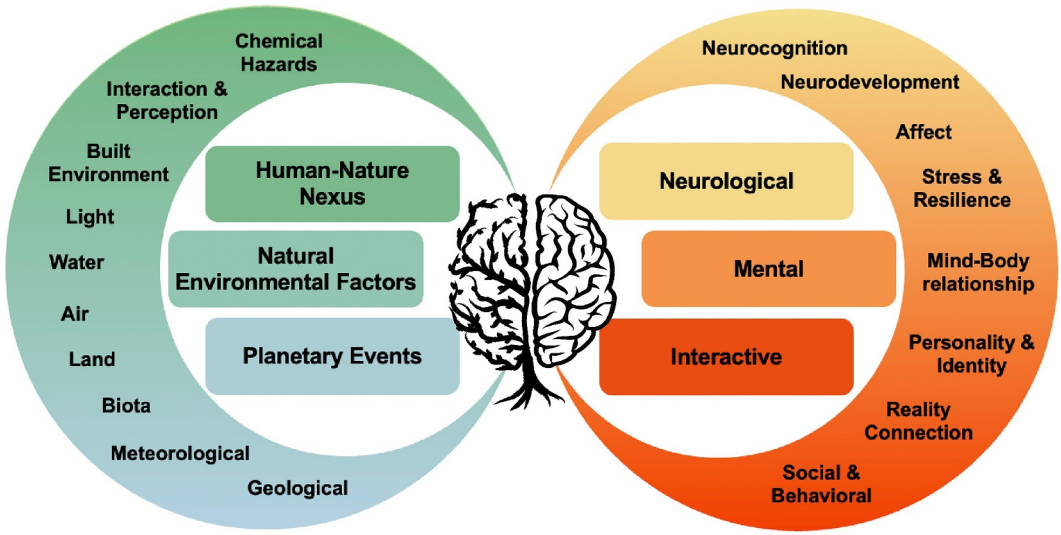

Figure 2. Conceptual framework developed for structuring the EnvironMental Health intersection for the scoping review of reviews process.

et al., 2015), contamination (Legg et al., 2023), green and blue spaces (Gascon et al., 2015; McCormick, 2017; Vanaken & Danckaerts, 2018), noises (Dzhambov & Dimitrova, 2014; Guski et al., 2017), and the built environment (T. H. M. Moore et al., 2018; Smith et al., 2017; Sui et al., 2022) with specific mental and cognitive health sequelae. However, none have considered how these environmental and mental health facets are intricately and systematically intertwined. Large multi-national projects or consortia, such as the EU-funded environMENTAL for "reducing the impact of major environmental challenges on mental health" (CORDIS, 2022; Schumann, 2023) or the trust-funded Connecting Climate Minds for "catalyzing a global research community at the intersection of climate change and mental health" (Connecting Climate Minds, 2024; Lawrance et al., 2024) are timely initiatives aiming at the generation of impactful work at the intersections of the environment and mental health. Given the rising environmental changes and challenges driven by human activity, it is essential to understand how natural and built environments—and the alterations to them—can positively and negatively affect both short- and long-term mental and cognitive health outcomes.

2. Methods

2.1. Development of a Framework for EnvironMental Health

To comprehensively organize, identify, and describe the relationships between the environment and mental and cognitive health, we identified the need for a conceptual framework (Figure 2). Both the environment, and mental and cognitive health were assigned to an axis, with the goal of encapsulating each individual field in its entirety and enabling links to be drawn between the two. We explicitly focused on the impact of the environment on mental and cognitive health, not vice versa. Environmental factors were labeled as "inputs" and mental and cognitive health factors as "outcomes." We defined "environment" as the physical, chemical, biotic, and abiotic parameters or conditions in which humans exist. This includes aspects of the natural and built environment, the quality of environmental parameters, environmental events, and environmental exposures. Our definition of environment explicitly excludes primarily sociological phenomena, sometimes called contextual environmental factors (social, political, economic, or regulatory; e.g., the presence of prisons, hospitals, schools, job strains or shift work, etc.), environmental concepts in isolation of environmental conditions (e.g., greenwashing, the idea of climate change in non-affected areas), human actions related to the environment (e.g., recycling, climate activism, conservation efforts), and individual behavioral exposures not explicitly associated to environmental factors but predicated by choice (e.g., first-hand cigarette smoking, drug use). In this context, "mental and cognitive health" encompasses all neurological, mental, cognitive, emotional, psychological, or social factors which include, but are not limited to, illnesses, health status, health care, quality of life, development, or functioning related to any and all of the factors previously mentioned. Our definition of mental and cognitive health excludes primarily

physical health, as well as biochemical factors without a clear and explicit link to another facet of mental or cognitive health (see Tables S1 and S2 in Supporting Information S1).

2.2. Structure for Environmental Inputs and Mental/Cognitive Health Outputs

In the development of the environmental inputs, we utilized scholarly literature and expert knowledge and identified three broader categories: (a) *planetary events*, (b) *natural environmental factors*, and (c) *the human-nature nexus*. *Planetary events* include all phenomena related to the Earth's macrostructure and were further divided in two subcategories: (a) *meteorological*, for phenomena related to climate and weather, and (b) *geological*, for all other natural events, such as earthquakes, volcanoes, or tsunamis. *Natural environmental factors* include categories for all natural constituents: (a) *light*, (b) *water*, (c) *air*, (d) *land*, and (e) *biota*. While these categories were based on natural phenomena, they also include human-made environmental stimuli that can be defined as such (e.g., non-natural lighting). Finally, *the human-nature nexus* encompasses aspects of the environment that are profoundly influenced or formed by human action. It was divided into three subcategories: (a) *interaction & perception*, for the interaction with and perception of nature, (b) *built environment*, for non-natural environments such as housing quality and environmental layout, workplaces (such as occupational environments), and surroundings that have been restructured by humans, and (c) *chemical hazards*, for pollutants attributable to human activity, including environmental occupational hazards, for example, caused by exposure to pollutants. This division into subject areas and categories was found to capture terms with sufficient granularity and enable a deeper analysis of research clusters and gaps (see Supporting Information S1, specifically Table S3 and S4).

The development of the mental and cognitive health axis was mainly guided by the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), the International Classification of Diseases (ICD) (APA, 2022; WHO, 2024), scholarly discussions, and exchange with experts. Our interest in elucidating positive and negative influences of the environment on mental and cognitive health, led us to synthesize the extensive classifications in the DSM-5 and the ICD and consider not only mental illnesses and disorders, but also mental wellness, improvements to cognition, and other non-clinical facets of mental and cognitive health. For this purpose, it was important to generate a more focused framework, and narrow down the possible outputs from the >20 wider categories defined in the DSM-5. We found the grouping of mental health factors into the following categories useful: (a) *neurological* reflecting acute cognitive and developmental disorders, (b) *mental* covering affect, stress, resilience and other mind-body disorders such as sleep quality, PTSD, or psychosomatic conditions and (c) *interactive* including psychotic disorders, substance use and abuse, as well as social or personality disorders. The *neurological* category was further divided in two subcategories: (a) *neurocognition*, including cognition, decision-making, language, and other aspects of brain function, as well as typically late-onset neurological conditions such as dementias, and (b) *neurodevelopmental*, which includes typically early onset neurological conditions, such as ASD, ADHD, as well as learning and language development. The *mental* category encompasses all isolated facets of mental well-being and is divided into three categories: (a) *affect*, which includes mood disorders but also positive mood, (b) *stress & resilience*, which includes post-traumatic stress, anxiety, obsessive-compulsive disorder, and general stress, and (c) *mind-body relationship*, which includes psychosomatic conditions, sleep, and all other general aspects of mental well-being. The *interactive* category was divided into (a) *personality & identity*, including dissociative personality disorder, gender identity, and sense of self, (b) *reality connection*, including psychoses and schizophrenia, and (c) *social & behavioral*, including all aspects of mental and cognitive health that are directly related to society or relationships, such as personal and community relationships, but also substance use disorders, and oppositional defiant disorder (see Supporting Information S1 for more details).

2.3. Review Strategy

Due to the size and scope of the subject area, we decided for a scoping review of review papers, aiming at a high level of knowledge synthesis (Aromataris et al., 2015, 2020; Fusar-Poli & Radua, 2018; Moher et al., 2009; Tricco et al., 2018). Based on scientific literature and expert discussions, our team of environmental scientists, engineers, public health specialists, and psychologists assembled 210 search terms with specific relevance to environmental *inputs* and neuropsychological *outputs*, covering all subject areas and categories (see Supporting Information S1 for details). To maximize recall and maintain precision, subject area limitation was considered to exclude studies solely focusing on topics from natural sciences in isolation from mental and cognitive health or

vice versa. We carried out a full document search in the Scopus database in January 2023, limiting results to those containing an abstract in English and a database-classification as "review." The retrieved review articles were added and organized in the Covidence Systematic Review platform and screened first based on title and abstract, second based on full-text, and additionally assigned into the conceptual framework (Covidence, 2024). Assignment of documents to multiple intersections in the framework was explicitly possible, and the assignment data was collected with a *database tool* based on the Qualtrics Survey format, with an implemented aggregation pipeline in R (Qualtrics, 2024). Due to the size of the corpus, we did not perform critical appraisal of any kind.

The full literature search resulted in 8,926 review documents, out of which 19 were removed as duplicates. An additional 8,069 documents were excluded during the title-abstract screening (for the full set of inclusion/exclusion-criteria see Supporting Information S1), leaving 838 for full-text review. The full-text review led to the removal of an additional 241 documents, leaving 597 documents included in the final corpus, representing approximately 6.7% of the originally retrieved articles (Figure 3). We followed the PRISMA guidelines and checklists for both systemic and scoping reviews, as well as the protocol in the JBI Manual for Evidence Synthesis (Aromataris & Munn, 2020; Moher et al., 2009; Page et al., 2021; Tricco et al., 2018). We gathered additional information from each document on population and geographic area of focus, where applicable, as well as specific mentions or descriptions of the concept of environmental justice (EJ). A detailed description of the methodology, inclusion/exclusion criteria, full list of the documents in the final corpus, as well as their metadata and assigned categories, and the limitations of the study can be found in Supporting Information S1–S3.

3. Results

With the retrieved data we turned our attention to the intersectional analysis. Although a review of reviews does not necessarily reflect the proportions, volumes and qualities of the inherent primary literature, we found the analysis of the intersections provided by the conceptual framework extremely useful for further discussion. A deeper analysis of the results and its underlying research opens many avenues for deeper understanding and the development of more tailored solutions to both environmental and mental health issues.

3.1. Chemical Hazards and Neurological Health

The most populated area of research was identified at the intersections of *chemical hazards* and *neurocognition* (28.1% of documents), and *chemical hazards* and *neurodevelopment* (18.4% of documents) respectively (Figure 4). Topics of these reviews included exposures to endocrine-disrupting chemicals, such as bisphenol A (BPA) and phthalates, heavy metals (e.g., lead), air pollutants, and pesticides, in associations with brain development, dementias, Parkinson's disease, autism, and ADHD (Buralli et al., 2023; Dick, 2006; Freire & Koifman, 2012; Goel & Aschner, 2021; S. Moore et al., 2022; Pezzoli & Cereda, 2013; Ribas-Fitó et al., 2001; Santa Maria et al., 2019). While this category was the most intensely studied, the contained research was highly varied, focusing on many different chemicals, pollutants, and neurodevelopmental and neurocognitive issues, each with unique biological mechanisms, suggesting that despite the number of reviews, knowledge in this subject area is far from saturated (Black et al., 2022; Liu et al., 2016). Not only do novel associations need to be further investigated, but more work is needed to understand mechanisms and pathways. The rapidly changing landscape of anthropogenic chemical hazards, and our increased understanding of it demands that research keep pace to fathom the environmental and health impacts and develop effective public health interventions to mitigate the hazards.

Despite the wealth of research on the relationships between *chemical hazards* and *neurological* health, there has been less linking of chemical pollutants to other facets of mental and cognitive health. Many of the documents that fell into other mental and cognitive health categories mainly focused on neurological health and only secondarily on other areas. Still, some examples explored associations with anxiety and stress (*stress & resilience*, 5.2%) (Dickerson et al., 2020; Trushna et al., 2021), psychosocial effects (*social & behavioral*, 4.4%) (Cox et al., 2017; Kim et al., 2021), and suicide and depression (*affect*, 6.9%) (Dickerson et al., 2020; Troiano et al., 2017) indicating a solid basis of work for future studies.

3.2. Built Environment and Affect

Independently, *neurocognition* had the highest density of research across all mental and cognitive health categories, followed closely by *affect*. However, while research on *neurocognition* was mostly focused on *chemical*

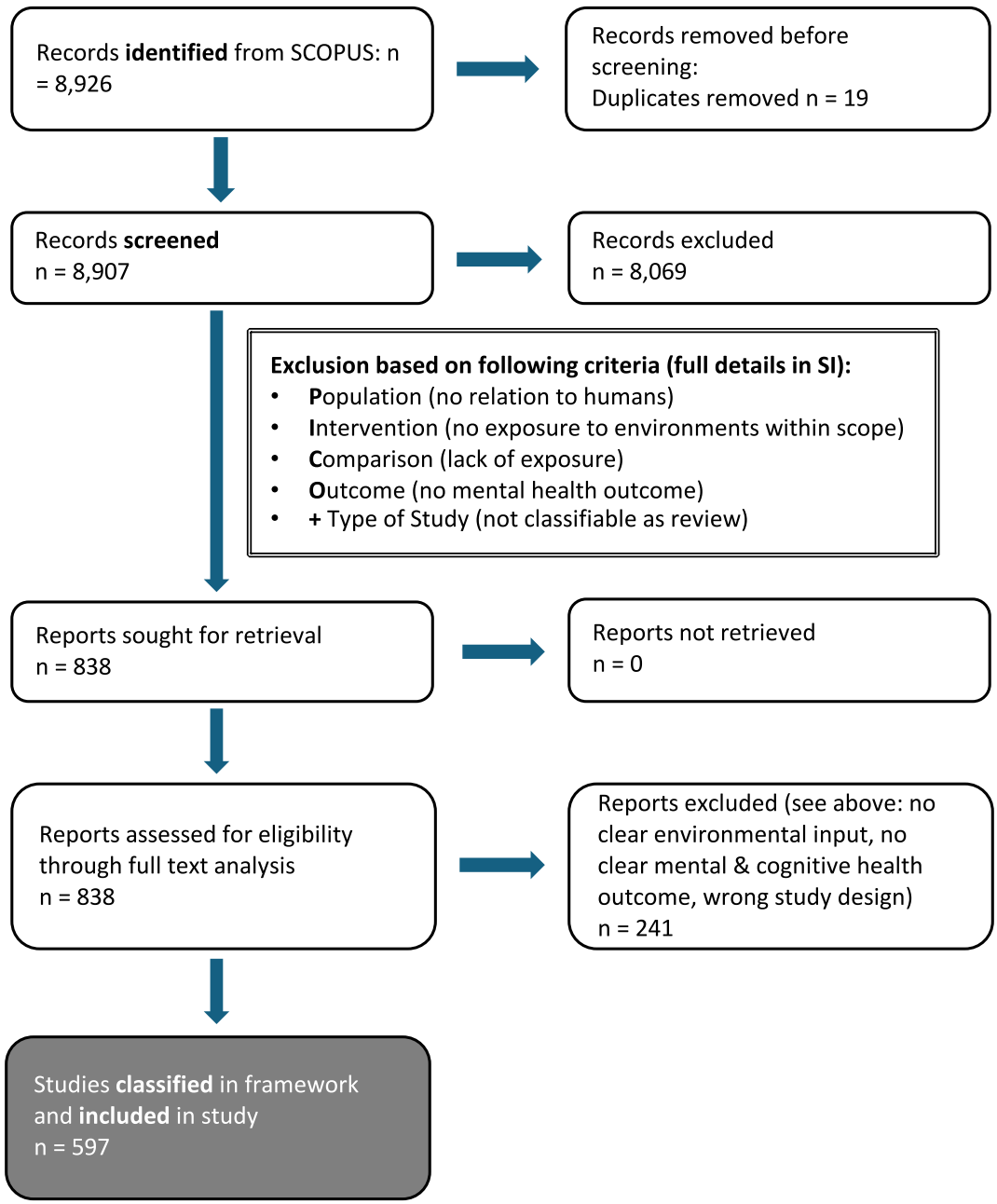

Figure 3. PRISMA-protocol of the full literature review (Page et al., 2021). A list of all the studies classified in the framework and included can be found under https://doi.org/10.17605/OSF.IO/EDJR7 (Nguyen, 2024). A detailed description of the inclusion-/exclusion criteria can be found in Supporting Information S1.

hazards (28.1%), *built environment* (9.5%), and *air* (9.1%), including those of occupational nature, research on *affect* was distributed more evenly across environmental factors (1.3%–10.6%), suggesting potentially broader and more overlapping connections. The most common intersections with *affect* were *built environment* and *interaction & perception*, which also mirrored each other across other facets of mental and cognitive health, suggesting overlapping topics. Both *built environment* and *interaction & perception* most frequently intersected with *mind-body relationship* (11.7% each), *affect* (10.2% and 10.6%, respectively), *neurocognition* (9.5% and 6.0%), and *stress & resilience* (8.4% and 8.0%). These reviews often connected noise, green space (both human-made and natural), and building design with sleep, cognition, dementias, mood, and stress, many of which likely also overlapped with the *light* and *land* categories (Nukarinen et al., 2022; Torresin et al., 2019; Xu et al., 2022).

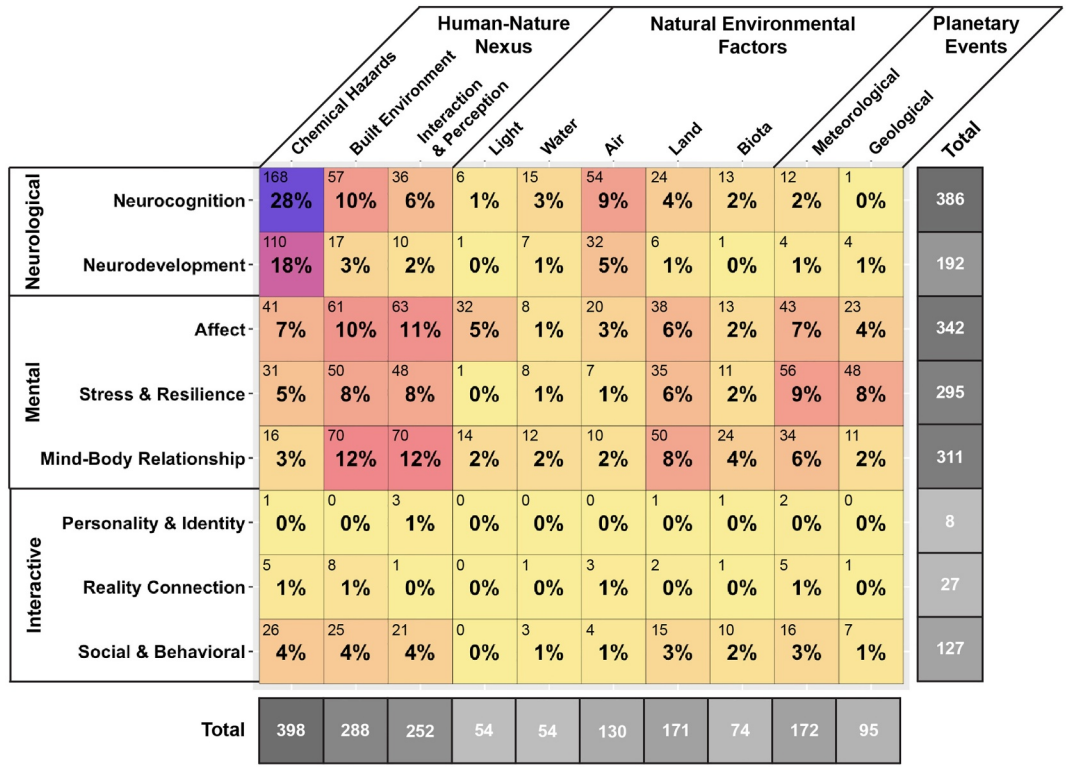

Figure 4. Heat map illustrating the distribution of reviews within the EnvironMental Health framework; percentages are out of total reviews in the corpus (597). Since reviews could be assigned to multiple categories, percentages sum to >100% and numbers might not accurately reflect the quantity of the reviews.

These research areas are of increasing importance given ongoing global urbanization and digitalization (Creutzig et al., 2022; Elmqvist et al., 2021), and should definitely be considered for future research and funding priorities.

3.3. Planetary Events and Stress

A significant number of reviews was found at intersections between the *meteorological* and *geological* categories and *stress & resilience* (9.4% and 8.0%, respectively), *affect* (7.2% and 3.9%), and to a lesser extent, *mind-body relationship* (5.7% and 1.8%). Most of these reviews highlighted specific and highly localized extreme weather events and natural disasters and their connections to post-traumatic stress disorder (PTSD), anxiety, depression, and general well-being (Blanc et al., 2020; Murakami et al., 2018). Although some discussed climate change more generally, we specifically excluded reviews that focused on climate anxiety (i.e., anxiety related to the mere idea of climate change), meaning that the papers at this specific intersection all focused on relationships between stress and discrete meteorological manifestations of a changing climate.

3.4. Natural Environmental Factors

Overall, the *natural environmental factors* categories had fewer connections to any mental and cognitive health facets, with a few notable exceptions. A significant amount of research intersected *air* with *neurocognition* (9.0%) and *neurodevelopment* (5.4%), many of which focused on gas molecules and air pollutants respectively, including ozone (O_3), nitrogen dioxide (NO_2), carbon dioxide (CO_2), and fine and coarse particulate matter ($PM_{2.5}$ and PM_{10}) as it relates to dementias (Bishop et al., 2022; Singh et al., 2022), Parkinson's disease (Dhiman et al., 2022), and autism (Flores-Pajot et al., 2016; Lin et al., 2021), likely overlapping with documents from the *chemical hazards/neurocognition* and *chemical hazards/neurodevelopment* categories (Bhui et al., 2023; Gartland et al., 2022). A smaller number of documents connected *air* with *affect* (4.3%) and *stress & resilience* (1.2%), mostly exploring associations between air pollution and anxiety and depression, indicating that this could be a growing area for future research (Borroni et al., 2022; King et al., 2022; Zundel et al., 2022). *Light* almost exclusively intersected with *affect* (5.4%), and almost all reviews focused on seasonal affective disorder (SAD)

and light therapy approaches for depressions (Benedetti et al., 2005; Nussbaumer et al., 2015; Partonen & Lönnqvist, 1998). However, a few reviews also suggested its promise in other contexts, such as *neurocognition* (1.0%), specifically attention and alertness in occupational environments (Pachito et al., 2018), and *mind-body relationships* (2.3%), such as sleep (often in relation to mood), which are highly interesting areas for further exploration (Golmohammadi et al., 2021; Menculini et al., 2018; Siraji et al., 2023; van Maanen et al., 2016). Interestingly, the influence of nighttime lights on mental health was not specifically represented in our analyzed literature corpus. Some research suggested a significant connection between *land* and *mind-body relationships* (8.4%), but less links to *stress & resilience* (5.9%), *affect* (6.4%), and *neurocognition* (4.0%), and a small number of documents connecting to *neurodevelopment* (0.4%) (Aghabozorgi et al., 2023; Bray et al., 2022; Sprague et al., 2022). Most focused-on relationships between green space and dementias, attention, and general stress and mental well-being, many of which likely overlapped with the *built environment*. While some associations in these areas are apparent, research should be expanded to better understand mechanisms of association and best practices to promote mental and cognitive well-being with the development and integrity of green spaces (Bray et al., 2022). Importantly, very few documents represented connections between *biota* (all <5.0%), *water* (all <3.0%), and *light* (all except *affect* <3.0%) and most facets of mental and cognitive health. Many of the documents that did intersect with the *biota* category highlighted relationships between plants and general effects on stress and well-being (though some included schizophrenia and dementias), but many of these highlighted plants as related to green space and were also included in the *land* category (Han et al., 2022; Soga et al., 2017; Taghipour et al., 2021). One review noted a possible association between fungal toxins and autism spectrum disorder, suggesting that more focus on mycotoxins/biotoxins and neurodevelopment should be warranted (Serkan et al., 2021). A small but notable number of reviews intersected *water* with both *neurocognition* and *mind-body relationship*, highlighting the connections between arsenic, pesticides, and other heavy metals and pollutants in drinking water and neurodevelopment and neurodegeneration, as well as possible links between blue space and general mental well-being (Gascon et al., 2017; Hasanvand et al., 2020; McClintock et al., 2012; White et al., 2020). This small presence of impactful research suggests that both *water/neurocognition* and *neurodevelopment* and *water/mind-body relationships* are understudied compared to other major categories and may benefit from increased investment and attention.

4. Discussion

4.1. Research Gaps and Emerging Areas of Research

Much less than half of the included documents were classified across all the *interactive* categories as compared to the *neurocognition* subcategory alone. A Sankey diagram is a good means of visualizing the proportional interconnectedness of individual research topics within the overall context (see Figure 5). There was a moderate number of documents that intersected with the *social & behavioral* category across many different environmental inputs. This indicates that many of these areas, specifically intersections with *chemical hazards*, *built environment*, and *interaction & perception*, are burgeoning and could warrant significant additional research activity (Berry et al., 2021). Specifically, we found notable reviews suggesting associations between natural resource extraction and biopsychosocial impacts, green space and loneliness, and indoor environments and behavioral challenges (Astell-Burt et al., 2022; Cox et al., 2017; Mueller-Schotte et al., 2022). Both the *land* and *meteorological* categories also showed areas of growing research activity related to the *social & behavioral* category, namely the possible exposure to green space as an alternative treatment for substance use disorder and the mental well-being of indigenous communities within a changing climate (Berry et al., 2021; Middleton et al., 2020).

Although current research has been limited, there is increasing evidence on the associations between schizophrenia and multiple environmental factors, including air and water pollution, climate, and urbanicity, suggesting that additional research efforts at the intersections of *reality connection* and *chemical hazards*, *built environment*, *air*, *water*, and *meteorological* could be beneficial to fully elucidate the risks of environmental and possibly occupational exposures for these types of disorders and conditions (Boydell, 2001; Song et al., 2023; van Os et al., 2010). One review found evidence that multiple components of air pollution were associated with an elevated risk of schizophrenia; however, their review only included 17 articles, mostly from Asia, so additional research would be beneficial to corroborate and expand upon their findings (Song et al., 2023).

In intersections with no documents at all, we were unable to assess subject area potential. However, it could be useful to explore if any other known mechanisms or associations suggest that these could be areas for further

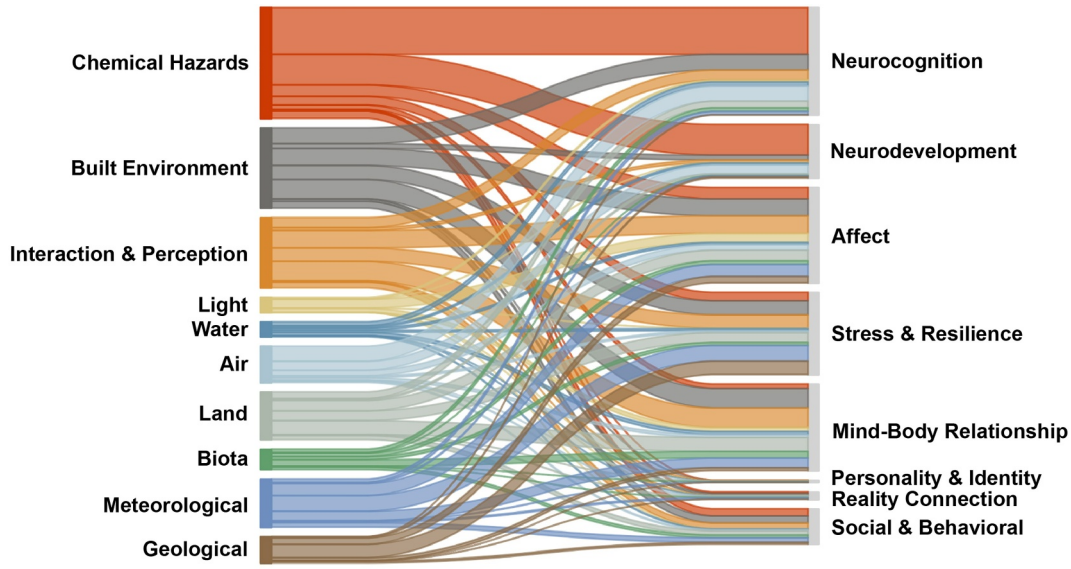

Figure 5. Sankey Diagram illustrating the interconnections and relative weights of review categorizations within the EnvironMental Health framework.

exploration. Notably, there were relatively few reviews that highlighted *reality connection* across any facet of the environment, and almost none that focused on *personality & identity*. No documents in the corpus specifically focused on topics of personality or identity, although some mentioned them secondary to other mental and cognitive health issues, such as dementias or schizophrenia. There may truly be no association between *personality & identity* and many environmental factors; however, some preliminary research could be useful to confirm this.

Whether or not research focused on the harms or benefits of the environment on mental and cognitive health, appeared highly dependent on its category on the environmental axis. The *chemical hazards*, *geological*, *meteorological*, and *air* categories all primarily explored detrimental impacts on mental and cognitive health, while the *land*, *light*, and *built environment* categories were more evenly distributed between harmful and beneficial effects. Conserving and restoring our environments has the potential to be a highly cost-effective method of stabilizing and improving the populations mental and cognitive health (Binagwaho et al., 2022; Trautmann et al., 2016; Vos et al., 2020), so it is important to develop a better balance of research that does not succumb heavily to negativity bias (Soroka et al., 2019) and explores the most effective public health and environmental management interventions to both heal and prophylactically prevent mental illness and cognitive disorders (Alegría et al., 2022).

To assess the growth of the field during the past year of the development of this study, we performed a duplicate literature search in March 2024, which resulted in 10,913 total documents. Assuming the same percentage of documents would be accepted in the final corpus, this would equate to an additional 134 review documents (22% increase) published in the past 14 months, further demonstrating the timeliness and need of this study.

4.2. Populations, Geographies, and Environmental Justice

About 40% of included reviews focused on one or more specific populations. The most discussed populations were *children & adolescents* (24.0% of corpus), followed by *in-utero (unborn)* (9.0%), *older adults (65+)* (4.0%), and *outdoor workers* (3.5%). The vast majority of these were identified at the intersections of *chemical hazards* or *built environment* with *neurological* health. A total of 26.8% and 63.6% of reviews at the *chemical hazards/neurocognition* and *chemical hazards/neurodevelopment* intersections respectively focused on *children & adolescents*, and 11.9% and 31.8% on *in-utero (unborn)*, both largely relating to the influence of chemicals on the development of autism and attention disorders. On the other end of the age spectrum, 17.5% of reviews at the *built environment/neurocognition intersection* focused on *older adults (65+)*, mostly highlighting green space and

indoor building-related factors and their relationships with dementias (Mueller-Schotte et al., 2022; Sun & Fleming, 2018; Zagnoli et al., 2022).

Of the 597 included reviews, only 138 could be clearly assigned to distinct geographic areas. Many of these assigned reviews fell into the *geological* and *meteorological* categories, as almost all of those reviews focus on location-specific events (Beaglehole et al., 2018; Murakami et al., 2018). Of the reviews that specified a geography, 30% were focused on Europe, 25% on North America, and 30% on Asia, while only 8% were focused on South and Central America, 5% on Oceania, and only 1% (2 reviews) on Africa. This indicates a significant need for more research focused on populations in the Global South, where health impacts of climate change are expected to be experienced most drastically (Jang et al., 2021; Kjellstrom & Weaver, 2009). We note that a review without a specified geography of focus does not necessarily have an equitable global framing. While some reviews took an intentional global lens, many of the geographically non-specific reviews in the corpus defaulted or were biased toward countries in the Global North. Because most reviews in our corpus were published in the Global North and per the inclusion criteria, all were in English, our corpus is very likely skewed toward reviews both intentionally and unintentionally focused on these areas. Considering the major discrepancies between research available in our corpus, we strongly recommend that future research efforts focused on communities in the Global South. Understanding the limitations of a review of reviews in accurately reflecting the underlying primary literature, we firmly believe that only an inclusive approach, with the consideration of more general populations and the global south, will unlock the full potential of understanding environmental health.

Only 52 out of 597 reviews (8.7%) contained a specific mention of environmental justice (EJ) or its underlying related principles (Lane et al., 2023). While a limited number of these reviews concentrated on EJ, many only make brief mentions of socioeconomic disparities or equity in the context of mental and cognitive health despite the context of this study being highly relevant (Cox et al., 2017; Malecki et al., 2022; Wormley et al., 2004). Only six reviews (1.0%) centered on indigenous populations and only five (0.8%) specifically highlighted a racial or ethnic minority. It is therefore imperative to expand future research on the environment and mental and cognitive health to make EJ a focal point and actively include marginalized populations in research design, implementation, and follow-up, especially when considering the extent to which EJ concerns have been documented in relation to physical health and the vitality of ensuring equitable environmental well-being within communities and globally, and in the larger context of a changing climate (Johnston & Cushing, 2020; Tariqi & Naughton, 2021).

5. Conclusions

Through the development of the conceptual framework and this scoping review of review papers, we have opened an avenue to a structure with which to understand the impact of the environment on mental and cognitive health and amassed the existing evidence within the framework. We aimed to coalesce the vast amounts of disparate research connecting environmental influences with mental and cognitive health outcomes to organize the field and provide a clearer direction for future research. The significant overlaps between both environmental and mental health categories, warrant for a deeper study of these interactions and open many doors for further discussions.

The persistent silos of academic research among many disciplines can hinder the understanding of such complex fields and the development of holistic, multidisciplinary solutions. Our study demonstrates a vast, multifaceted, and burgeoning field of research at the intersection of the environment and mental and cognitive health, which necessitates increased attention and funding. There is a clear and urgent need for more strategic action to protect against mental and cognitive illness, as well as a concerted effort to promote environmental sustainability and climate change mitigation. Leveraging the co-benefits between the environment and mental and cognitive health can be a powerful way to accomplish both goals. The potential of the environment to modulate mental and cognitive health remains an exciting frontier open for exploration. A thorough, comprehensive, and holistic understanding of environmental health is not only an efficient approach to decrease the prevalence and costs of mental and cognitive health conditions worldwide, but it also represents a planetary solution to advance necessary behavioral and societal change (UNEP, 2019). Bridging communication across scientific disciplines like psychology, public health, environmental science, chemistry, and engineering offers an extremely powerful path to move toward a healthy, sustainable future.

Conflict of Interest

The authors declare no conflicts of interest relevant to this study.

Data Availability Statement

The authors declare that the data supporting the findings of this study is available within the paper and its supplementary information files. All literature classified in the framework and included in this study for this submission (following PRISMA guidelines), as well as the code for data cleaning and analysis associated with it is available at https://doi.org/10.17605/OSF.IO/EDJR7 (Nguyen, 2024).

Acknowledgments
The authors would like to express their gratitude towards the Yale University Library System for support on literature retrieval. We gratefully acknowledge support from Yale School of the Environment's—FES Sustainability Strategy Fund.

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