



OPEN Detecting climate anxiety in therapy through natural language processing

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A well-documented consequence of global warming is increased psychological distress and climate anxiety, but data gaps limit action. While climate anxiety garners attention, its expression in therapy remains unexplored. Natural language processing (NLP) models can identify climate discussions in therapy, aiding therapists and informing training. This study analyzed 32,542 therapy sessions provided by 849 therapists to 7,916 clients in U.S. behavioral health programs between July 2020 and December 2022, yielding 1,722,273 labeled therapist-client micro-dialogues. Climate- and weather-related topics constituted a mere 0.3% of the sessions. Clients exhibiting higher levels of depressive or anxiety symptoms were less likely to discuss weather and climate compared to those with mild or no symptoms. Findings suggest that although global warming is known to impact mental health, these issues are not yet adequately addressed in psychotherapy. This study suggests a potential gap between the documented mental health concerns associated with climate change and their representation in psychotherapy. NLP models can provide valuable feedback to therapists and assist in identifying key moments and conversational topics to inform training and improve the effectiveness of therapy sessions.

Keywords Climate-aware therapy, Climate change, Eco-anxiety, Machine learning, Real-world evidence, Psychotherapy

Climate change is an immediate and growing global hazard. In addition to the threat to rising sea levels, ecosystem collapse, and more frequent and severe weather events, a wide range of mental health consequences has been linked with global warming and the climate crisis^{1,2}. A recent meta-analysis found that although the effect sizes varied greatly between studies and not all were statistically significant, exposure to climate events, pollution, and fewer green spaces was related to an increased prevalence of post-traumatic stress disorder, depression, and anxiety symptoms as well as higher risk of suicide and autistic spectrum disorders (the latter following prenatal exposure)³. Negative psychological experiences such as fear, anger, despair, and grief have been linked to climate-related events, and these consequently lead to long-term increases in psychological discomfort, hospitalizations, and suicide rates⁴. Additionally, a recent global survey discovered that over 45% of young people claim that their daily functioning is hampered by emotions associated with the climate crisis⁵.

As the effects of climate change worsen, there have been growing concerns about climate anxiety, also known as eco-anxiety or climate distress^{6–8}. Climate anxiety is defined as the anxiety stemming from the global climate crisis and the looming threat of environmental disaster⁹. The term “ecological grief” was also proposed to describe the sadness created by the realization of the anticipated or actual loss of ecosystems, landscapes, species, and ways of life^{10,11}. The early research in this area has focused on how to handle acute trauma associated with climate-related disasters like the aftermath of Hurricane Katrina and forewarns of the growth in chronic stress associated with climate change leading to a range of disorders¹². More recent studies have examined the negative impacts of climate change on psychological well-being, physical and mental health, and social relationships at large^{4,13–15}. In a 2021 study, 54.7% of respondents reported experiencing eco-anxiety “some of the time” and 11.1% experienced it often or always¹⁶. Nevertheless, there exists variation in how climate anxiety is perceived and defined in the literature, ranging from a rational reaction to an existential threat to a psychological disorder^{17,18}.

In recent years, professional organizations within the fields of psychology and behavioral health have recognized the importance of addressing the impact of climate change on their members and the populations they serve. Notable organizations such as the American Psychological Association, Society for Behavioral Medicine, and Academy for Eating Disorders are among the organizations that have established task forces and webinar

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series aimed at raising awareness and educating professionals on the effects of global warming^{19–23}. Scholars also proposed that health providers should take an active role in advocating for climate-aware policies and educating therapists and clients on the potential consequences of global warming on their mental health^{7,12,24}. The literature suggests that environmental difficulties were likely to be expressed more in treatment²⁵, and more than 70% of therapists surveyed in a study believed that climate change was relevant to their work, but half felt they had not received sufficient training on how to address relevant issues in therapy^{26,27}.

While these efforts demonstrate a growing recognition of the intersection between climate change and mental health, the extent to which climate-related distress is explicitly discussed in psychotherapy sessions remains largely unexplored. Despite the claims and initiatives made by professional organizations, there is a lack of empirical data on the actual prevalence and discussion of climate anxiety in therapy. In one qualitative study, 10 Swedish adults, recruited from climate or environmentally-related social media groups and who were living in a large urban area, were interviewed about their climate distress experience. Some participants of the 10 interviewed (the researchers did not indicate how many) mentioned climate anxiety as the primary driving factor for seeking psychotherapy, while others stated this was one reason for therapy, which they had perceived as exacerbating other concerns²⁸. In another qualitative study, 8 Australian therapists (practicing in urban, suburban, and rural areas) who had expressed concerns about climate change indicated that some of their clients had raised the climate crisis in their therapy sessions²⁹. Recent reviews and case reports suggest a number of interventions for eco-anxiety and climate anxiety^{30–32}. Taken together, these studies highlight the need for data-driven, professional guidelines on how clients discuss these issues in psychotherapy and how to best support those experiencing climate anxiety.

The present study aimed to bridge the gap between the growing concern over climate anxiety in the general public and the paucity of data on whether related concerns are raised and/or addressed in therapy sessions. Specifically, we investigated the frequency and extent of climate discussions in real-world therapy sessions, utilizing a large, geographically diverse dataset of treatments conducted in the U.S. We hypothesized that climate discussions will constitute less than 5% of the topics discussed. However, we also expected that the extent to which climate is mentioned would increase over time, as greater awareness of global warming has been documented.

Methods

Dataset description

This dataset comprised therapy sessions delivered by mental health providers (e.g., psychologists, social workers, and counselors) in behavioral therapy programs across the U.S. with the support of the Eleos Health AI platform described below. Use of the program required receiving client and provider informed consent prior to using the system. Ethics approval to analyze and report deidentified data was obtained by the Sterling Institutional Review Board (protocol #9545), and all research was performed in accordance with relevant guidelines and regulations. The dataset comprised treatment sessions provided from July 1, 2020 to December 31, 2022. The dataset includes 32,542 sessions delivered by 849 therapists to 7,916 clients in 23 behavioral health programs located in the following 12 states: Arizona, California, Colorado, Florida, Georgia, Illinois, Massachusetts, Maryland, Missouri, New York, Ohio, and Pennsylvania. Average session length was 58 min. The dataset also included depression (Patient Health Questionnaire [PHQ-9])³³ and anxiety (Generalized Anxiety Disorder-7 [GAD-7])³⁴ responses collected from clients every other week as well as the session's progress note. Figure 1 illustrates the study's design.

The eleos health platform

All 32,542 therapy sessions were delivered by mental health providers with the support of the Eleos Health artificial intelligence (AI) platform. The Eleos Health platform is a secure and HIPAA-compliant tool designed specifically for behavioral health³⁵. Therapists delivered the sessions using the platform, which captures and analyzes the therapist and patient's utterances during the treatment session. The platform includes an AI-based clinical decision-making support system and automates administrative tasks. The measurement-based care (MBC) component of the platform uses standardized assessment scales completed by clients to summarize and graph data immediately for the therapist's use during therapy and for sharing with the patient. The session data and MBC insights are also used to generate a progress note draft for the therapist, which can be edited and submitted as needed. In most organizations, the platform was integrated with the electronic health record (EHR) which allowed a seamless submission of the progress note into the client's digital record³⁶. This study was conducted in concert with the STROBE Checklist³⁷.

Data Processing

The sessions were transcribed using an automatic speech recognition system (ASR), provided by Amazon Web Services and further trained by a team of clinicians, as detailed in a previous publication³⁵. On a session level, our ASR system achieved a 98% accuracy in distinguishing between speakers during therapy sessions. Amazon reports that their Word Error Rate (WER), a common metric used to evaluate the accuracy of speech recognition systems, is 11.2%³⁸.

We employed a custom machine learning (ML) model for speaker diarization to distinguish between clinician and client utterances within each therapy session, as detailed in previous work³⁵. Given the unstructured nature of session transcripts, we developed a treatment-specific diarization model tailored to therapy sessions. To build this model, a team of trained graduate-level clinicians annotated 2,500 therapy sessions, manually labeling each speaker as either 'client' or 'therapist.' This labeled dataset was then used to train the diarization model, which analyzes the full transcribed session and assigns speaker labels accordingly. For the classification algorithm, we used logistic regression with binary cross-entropy loss, optimizing the model through stochastic gradient

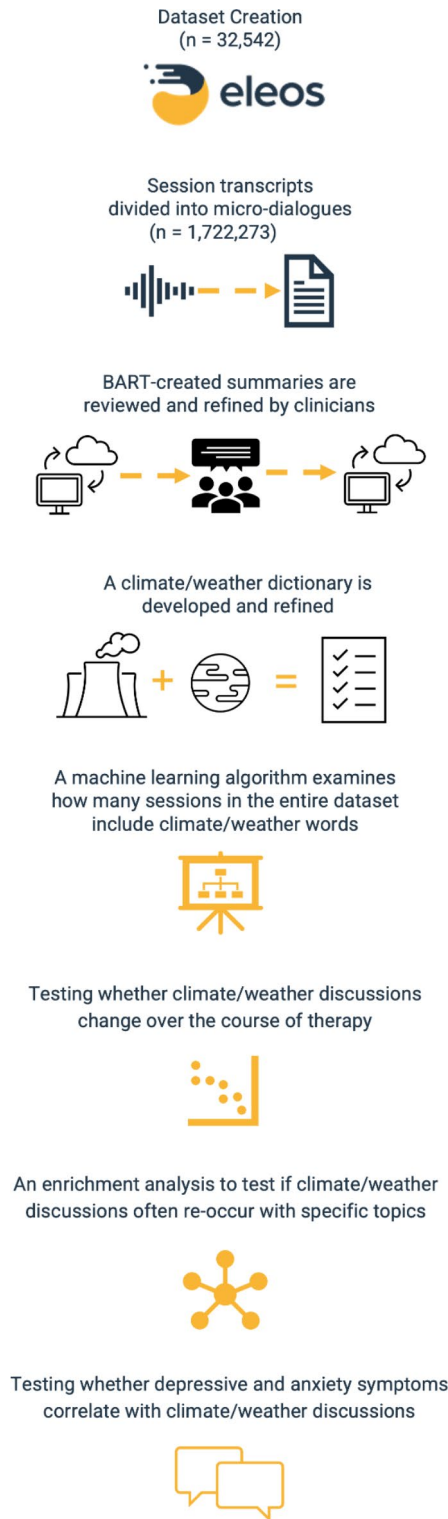


Fig. 1. Summary of the study method.

descent. Our in-house solution achieved 98% accuracy in differentiating between speakers in therapy sessions, demonstrating high reliability for this task³⁵.

Next, each session’s transcription was divided into smaller, meaningful parts of the conversation, referred to as “micro-dialogues”. Every micro-dialogue included both therapist and client utterances, typically comprising about 300 words, and focused on a specific topic, e.g. depression, marital relationship, substance use relapse prevention, or boundary setting³⁹. Each micro-dialogue was treated as a distinct unit and analyzed using natural

language processing techniques to extract relevant information and insights. The dataset used in this study included 1,722,273 micro-dialogues.

To extract the primary discussion topics from each micro-dialogue, we employed a BART (Bidirectional and Auto-Regressive Transformers) model⁴⁰. A team of clinicians then reviewed the micro-dialogues from 1,500 behavioral health treatment session recordings and their summaries, and refined the summaries for each micro-dialogue. Using these expert-generated summaries, the BART model was fine-tuned to summarize the key discussion points in micro-dialogues accurately. Following this training, the model demonstrated the ability to generate concise and coherent summaries that effectively captured the core elements of the conversations. To validate the accuracy of these AI-generated summaries, we conducted a review involving eight therapists with advanced training in clinical psychology or social work. These clinicians evaluated 1,144 summaries, rating them as highly coherent (85.0%), clinically relevant (89.2%), and comprehensive (78.4%)⁴¹. This method is consistent with previously published research on testing ambient AI models in community-based behavioral health clinics^{39,42}.

Classifying climate- and weather-related terms

To accurately detect micro-dialogues related to climate and weather, we started by creating a broad dictionary of words that may be associated with these topics. We used our proprietary word2vec model⁴¹, which was trained on Eleos' in-house data, to expand the dictionary. The dataset used for training consisted of 17,607 de-identified behavioral treatment sessions conducted by 322 therapists and delivered to 3,519 patients across 37 behavioral health care programs in the United States³⁵. These sessions included a wide variety of therapeutic modalities and clinical presentations, ensuring broad applicability of the model to real-world therapy contexts and conversations one may have with their therapist. Along with session transcripts, the dataset also incorporated associated progress notes from clients' EHR. All personal health information was fully de-identified to protect client confidentiality, in accordance with HIPAA guidelines. The inclusion of both session dialogues and clinical notes allowed the model to capture a rich semantic understanding of clinical conversations, which was crucial for expanding the dictionary to include terms relevant to weather, climate, and related emotional discussions⁴³. This dataset represents a diverse range of behavioral health conditions and interventions, contributing to the robustness of the word2vec model. The model was trained using the Continuous Bag of Words architecture, where a five-word window was used to predict the central word. The vocabulary was expanded by querying the top 10 semantically related words to each item in our base dictionary, using cosine similarity to measure closeness between word vectors. For instance, the term 'climate' expanded to include related terms such as 'environment', 'global warming', and 'greenhouse gasses'. The expanded dictionary was further refined by clinical experts to ensure relevance. We chose a permissive approach to weather and climate discussions to create a larger dataset that would allow us to later discard non-related sentences. This dictionary included 425 terms (detailed in Fig. 2).

Next, We fine-tuned the pre-trained BART model, originally designed for text summarization, to function as a sequence classifier using the Transformers library. To accomplish this, we added a linear classification layer on top of the model's pooled output, allowing it to map encoded representations of dialogues to class probabilities⁴². A preliminary review of the micro-dialogues indicated that weather-related terms were often used either as part of mindfulness exercises (e.g., "Imagine placing each thought on a cloud and letting it float away") or metaphorically to describe emotions (e.g., "I felt flooded with anger"). To train the classification model, two therapists annotated 534 micro-dialogues, labeling whether each dialogue contained climate/weather-related content. The inter-rater reliability for this annotation task, measured using Cohen's Kappa, was 0.77, indicating substantial agreement. The fine-tuning process involved supervised learning using these therapist-labeled dialogues. The model was optimized using binary cross-entropy loss and stochastic gradient descent⁴⁴. The

'abaddon', 'abnormality', 'acacia', 'acclimate', 'acidic', 'acids', 'acreage', 'activism', 'activists', 'aerosol', 'aerosols', 'aerospace', 'africa', 'aftermarket', 'agencies', 'agitation', 'agonies', 'agoraphobia', 'agricultural', 'agriculture', 'aircraft', 'albacore', 'alcoa', 'alertness', 'aloe', 'alternated', 'america', 'amino', 'ammonia', 'anarchism', 'anarchist', 'annexed', 'antioxidants', 'arctic', 'arctic biofuels', 'argon', 'arid', 'arkansas', 'armie', 'ashland', 'ashore', 'asphalt', 'aspirated', 'aspirating', 'aspiration', 'asteroid', 'atlantean', 'atlassian', 'atmosphere', 'atmospheric', 'auckland', 'audie', 'aura', 'austerity', 'authoritarian', 'automotive', 'barn', 'beach', 'bin', 'bins', 'biocompatible', 'biogen', 'biomass', 'biomedical', 'biotech', 'blacktop', 'blistering', 'blizzard', 'blizzards', 'blooms', 'botanicals', 'brackish', 'breathable', 'breeze', 'breezy', 'brightly', 'brightness', 'carbohydrate', 'carbohydrates', 'carbon', 'carbon dioxide', 'chilli', 'chilly', 'climactic', 'climate', 'climate change', 'climates', 'climatic', 'cloudiness', 'clouds', 'cloudy', 'co2', 'coastal', 'cold', 'colder', 'colds', 'colonization', 'compost', 'composting', 'compounds', 'concentrations', 'conservation', 'conserve', 'conserving', 'consortium', 'consumes', 'consuming', 'consequences', 'coolant', 'cooling', 'cools', 'cop', 'cove', 'daffodils', 'dampness', 'darken', 'deers', 'democratic', 'dendrites', 'deniers', 'desert', 'detoxify', 'diesel', 'diffusers', 'dim', 'dioxide', 'disasters', 'disinfecting', 'disparities', 'dolphin', 'dolphins', 'doom scroll', 'downpour', 'dragonflies', 'drainage', 'dried', 'drier', 'dries', 'drip', 'drips', 'drought', 'dunes', 'earthquake', 'earthquakes', 'ecological', 'ecology', 'ecosystem', 'electric', 'electrical', 'electricity', 'electro', 'elements', 'emission', 'emissions', 'engines', 'environment', 'environmental', 'environments', 'epa', 'equator', 'erosion', 'ethylene', 'evacuated', 'everglades', 'exhalation', 'exploitation', 'extreme', 'extremes', 'factories', 'farms', 'fertilize', 'fertilizer', 'fire', 'firefighters', 'firehouse', 'fires', 'flame', 'flames', 'flashes', 'flax', 'flood', 'flooded', 'flooding', 'floods', 'flouting', 'flowering', 'flux', 'forecast', 'forest', 'forests', 'forrestal', 'fossil', 'fossil fuels', 'freezing', 'freshwater', 'froze', 'frozen', 'fuel', 'fueled', 'fueling', 'fuels', 'gases', 'gasoline', 'geological', 'ghg', 'glacier', 'global', 'global south', 'global warming', 'green new deal', 'greenery', 'greenhouse', 'greenhouse earth', 'greenhouse gas', 'greens', 'greenwashing', 'groundwater', 'gulf', 'hail', 'hailstorm', 'haitian', 'harvest', 'heat', 'heater', 'heaters', 'heats', 'heatwave', 'heightens', 'hot', 'hotter', 'humid', 'humidifier', 'humidity', 'hurricane', 'hurricanes', 'hydrant', 'hydraulics', 'hydrocodone', 'hydrogen', 'icy', 'industrial', 'inhalation', 'landslides', 'lightning', 'marin', 'meteorology', 'methane', 'microcosms', 'microgreens', 'mitigation', 'moisture', 'monsoon', 'monsoons', 'moss', 'n2o', 'nitrogen', 'nitrous oxide', 'northern', 'nuclear', 'ocean', 'oceans', 'organics', 'overflowing', 'oxygen', 'ozone', 'pandemic', 'petroleum', 'plant', 'planted', 'planter', 'planters', 'planting', 'plants', 'polar', 'pollution', 'populating', 'ppm', 'precipitation', 'rain', 'rained', 'raines', 'rainfall', 'rainier', 'raining', 'rains', 'rainstorm', 'rainwater', 'rainy', 'recyclables', 'recycle', 'recycled', 'recycling', 'redwoods', 'regional', 'reinstill', 'renewable', 'renewable energy', 'renewal', 'reservoirs', 'reusable', 'reuse', 'rippled', 'ripples', 'river', 'rivers', 'scenery', 'sea', 'seabirds', 'seasonal', 'seasonally', 'sediment', 'snow', 'snowed', 'snowing', 'snows', 'snowstorm', 'snowstorms', 'snovy', 'soil', 'soils', 'solar', 'southern', 'sphere', 'storm', 'storming', 'storms', 'stormy', 'stratosphere', 'submerged', 'succulent', 'succulents', 'summerland', 'sump', 'sun', 'sunflower', 'sunlight', 'sunny', 'sunshine', 'sustainability', 'sustains', 'swarm', 'tempe', 'temperature', 'temperatures', 'tempter', 'thaw', 'thaws', 'thermal', 'thermometer', 'thermostat', 'thrives', 'thunder', 'thundering', 'thundershower', 'thunderstorm', 'thunderstorms', 'tidal', 'tornado', 'tomatoes', 'transmission', 'tree', 'trees', 'tropical', 'troposphere', 'trumpets', 'tsunami', 'turbo', 'turtles', 'undercurrent', 'underwater', 'unfccc', 'uninhabitable', 'vapor', 'vegetation', 'vegetative', 'ventral', 'vents', 'viruses', 'volcano', 'volcanoes', 'warm', 'warmer', 'warming', 'waste', 'wasted', 'wasteful', 'wastes', 'wasting', 'waterfall', 'waterfalls', 'waterproof', 'waterproofing', 'waves', 'weather', 'weather emission', 'western', 'wetlands', 'wetsuits', 'wetter', 'white washed', 'white water', 'wildfire', 'wildfires', 'wind', 'winding', 'windmills', 'winds', 'windy', 'winter', 'winters', 'wintertime', 'woods', 'woody', 'Summer', 'Spring', 'Water', 'Dry', 'Season', 'Autumn', 'Spring', 'cyclone', 'Ice', 'Energy', 'Summertime', 'Raindrops'

Fig. 2. Weather and climate-related words.

classification model demonstrated solid performance on the test set, achieving precision, recall, and an F1 score of 0.84, effectively distinguishing weather-related terms used in literal versus metaphorical contexts.

To classify the 1,722,273 micro-dialogues, we first used the broad dictionary to filter out micro-dialogues where clients did not mention climate/weather at all. This procedure ruled out about 90% of the sessions' content. We then ran the transformer-based model on the remaining micro-dialogues to create a dataset consisting only of session segments with climate/weather discussions. We did not include micro-dialogues from the first and last 5 min of the session to minimize the chance that the weather was mentioned as part of a small talk.

Data analysis plan

In order to contextualize the frequency of discussions on various topics in therapy, we calculated the percentages for the top 5 most frequently discussed topics overall. To gain insights into the temporal dynamics of these topics, we also examined the proportion of therapy sessions that incorporated the 5 most discussed topics for each quarter spanning from Q3 2020 to Q4 2022. These analyses were carried out on a random sample of 3,246 therapy sessions from all behavioral programs in our dataset, comprising 10% of the overall sample. Next, to determine how frequently climate/weather was mentioned by clients during psychotherapy, we computed the proportion of therapy sessions and progress notes that included climate/weather topics for each quarter between Q3 2020 and Q4 2022 both across the U.S. and in different regions of the country. These analyses were conducted on the entire dataset, i.e. 32,542 therapy sessions. To further understand the content of the sessions, we distinguished between micro-dialogues discussing climate change explicitly and those addressing the weather. Additionally, to identify any increase in the mention of weather and climate topics in therapy sessions over time, we analyzed the frequency of these terms as treatment advanced, from session 1 to session 20. We also conducted an enrichment analysis to identify discussion topics that were over-represented among clients who engaged in conversations about weather or climate issues, compared to those who did not mention these topics. This analysis allowed us to determine which specific topics were disproportionately discussed by clients concerned with climate-related issues. The visual representation of each topic in the analysis is a function of its frequency, with larger dots indicating higher frequency of discussion⁴⁵. This approach provides insights into the thematic connections between climate-related discussions and other therapeutic topics, thereby highlighting potential areas of focus for therapists working with clients experiencing climate anxiety. Finally, to examine the prevalence of climate/weather discussions among specific client groups, we used independent samples t-tests to compare the frequency of mentioning climate or weather in therapy between clients with moderate, moderate-severe, or severe baseline depression and anxiety and those with mild or no symptoms. This analysis included the entire sample, comparing clients who mentioned climate/weather terms to those who did not, to understand the differences in discussion patterns based on symptom severity.

Results

The percentage of weather/climate discussions over time

Of the 32,542 sessions and the 1,722,273 micro-dialogues provided with the support of the Eleos Health platform from July 1, 2020 to December 31, 2022, climate/weather discussions constituted 0.32–0.7% of the micro-dialogues across the U.S. (see Fig. 3). Overall, weather/climate were mentioned by clients at least once in 5,414 sessions (16.6%). Micro-dialogues directly related to climate change or global warming were mentioned in 110 sessions (0.3%). Additionally, analysis of the deidentified progress notes found that weather/climate appeared in less than 0.1% of overall session summary content. Therapists mentioned weather/climate in 0.25% of all micro-dialogues (range: 0.19–0.38%). Findings of all rates of climate/anxiety discussions in each time point and each region of the U.S. appears in (Table 1).

Further, an analysis of the prevalent themes that occupy the discussions within therapy sessions found that the 5 most discussed topics were the treatment (9.75% of all themes discussed), interpersonal relationships (7.45%), family dynamics (6.95%), coping skills (6.72%), and alcohol (5.61%). Figure 4 illustrates the distribution of the 5 most frequently discussed topics across therapy sessions for each quarter, encompassing the time period from Q3 2020 to Q4 2022.

Climate/weather micro-dialogues change as therapy progresses

The analysis found that weather/climate were discussed more frequently as therapy progressed, from session 1 to session 20. However, these topics were raised in less than 1% of micro-dialogues. Figure 5 illustrates climate/weather discussions over time.

Enrichment analysis

Enrichment analysis to examine the topics discussed by clients during therapy sessions (see Fig. 6) revealed that when clients engaged in discussions about climate/weather, they tended to focus on a variety of psychological domains such as self-care, stress management, hygiene, interpersonal skills, driving, leisure, and holiday celebrations. Among the clients who did discuss the weather/climate, the top topics were self-care (17.04%, e.g. "There will be nicer weather this weekend and I'll be able to go for a walk"); interpersonal communication (14.04%, e.g. "it's been too cold [lately]... I'm finally ready to go outside. Today will be a perfect day to go out there. But there's too many people out and I'll have to socialize and I don't want to see people but they don't understand that."); therapy (11.65%, e.g. "I skipped last week's DBT group since it was raining cats and dogs and I didn't feel like getting outside"); stress (6.89%, e.g. "I guess once the sun comes out I will feel less anxious"); and leisure activities (5.46%, e.g. "We are planning our daughter's birthday party in the park this Sunday. It's going to be a nice weekend").

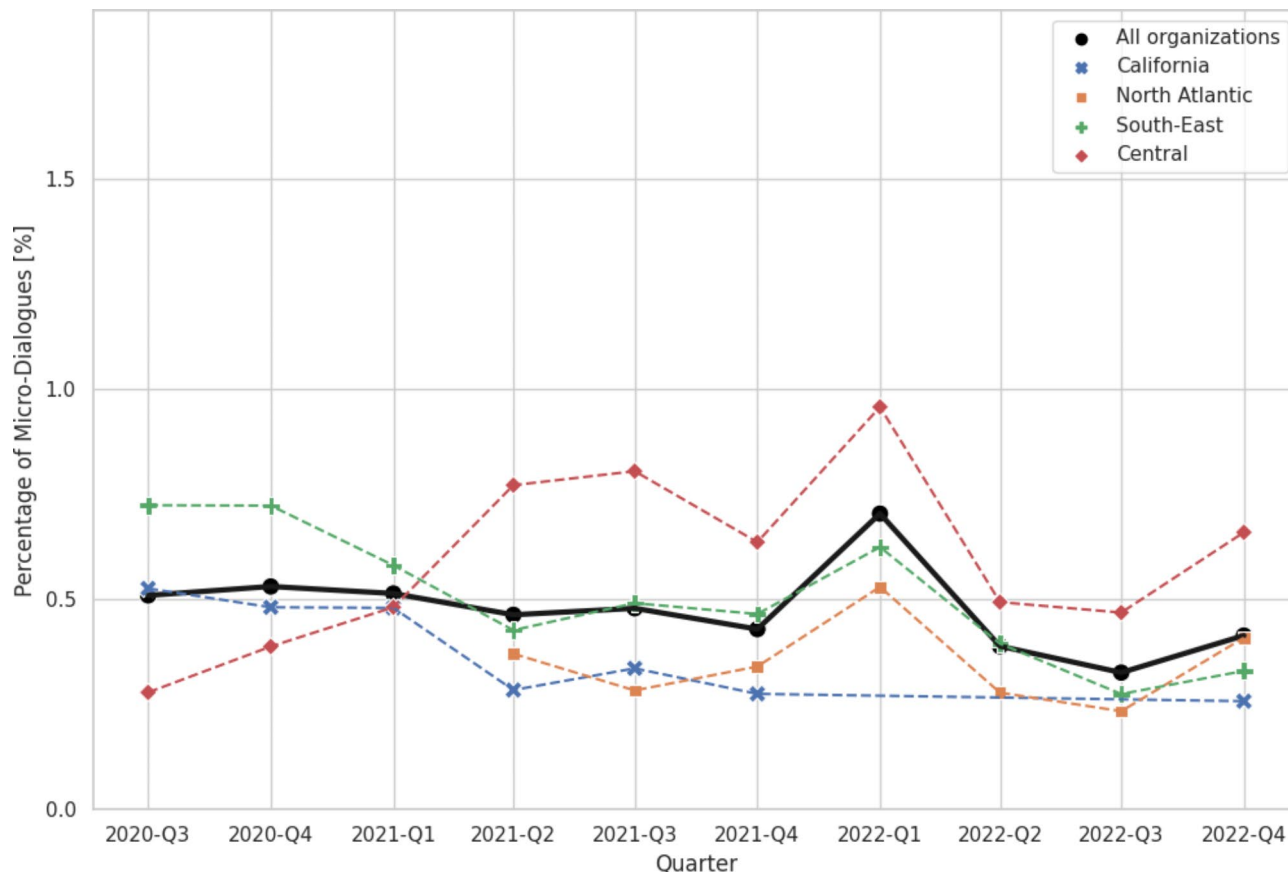


Fig. 3. Discussions of the weather or climate in therapy sessions across The U.S and In specific geographical regions (N = 32,542).

Quarter	All organizations	California	North Atlantic	South-East	Central
Q3_2020	0.51	0.52		0.72	0.28
Q4_2020	0.53	0.48		0.72	0.39
Q1_2021	0.51	0.48		0.58	0.48
Q2_2021	0.46	0.28	0.37	0.43	0.77
Q3_2021	0.48	0.33	0.28	0.49	0.80
Q3_2021	0.43	0.27	0.34	0.46	0.64
Q1_2022	0.70	-	0.53	0.62	0.96
Q2_2022	0.39	-	0.28	0.39	0.49
Q3_2022	0.32	-	0.23	0.27	0.47
Q3_2022	0.41	0.26	0.41	0.33	0.66
Overall	0.47	0.38	0.35	0.50	0.59

Table 1. Rates (%) of climate/anxiety discussions in therapy sessions across time points and U.S. regions.

Comparing client groups

Independent samples *t*-tests found that clients with greater depressive or anxiety symptoms mentioned the climate/weather significantly less than those with fewer symptoms: clients with moderate, moderate-severe, or severe self-reported depression or anxiety discussed this topic less than those with mild or no symptoms: 0.31% (SD = 0.63) versus 0.42% (SD = 0.73), $t = 4.43, p < .001$ for depression and 0.34% (SD = 0.70) versus 0.41% (SD = 0.70), $t = 2.47, p = .01$ for anxiety.

Discussion

The current study investigated the extent of climate discussions in real-world therapy sessions. This is the first study to analyze real-world data from therapy sessions to assess how the documented mental health concerns associated with global warming are represented and discussed in psychotherapy. The findings suggest that the

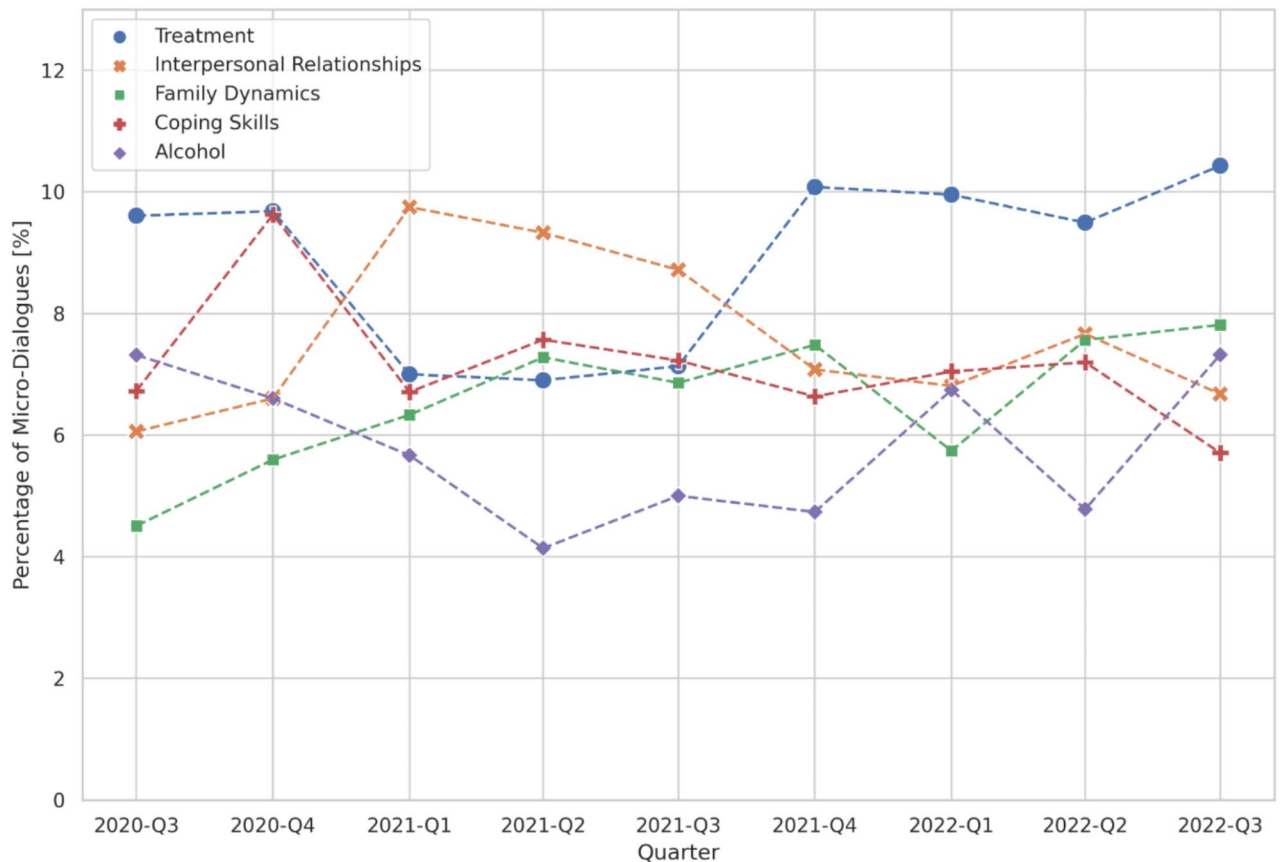


Fig. 4. Proportion of the top 5 discussed topics in therapy sessions by quarter: Q3 2020 to Q4 2022 ($N = 3,246$ sessions).

5 most discussed themes in the 32,542 therapy sessions analyzed in this study were mostly relational (i.e., the therapy the client was receiving, interpersonal relationships, and family dynamics) or related with coping skills and alcohol use. Climate discussions constituted a very small proportion of the topics brought up by clients during therapy sessions, and that when the climate or the weather were mentioned, it was in the context of self-care or leisure activities. Climate change or global warming were explicitly mentioned in only 0.3% of sessions. Despite previous claims in the mental health literature regarding the growing prominence of climate distress and eco-anxiety in therapy, this study reveals contrasting findings. While there was an observed increase in climate and weather discussions between July 2020 and December 2022, even doubling in certain U.S. regions during this period, these topics were mentioned in no more than 2% of all micro-dialogues. Further, in contrast to evidence that eco-anxiety is positively correlated with depression, anxiety, and stress⁴¹, this study found that clients who had *greater* depressive or anxiety symptoms discussed climate/weather significantly *less* than those with mild symptoms.

The dataset analyzed in this study of 32,542 treatment sessions of 7,916 clients in 23 behavioral health programs across 12 states could be somewhat representative of the broader population seeking mental healthcare. Therefore, the results indicating a scarcity of discussions of climate anxiety or eco-anxiety in therapy can be attributed to several factors. First, climate anxiety as a distinct entity is a relatively recent phenomenon and may not yet have been widely recognized by mental health professionals^{46,47}. The effects of climate change on mental health are complex and can manifest in various forms, such as depression, anxiety, and obsessive-compulsive disorder. Therefore, therapists may not specifically identify climate anxiety as a separate problem, but rather address its symptoms as part of a broader diagnosis. Second, it is also possible that climate anxiety is not frequently discussed in psychotherapy due to a lack of training and resources for therapists⁴⁸. Climate change can be a sensitive and complex topic, and therapists may not feel equipped to address it effectively. The effects of climate change are not necessarily conscious, but rather lead to difficulties in many life domains, such as respiratory issues, discomfort, and the cost of goods like gasoline. Global warming may be a contributing factor to mental health problems, but the anxiety clients express is not about the climate crisis⁴⁹. Moreover, the relationship between climate change and mental health is still an emerging field, and more research is needed to fully understand its implications and how best to address it in therapy settings. Third, it is important to consider the role of cultural and societal attitudes toward climate change in the under-representation of climate anxiety in psychotherapy. Climate change may not be perceived as a pressing mental health issue, and societal attitudes towards it may shape individuals' willingness to discuss it in therapy⁵⁰. Perhaps clients and therapists do not

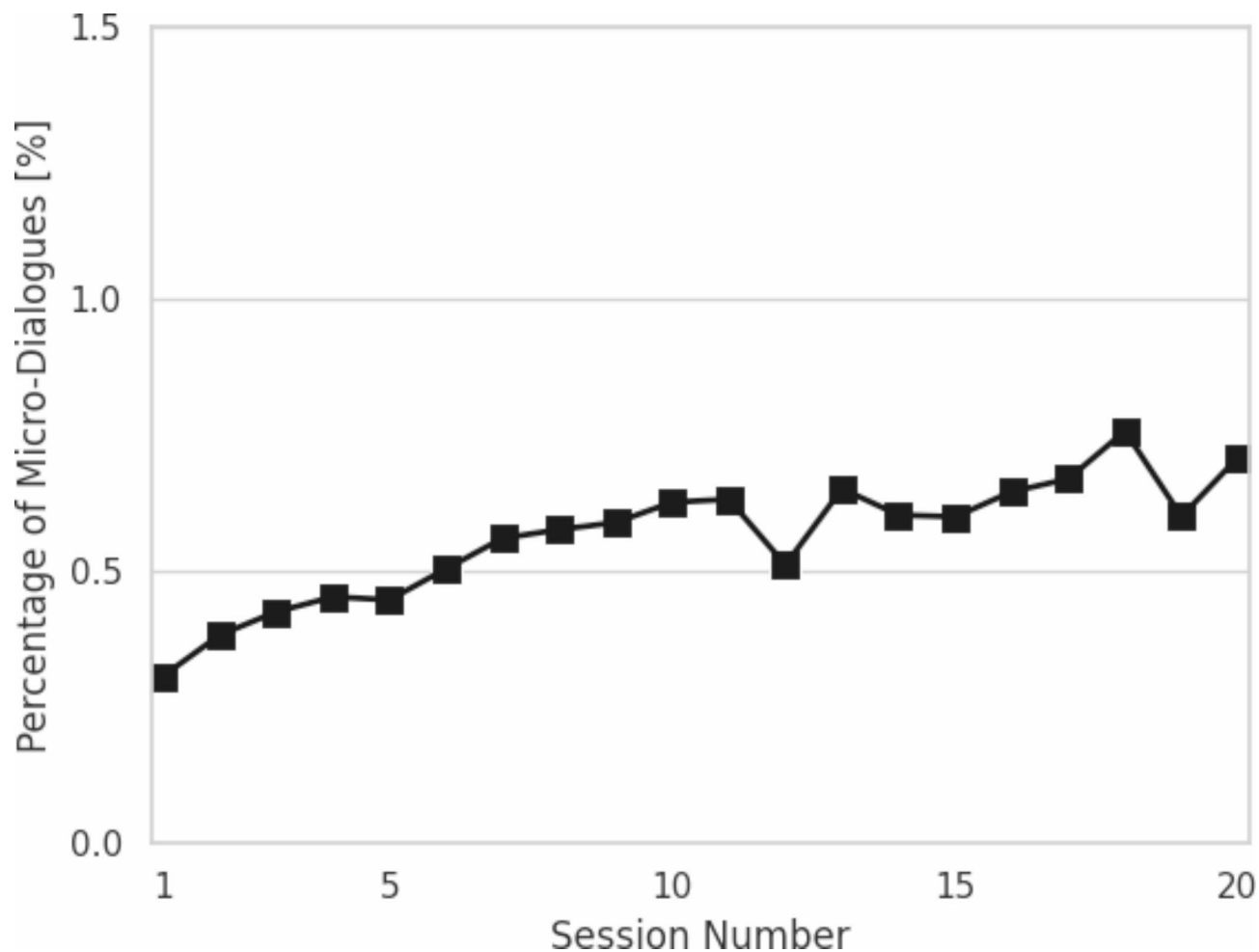


Fig. 5. Climate/weather discussions from session 1 to session 20.

perceive this issue as relevant for therapy, similarly to how gender roles and racism have not been discussed in therapy in the past^{51,52}. Fourth, another potential interpretation of this study's findings is that clients may not view their therapy sessions as a suitable platform to express their worries about the climate crisis. Instead, they may prioritize issues that are perceived as more pressing and more within their control. Notably, a majority of the therapy sessions in this study took place during the COVID-19 pandemic, which may have diverted clients' attention towards more immediate concerns. Fifth, the existing literature regarding the discussion and treatment of climate anxiety in mental health sessions primarily stems from studies involving a specific subset of individuals who have expressed explicit interest in and distress about the climate crisis. In contrast, the present study included a broader cohort of clients undergoing treatment in mental health programs for various concerns. Further, earlier studies have analyzed self-reports from either therapists or clients, while this study's utilization of innovative NLP techniques enables the collection of more objective data pertaining to therapy discussions³⁵. In light of these data, it could be inferred that eco-anxiety may not be as prevalent as previously hypothesized.

Therapy should find ways to make life less tough for people in a rapidly changing world. Findings of this study suggest that climate/weather discussions constituted a small percentage of topics discussed in therapy sessions across the U.S. in general as well as in specific geographical areas. Even if this is a rare occurrence, mental health providers should advocate for additional ways of understanding psychological distress and whether it is created by climate change⁵³. At the same time, if therapists want to play a role in mitigating the psychological impacts of climate anxiety, they have the responsibility and ethical commitment to rely on evidence and fact-check popular beliefs.

The study also highlights the potential of using technology in collecting and analyzing data from therapy sessions and connecting these with data from MBC measures to increase therapy relevance and efficacy. Harnessing the power of AI and NLP in therapy can aid in the identification and analysis of key themes and topics discussed in therapy sessions, including those related to mental health issues. This can provide valuable insights for therapists and other stakeholders into the mental health concerns of local communities and help them develop more targeted and effective interventions. Additionally, the use of technology in clinical practice can help overcome some of the limitations of traditional data collection methods, such as reliance on self-reported data, which can be biased or incomplete, especially when reviewed retrospectively in light of new theories or

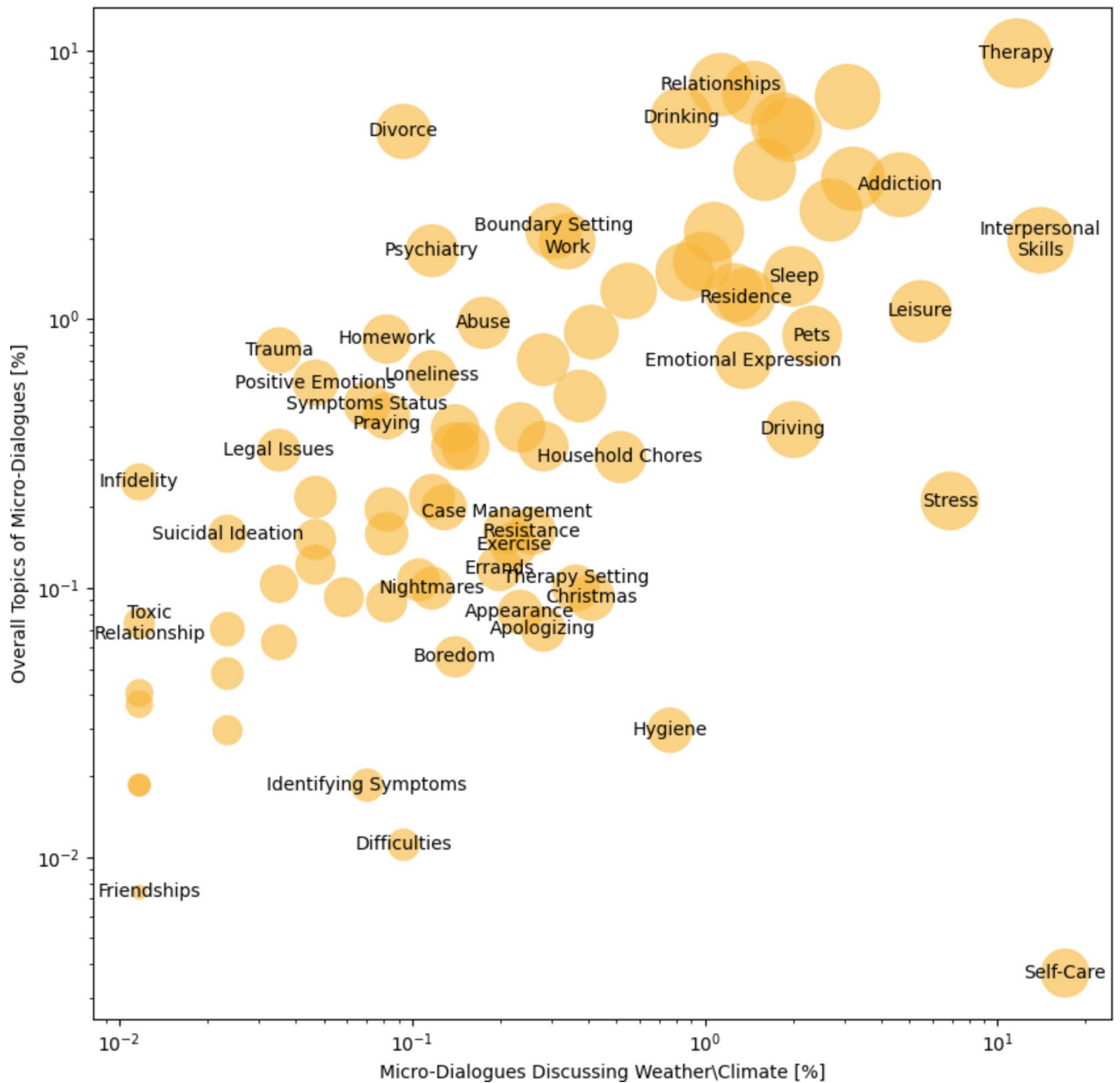


Fig. 6. Enrichment analysis of conversation topics discussed by clients when climate/weather were mentioned.

evidence⁵⁴. By providing more objective and comprehensive data, technology has the potential to enhance our understanding of the factors contributing to mental health issues and improve the quality of care provided to individuals experiencing mental anxiety. However, it is important to remember the ethical implications of using technology in therapy, including issues of privacy and data security, and ensure that appropriate consent and safeguards are in place to protect the rights and interests of individuals participating in therapy.

Limitations

Strengths of this study include a geographically diverse sample, data from the past few years, and access to the largest dataset of therapy sessions provided in real-world settings. Limitations include the absence of participants' demographic data and how social determinants of health may affect interest in and urgency of climate concerns. These limitations affect the generalizability of the data to the total population, as younger individuals and those with a higher risk of being affected by climate change, may be more concerned by it and possibly bring it up in therapy more frequently. Similarly, we did not explore whether the way therapists framed their discussions or their personal attributes, such as training, influenced the likelihood of climate or weather discussions, which may introduce bias into the results.

Of note, the data on the accuracy of the AI-generated summaries was not assessed for inter-rater agreement. Furthermore, the study made several assumptions in its methodology, such as using specific terms to capture

climate/weather discussions in therapy sessions. This assumes that participants consistently use identifiable, explicit language when discussing climate concerns, which may not always be the case. A broader list of climate-related terms could have potentially identified more micro-dialogues on the subject. Future research should address these limitations to provide a more comprehensive understanding of the role of climate anxiety in therapy, potentially expanding the dictionary of terms and considering therapist influences.

Conclusion

Therapists have the potential to contribute to climate awareness and foster a broader societal understanding of how global warming affects mental and physical health⁵⁵. However, the integration of climate-related discussions in therapy must be guided by empirical evidence⁵⁶. This study lays the foundation for future research and professional development concerning the intersection of climate change and mental health. While it is plausible that climate change issues will increasingly appear in therapy sessions as their impacts become more pronounced, our findings suggest that these topics are not yet prevalent in community mental health settings. It is important for the mental health field to be prepared to meet emerging needs without presupposing that climate anxiety is a primary concern for every client. We must remain responsive to our clients' needs, recognizing climate anxiety's existence while respecting each client's individual priorities and concerns.

Data availability

Data Availability Statement The dataset generated and analyzed during the current study is not publicly available due to privacy and confidentiality reasons.

Received: 10 February 2024; Accepted: 3 October 2024

Published online: 29 October 2024

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Author contributions

SSS, LB and SAR conceptualized the study and the methodology; LB conducted all data analyses and prepared Figs. 1, 2, 3 and 4; Table 1; SSS guided the labeling process of the therapist-client micro-dialogues; SSS drafted the main manuscript text which LB and SAR reviewed and provided feedback on. All authors reviewed and approved the final manuscript.

Declarations

Competing interests

LB and SSS are employees of Eleos Health whose artificial intelligence platform was used to generate the data analyzed in this study. SAR is an unpaid advisor of the company.

Additional information

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