Climate change, concern, and children: A systematic review exploring the intersection of climate change, mental health, and reproductive decision-making

Hope Dillarstone*, Laura J. Brown&, Elaine C. Flores

1 Institute for Global Health, University College London, London, United Kingdom
2 Centre on Climate Change and Planetary Health, London School of Hygiene and Tropical Medicine, London, United Kingdom
3 Stanford Centre on Innovation in Global Health, Stanford University, Stanford, USA

Short Title: A systematic review on climate change, mental health, and reproductive decisions

*Hope Dillarstone, MSc

Institute for Global Health, University College London, 30 Guildford Street, London, WC1N 1EH, United Kingdom

e-mail: hope.dillarstone.21@ucl.ac.uk

Word Count: 8701 (including figure titles, legends, and tables and excluding acknowledgements and references)

*These authors contributed equally to this work.
&These authors contributed equally to this work.

Keywords: Climate change, mental health, reproductive decision-making, systematic review
Abstract

The impact of climate change on reproductive decision-making is becoming a significant issue, with anecdotal evidence indicating a growing number of people factoring their concerns about climate change into their childbearing plans. Although empirical research has explored climate change and its relationship to mental health, as well as the motivations behind reproductive decision-making independently, a gap in the literature remains that bridges these topics at their nexus. This review endeavours to fill this gap by synthesising the available evidence connecting climate change-related concerns with reproductive decision-making and exploring the reasons and motivations behind this relationship.

A systematic review using six databases was conducted to identify relevant literature. Included published and unpublished studies reported quantitative, qualitative, and mixed-methods data related to: (1) climate change, (2) mental health and wellbeing concerns, and (3) reproductive decision-making. Findings were synthesised narratively using a parallel-results convergent synthesis design and the quality of studies was appraised using three validated assessment tools.

Four hundred and forty-six documents were screened using pre-defined inclusion criteria, resulting in the inclusion of thirteen studies. The studies were conducted between 2012 and 2022 primarily in Global North countries (e.g., USA, Canada, New Zealand, and European countries). Climate change concerns were typically associated with less positive attitudes towards reproduction and a desire and/or intent for fewer children or none at all. Four
themes explaining this relationship were identified: uncertainty about the future of an
unborn child, environmentalist views centred on overpopulation and overconsumption,
meeting family subsistence needs, and environmental and political sentiments.

The current evidence reveals a complex relationship between climate change concerns and
reproductive decision-making, grounded in ethical, environmental, livelihood, and political
considerations. Further research is required to better understand and address this issue with
an intercultural approach, particularly among many highly affected Global South populations,
to ensure comparability and generalisable results.

1. Introduction

Climate change is often regarded as “the biggest global health threat of the 21st century” [1]
due to the direct threat of rising average temperatures and climatic hazards,
paralleled with indirect effects including water and food insecurity and changes to disease
epidemiology. At the same time, tackling climate change is also posited as “the greatest
global health opportunity of this century” [2] [p.1861], as mitigation and adaptation
responses can reduce disease burdens, alleviate poverty, and confront global inequity.
Climate change is already having a ubiquitous impact on human health, with adverse effects
projected to increase even further, albeit with a degree of heterogeneity between countries
and populations [3]. A recent emergence of studies and policy are exploring the link between
climate change and mental health. This came to the fore with the coining of new concepts
such as ‘eco-anxiety’, fast becoming a buzzword in public discourse as it describes the
“chronic fear of environmental doom” [4] [p.29] that continues to proliferate in the minds of
individuals worldwide [5]. Other analogous terms have also emerged including climate
trauma [6], ecological grief [7], and solastalgia [8], which all describe a form of emotional
response towards ecological issues associated with climate change.

Over the last decade, a novel connection has been formed between these psychological
effects of climate change and human reproductive decision-making. Anecdotal evidence from
news outlets, surfacing largely from countries in the Global North, has revealed a growing
number of individuals reconsidering their reproductive decisions in light of their concerns
about climate change [9] [10]. Yet, empirical research studying the intersection of climate
change, mental health and wellbeing, and reproductive decision-making remains a nascent
endeavour. It is important to note that although the Global North and Global South divide is
critiqued for being oversimplistic [11], the terms are referred to throughout this review in
favour of the ‘developed’ and ‘developing’ dichotomy that implies an inherent hierarchical
nature.

This study aims to fill this gap by synthesising the current empirical evidence investigating the
relationship between climate change-related concern and reproductive decision-making. As
the health effects of climate change become ever more pervasive, it is logical to assume that
these concerns will continue to diffuse among populations and potentially influence
reproductive decisions [12]. Consequently, this matter has far-reaching implications across
multiple disciplines including public health policy and environmental politics, emphasising the
immediacy of this research. A systematic review was conducted and a total of thirteen
studies were identified for inclusion (Fig 1).
1.1 Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as being, “attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods” [13] [p.7]. Despite ongoing debates in the media regarding the anthropogenic nature of climate change, the Intergovernmental Panel on Climate Change (IPCC) reported with 95% certainty that human activity is the primary cause [14], leading to a consensus that it is “marked by human influence” [15] [p.119]. Human activities, notably the burning of fossil fuels, have led to a significant increase in greenhouse gas (GHG) emissions, and consequently, the global surface temperature is currently averaging 1.2°C warmer compared to pre-industrial times (1850-1900) [3] [16]. With this alarming rise, climate change has been inextricably tied to the intensification and increased frequency of climatic hazards worldwide such as heatwaves, storms, drought, and flooding. Together with indirect effects including food and water insecurity and increased air pollution, climate change is having a detrimental impact on the social and environmental determinants of human health [17].

1.2 Climate Change and Mental Health

Climate change has been expedited to one of the top priorities on the international political agenda over the last few decades following scientific evidence connecting it with adverse
These health effects are continuing to unfold across the globe with reported rises in premature deaths, infectious diseases, non-communicable diseases, and mental illnesses all attributed to climate change [2]. Whilst causality cannot be easily inferred as drivers of poor health are often complex and intertwined, the empirical evidence undoubtedly shows that climate change is a contributory exacerbating factor.

Whilst impacts to physical health have historically been the focus of academic inquiry, climate change also impacts mental health both directly, from exposure to climatic hazards, and via numerous indirect pathways including loss of livelihood, displacement and forced migration, and armed conflict and interpersonal violence [19] [20]. These risk factors can lead to the onset of mental health conditions and adverse psychosocial outcomes such as depression, anxiety, substance use, and suicidal actions, or have a compounding effect for those already living with these conditions [21]. Moreover, these effects are experienced disproportionately by the most disadvantaged members of society including people with pre-existing chronic disease(s) and/or disability as well as minority groups, people with low-incomes, and women and children. Adopting an intersectionality lens, which considers the systems of privilege and oppression resulting from the intersection of an individual’s multiple social identities [22], serves as a reminder that many people occupy a combination of these marginalised identities which may work in tandem to further increase their vulnerability to climate change [23].

Mental health is broadly defined as “a state of mental well-being that enables people to cope with the stresses of life, realize their abilities, learn well and work well, and contribute to their community” [24] [para.1]. Under this comprehensive definition, contemporary climate
change research is also beginning to take heed of less pathological responses arising from an
awareness of the slow and gradual changes to environmental conditions [25]. This
phenomenon is now commonly referred to as ‘eco-anxiety’, which encompasses a range of
negative emotional responses including fear, anger, guilt, dread, and anxiety itself towards
the climate crisis and ensuing environmental deterioration [25]. Despite being a neologism,
this term is gaining traction within public discourse as many individuals begin to identify with
these feelings. Alternative terminology has also emerged to describe this affective dimension
of climate change including solastalgia, which describes “the distress that is produced by
environmental change impacting on people while they are directly connected to their home
environment” [8] [p.S95], and ecological trauma which is the “experience of witnessing –
consciously or not – the pervasive abuse and destruction of the natural world” [26] [para.2].

Attempting to quantify and measure emotional responses to climate change is not a simple
feat considering the diverse array of mental health outcomes. However, one framework is
prominent in the literature – the New Ecological Paradigm (NEP). The NEP is a widely
adopted measure of an ‘ecological worldview’ that uses a Likert-type scale containing fifteen
questions related to environmental concern [27]. This framework has been used to
investigate the relationship between climate change concern and shifts in individual and
collective behaviour as whilst some individuals may become paralysed by their feelings,
others are galvanised into action, and modify their behaviour accordingly [28]. These may
include changes to ‘everyday’ behaviours such as recycling, diet, or consumption patterns,
but potentially could influence behaviours of even greater magnitude, such as reproductive
decisions.
1.3 Reproductive Decision-Making

Reproductive decision-making “involves decisions about parenthood (whether and when to be a parent, and the number and spacing of children one wishes to have), including decisions around contraceptive usage and fertility” [29] [p.2]. These decisions are often multi-factorial, in flux, and consequently made over time [30]. The T-D-I-B model is a theoretical framework of reproductive decision-making, breaking down the process into a five-step psychological sequence [31] [32] (Fig 2). These discrete steps are, however, often incorrectly used interchangeably in analyses of environmental concern and reproductive decision-making, particularly with ‘desire’ and ‘intention’. Whilst both terms describe psychological states, desires represent what someone hopes or wishes for, whilst intentions represent desires evaluated with respect to what is achievable in reality [31].

Fig 2. A model of reproductive decision-making combining the T-D-I-B model with climate change concerns

Note. Adapted from: Miller (1994; 2011).

The dashed line represents the possibility of climate change-related concern acting as an intervening variable, mediating the transition between traits and desires, and desires and intentions respectively.

Over the last half-century, changes in childbearing patterns, most noticeably observed in the Global North, have seen a greater proportion of adults now choosing to abstain from parenthood and remain voluntarily childfree [33]. These demographic shifts have been linked to macro-level social changes such as the 1970s feminist movement that expanded women’s reproductive rights, as well as individual-level decision-making, with many citing freedom from childcare responsibility, and maintaining close relationships with their partner as determinants of their decision to remain childfree [34]. These decisions are inherently
shaped by normative pressures and structural constraints that are culturally dependent, and variation both within and between Global North and Global South contexts is therefore likely.

The term ‘childfree’ is isolated as a distinct concept from ‘childless’, where the former refers to the ability to have children but choosing not to as a result of sociocultural shifts in societal norms, whilst the latter simply refers to an inability to reproduce despite wishing to have children [30]. This dichotomy is problematised as many describe feeling forced into the decision due to their climate change concerns which does not resonate with the typically voluntary nature of choosing to remain childfree [35]. This subset of individuals will therefore be referred to using more specific nomenclature, ‘environmentally childfree’, defined as “not hav[ing] children or restrict[ing] reproduction... partly or fully out of environmental concerns” [36] [p.201].

1.3.1 Reproductive Decision-Making in Response to Climate Change

Opposing theoretical stances exist that posit the causal relationship between climate change and childbearing decisions. Demand theories of fertility propose that a better quality of immediate environment is conducive to larger populations due to an abundance of natural resources [37]. This is reversed if the environment deteriorates, as in the case of climate change, where limited availability of resources means that some people may opt to control and limit their reproduction. However, critiques of this position propose a decline in agricultural productivity will lead people to increase their crop cultivation to fulfil their subsistence needs [38]. Consequently, families may decide to have more children to have a larger labour force, leading to a ‘vicious circle’ that will further exacerbate the existing
pressures that climate change imposes on the environment [37]. Whilst the direction of the
links between climate change and reproductive decision-making is contested, less academic
attention has been paid to the role of mental health and wellbeing in shaping these
decisions.

1.4 The Current Study

1.4.1 Climate Change, Mental Health, & Reproductive Decision-Making at the
Nexus

The three broad themes of climate change, its impact on mental health and wellbeing, and
reproductive decision-making have been united as a topic garnering significant public
attention within media polls, blog posts and, more colloquially, in conversations amongst
friends and family [35]. In 2018, a nationally representative New York Times survey
distributed to 1,858 childfree American men and women aged 20-45 found that 33% of
participants selected the response ‘worried about climate change’ as a reason for remaining
childfree [39]. Perhaps most visibly, this nexus was spotlighted with the recent emergence of
three collectives: Conceivable Future in the United States (US), BirthStrike in the United
Kingdom (UK), and No Future No Children in Canada, comprised of individuals who are
reconsidering or refusing to have children due to the ongoing effects of climate change.
These activist interventions seek to ring an “existential alarm” [35] [p.1], by using their
reproductive power politically to galvanise governments into taking the necessary action for
climate change mitigation and adaptation.
1.4.2 The Research Gap

Despite becoming an advocacy priority, relevant empirical research on this topic is still in its infancy. Given that climate change, mental health, and reproductive decisions affect everyone, and that their nexus is attracting increasing attention in public discourse, further empirical investigation is necessary. This phenomenon also has far-reaching implications for environmental politics and public health policy. Firstly, the emergence of collectives including BirthStrike moved this topic into the realm of politics by exerting pressure on governments to prioritise climate change within their agendas. Within public health policy, greater resource investment into global mental healthcare will be crucial as the continuing effects of climate change predict a surge in common mental health disorders and feelings of eco-anxiety [40]. Consequently, this review enters the field at a critical juncture for gaining a greater understanding of reproductive decision-making in response to climate change concerns.

1.4.3 Research Question, Aims, and Objectives

Research Question: ‘How do climate change-related concerns affect individuals’ reproductive decision-making?’

For the purposes of this review, ‘concern’ is defined as a worried or anxious feeling, rather than its more neutral definition of a matter of interest or importance. Despite its ambiguity, this word was chosen as it is used widely in the literature and allowed for more relevant negative mental health emotions to be included. ‘Climate change-related concern’ specifically refers to any negative emotional response towards events associated with the anthropogenic root causes of climate change, in addition to previously witnessed and future
projected consequences of climate change. This phrase will be used interchangeably with ‘environmental concern’ in accordance with the literature and for the purposes of brevity.

Aims: To understand how climate change-related concerns are linked to reproductive decision-making, and to explore the reasons and motivations behind this relationship.

Objectives:
1. To summarise the available quantitative, qualitative, and mixed-methods evidence investigating how climate change-related concerns link to reproductive decision-making
2. To explore the specific environmental concerns and factors shaping people’s reproductive attitudes and decisions
3. To make future recommendations for research, policy, and practice priorities in the field

2. Methodology

2.1 Databases
The literature search was conducted on the 11th of July 2022 and the following databases/platforms were searched to provide comprehensive coverage of the relevant literature: Web of Science Core Collection (WOS) (1990 – present), ProQuest Central (1806 – present), OvidSP Global Health (1973 – present), OvidSP PsycINFO (1967 – present), OvidSP
MEDLINE (1946 – present), and EBSCO GreenFILE (1913 – present). WOS and ProQuest Central are multidisciplinary and include literature encompassing the cross-disciplinary themes of climate change, mental health, and reproductive decision-making within the research question. Global Health is a public health database which also includes articles discussing these three themes. The final three databases were selected as they each specialise in one of these disciplines: PsycINFO provides an index of literature from psychology and was relevant to the mental health branch; MEDLINE is a biomedical database exploring medicine and the healthcare system and provided insight into reproduction; and finally, GreenFILE covers publications focusing on human impact on the environment.

Additional relevant papers were found by handsearching the reference lists of included papers (backward snowballing) and reviewing publications that have cited them (forward snowballing) [41]. Google Scholar was also used to search for both published and unpublished grey literature in an effort to diminish publication biases.

### 2.2 Search Strategy

The initial search strategy was formulated on WOS and then adapted to fit the formatting guidelines of the other databases. The search strategy consisted of three separate strands that were combined together to identify studies that focussed on (1) climate change, (2) mental health and wellbeing concerns, and (3) reproductive decision-making. On an initial exploratory search, the search terms included neutral ‘mental health’ terms and broader ‘climate’ and ‘environment’ synonyms. However, upon finding a large quantity of unrelated articles, these were refined to ensure the search had a narrower focus, specific to the
research question. As well as synonyms, the search also incorporated Boolean terms, wildcards, truncations, and medical subject headings (MeSH) to ensure that all appropriate terminology was captured (S1 Table; S2 Table).

2.3 Eligibility Criteria

As research in this field is still incipient, exclusion criteria were not extensive (S3 Table). Firstly, no limits were placed on geographical location to allow for critical reflection on any discernible differences between countries or geographical gaps in current research. The search was also not limited by study design resulting in a review with methodologically triangulated data. Based on the population, exposure, outcome (PEO) framework, during initial abstract screening, articles on plant or animal reproduction were excluded. At full-text screening, literature exploring retrospective reproductive decision-making and/or the intersection of climate change and fertility outcomes, without also addressing mental health concerns, were also excluded. Primary studies, books, and book chapters were all eligible for inclusion as long as they included empirical methodology and findings. Non-peer reviewed publications including newspaper and magazine articles and blog posts were excluded. Peer-reviewed journals are less likely to publish studies with null results, whilst the opposite is true for statistically significant findings [42]; student theses were therefore also included to mitigate this publication bias to some extent. As the lead author of this review only speaks English, all papers that were published in a language other than English were excluded. Additionally, any study that was not available as open access or accessible through university library e-resources was excluded from analysis. Finally, no documents were excluded based
on date of publication as this may have unnecessarily restricted the scope of included literature.

2.4 Data Extraction and Synthesis

Data from the included studies were identified and extracted into a detailed spreadsheet. This included information on the article (first author, publication year, and title), measurement tools, location, participant information (sample size and demographic characteristics), reproductive focus, and key findings. Given the variation in exposure and outcome measurement, a meta-analysis was not feasible, and findings were instead described narratively in accordance with Popay et al.’s [43] guidance. Findings were analysed using a parallel-results convergent synthesis design [44] in which the quantitative, qualitative, and mixed-methods data were initially analysed independently before being consolidated in the discussion and interpretation of the results.

2.5 Risk of Bias Assessment and Quality Appraisal

The quality of included studies was assessed using peer-reviewed checklists to inform the final analysis and interpretation of the data (no studies were excluded based on quality). Different checklists were used according to study design: the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross-Sectional Studies [45], the Critical Appraisal...
Skills Programme (CASP) Qualitative checklist [46], and the Mixed Methods Appraisal Tool (MMAT) [47]. for the quantitative, qualitative, and mixed-methods studies respectively.

2.6 Ethical Considerations

Given primary data collection and/or secondary data analysis did not form part of this project, ethics approval was not required. There were no interactions with human subjects, hence no significant ethical considerations. As such, no risks were associated with reviewing the literature.

3. Results

446 articles were identified and uploaded to EndNote for screening. 104 duplicates were removed and a further 313 papers were excluded following screening of titles and abstracts for relevance. Lastly, full texts of remaining papers were single screened for eligibility, leaving a final total of 13 studies to be included within this review (Table 1).
## Table 1. Summary of characteristics from included studies

<table>
<thead>
<tr>
<th>1&lt;sup&gt;st&lt;/sup&gt; Author (Year)</th>
<th>Title</th>
<th>Measurement Tools</th>
<th>Location</th>
<th>Participants</th>
<th>Reproductive Focus</th>
<th>Key Findings</th>
<th>Quality Appraisal</th>
</tr>
</thead>
</table>
| Arnocky, et al. (2012) [48] | Environmental concern and fertility intentions among Canadian university students | Cross-sectional survey (using NEP, PHC, and RAS) | Canada (Ontario) | N: 139 (undergraduate students) Women: 90, Men: 49 Aged 17-44 (mean = 20.26) | Reproductive intention (child-number) and attitudes | • General environmental concern ($r = -0.34^{**}$) and pollution-related health concern ($r = -0.25^{**}$) negatively correlated with pro-reproductive attitudes.  
• Pollution-related health concern negatively correlated ($r = -0.18^{*}$) with increased reproductive intention (mediated by attitude towards reproduction). | Medium X Inclusion criteria not clearly defined |
| Davis et al. (2019) [38]   | The Problem of Overpopulation: Proenvironmental Concerns and Behavior Predict Reproductive Attitudes | Cross-sectional survey (using NEP, ECS, EBS, and RAS) | Canada (Ontario) | N: 200 (undergraduate psychology students) Women: 167, Men: 30 Aged 18-48 (mean = 20.21) | Reproductive attitudes | • General environmental concern negatively correlated ($r = -0.31^{**}$) with pro-reproductive attitudes.  
• Egoistic ($r = 0.28^{**}$) and altruistic ($r = 0.27^{**}$) concerns positively correlated with pro-reproductive attitudes, whilst biospheric concern was inversely correlated ($r = -0.18^{*}$). | High X Unclear is outcome measured in valid/reliable way |
<table>
<thead>
<tr>
<th>Study</th>
<th>Title</th>
<th>Design</th>
<th>Sample</th>
<th>Reproductive Intention (child-number)</th>
</tr>
</thead>
</table>
| De Rose et al. (2013) [49] | Climate Change and Reproductive Intentions in Europe | Cross-sectional survey (from 2011) (using single item measures of environmental concern and reproductive intention) | European Union (EU) Member States (27 countries) N: 8278 Gender balance unknown Aged 20-45 (mean = 33) | - Regardless of parity, climate change concerns were not significantly associated (at $\alpha = 0.05$) with additionally intended number of children.  
- Weak evidence (at $\alpha = 0.10$) of a positive association amongst those with one existing child, for whom strong climate change concerns were associated with a (slightly) larger intended family size (+0.19 children in the fully adjusted model). |
| Musialczyk (2020) [50] | Attitudes towards having Children in View of Climate Change | Cross-sectional survey (using NEP¹ and RAS³) | Ireland N: 135 Women: 69, Men: 66 Aged 18-45 (mean = 30.33) | - General environmental concern was negatively associated ($\beta = -0.38^{**}$) with pro-reproductive attitudes. |
| Szczuka (2022) [51] | Climate Change Concerns and the Ideal Number of Children: A Comparative Analysis of the V4 Countries | Cross-sectional survey (from 2011) (using single item measures of environmental concern and reproductive intention) | The Visegrád Four (V4) Countries (Czech Republic, Hungary, Poland, and Slovakia) N: 2036 Women: 1006, Men: 1030 Aged 18-45 (estimated mean = 31.64) | - For families generally, climate change concerns were positively associated with decreased reproductive intention in Hungary ($\beta = 0.886^{**}$) but negatively associated in Slovakia ($\beta = -1.124^{**}$).  
- For individuals personally, climate change concerns were negatively associated with increased reproductive intentions in Slovakia ($\beta = -0.748^{*}$), with weak evidence (at $\alpha = 0.10$) of a positive association in the Czech Republic ($\beta = 0.520$). |

**QUALITATIVE RESULTS**

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<table>
<thead>
<tr>
<th>Helm et al. (2021) [52]</th>
<th>No future, no kids—no kids, no future? An exploration of motivations to remain childfree in times of climate change</th>
<th>Content analysis and semi-structured interviews</th>
<th>NZ (Auckland and Christchurch) and US (Tucson)</th>
<th>Study 1 – N: 1157 (reader comments from topical online news articles) Study 2 – N: 24 Women: 17, Men: 4, Non-binary/Genderqueer: 3 Aged 19-35 (mean: 27.63)</th>
<th>Reproductive attitudes, desires, and intention (childbearing)</th>
<th>• Participants were concerned about future children contributing to overpopulation and overconsumption: &quot;I don't need to be adding another person into the world who would consume resources&quot; (p.118). • Participants felt guilty about bringing a child into a world that is 'doomed' from climate change: &quot;it does feel like kind of a gamble bringing a very young person into a world that you really are very unsure about the future of&quot; (p.119).</th>
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<tbody>
<tr>
<td>Krähenbühl (2022) [53]</td>
<td>'Environmental Childlessness?': Reproduction and (Im)Possible Futures amidst Environmental Crises</td>
<td>Semi-structured in-depth interviews (IDIs) &amp; private group discussions and one collective group discussion</td>
<td>Switzerland (Lausanne)</td>
<td>N: 14 Women: 7, Men: 6, Non-binary: 1 Aged 21-48 (mean: 29.07)</td>
<td>Reproductive intention (childbearing) and behaviour</td>
<td>• Pathways towards ‘environmental childlessness’ were two-fold: • Limiting ecological footprint: “the decision not to have children is intertwined with… trying to minimise…our impact on the environment” (n.p.) • Uncertainty of child(ren)’s future: “[W]hat is my responsibility to want to give life to someone who is going to struggle...?” (n.p.)</td>
</tr>
<tr>
<td>Source</td>
<td>Title</td>
<td>Methodology</td>
<td>Study Sites/Regions</td>
<td>Sample Size</td>
<td>Relationship between researcher and participant</td>
<td>Reproductive Desire and Intention (Child-number)</td>
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| Nakkerud (2021) [36]   | ‘There Are Many People Like Me, Who Feel They Want To Do Something Bigger’: An Exploratory Study of Choosing Not to Have Children Based on Environmental Concerns | Semi-structured interviews  | Norway (Oslo, Agder, Innlandet, & Viken) | N: 20 (including 3 couples) | Women: 7, Men: 12, Non-binary: 1 Aged 20-59 (mean unavailable – 55% aged 30-39) | Reproductive intention (childbearing) and behaviour | Two climate change-related concerns factoring into reproductive decisions:  
Ecological impact: “the child would contribute to destroying biological diversity by being a consumer” (p.204)  
Uncertain future: “it could be dangerous for a child to grow up in a world where all species die, and the climate gets warm” (p.204) |  |
| Rosen et al. (2021) [54] | “Burnt by the scorching sun”: climate-induced livelihood transformations, reproductive health, and fertility trajectories in drought-affected communities of Zambia | Semi-structured IDIs, key informant interviews and focus group discussions (FGDs) | Zambia (Chroma, Mazakuba, Mongu, Kalomo, & Senanga) | FGDs – N: 145  
Women: 75, Men: 70  
Age: 19-49 (median: 34)  
IDIs – N: 20  
Women: 20  
Aged 22-44 (median: 32)  
Informant interviews – N: 16 (stakeholders)  
Women: 7, Men, 9  
Aged: 25-73 (median: 34) | Participants desired smaller families to meet their subsistence needs: “The 6 children I desire to have may not have enough food to eat” (p.8)  
This conflicted with recognition of children as a source of household support: “My desire was to have 10 children so that some of them can help me because no one knows what the future holds” (p.8). | Reproductive desire and intention (child-number) |  |
| Rovin et al. (2013) [55] | Linking Population, Fertility, and Family Planning with Adaptation to Climate Change: Perspectives from Ethiopia | Semi-structured IDIs and FGDs | Ethiopia (Oromia and Southern Nations, Nationalities and People’s Regions) | FGDs (12) – N: 96  
Women: 48, Men: 48  
(Age range unavailable)  
IDIs – N: 42 (community members, leaders, and policymakers) | Participants were concerned about their ability to subsist with large family sizes: “everyone needs to have children based on the resources [they have], and I feel two to four children are enough” (p.25) | Reproductive desire and intention (child-number) |  |

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<table>
<thead>
<tr>
<th>Study</th>
<th>Title</th>
<th>Methodology</th>
<th>Sample</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smith et al. (2022) [56]</td>
<td>Pregnancy Intentions of Youth in the Era of Climate Change: A Qualitative Auto-Photography Study</td>
<td>Auto-photography and IDIs</td>
<td>Canada (British Columbia)</td>
<td>N: 7 (nulliparous individuals with 33 photographs) Women: 7 (assigned female at birth) Aged 18-25 (mean unavailable) Reproductive intention (childbearing) and behaviour • 6/7 participants stated that climate change has already or may affect their reproductive decision-making: “I wouldn’t want to have children... because of just the dire future that I’m predicting” (p.5) • Five themes in participants’ narratives: planning for a ‘dire future’, experiencing anxiety, calls for systemic change, catalysing events, and feeling like an outlier.</td>
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<tr>
<td>Schneider-Mayerson (2022) [57]</td>
<td>The environmental politics of reproductive choices in the age of climate change</td>
<td>Survey (16 open-ended questions &amp; 24-31 multiple choice questions) (same data set as Schneider-Mayerson &amp; Leong, 2020)</td>
<td>US</td>
<td>N: 607 (‘climate-concerned’ individuals) Women: 446, Men: 131, Gender-diverse: 30 Aged 27-45 (mean unavailable) Reproductive intention (childbearing) and behaviour • Parental investment in environmental politics and children as future environmentalists reported as reasons to have children, e.g. “I thought about how I will raise my kids to be educated about climate change and how they can be a force for good, for fighting it” (p.163). • Opportunity cost of parenting and fertility as a socio-political tool reported as reasons not to have children, e.g. “I am relieved that I did not have a child because this choice...”</td>
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</tbody>
</table>
Schneider-Mayerson (2020) [58] | Eco-reproductive concerns in the age of climate change | Survey (16 open-ended questions & 24-31 multiple choice questions) | US | N: 607 (‘climate-concerned’ individuals) Women: 446, Men: 131, Gender-diverse: 30 Aged 27-45 (mean unavailable) | Reproductive intention (childbearing) | • 96.5% of respondents ‘extremely’ or ‘very’ concerned about the impacts of climate change on their child(ren)’s health and wellbeing: “I don’t want to birth children into a dying world” (p.12). • 59.8% of respondents ‘extremely’ or ‘very’ concerned about the carbon footprint of reproduction: “I cannot produce another person that will continue to destroy the planet, as they will inherit my first world lifestyle” (p.9). | High X Unclear if quantitative components adhere to quantitative quality criteria

**Note.** ¹New Environmental Paradigm (NEP); ²Pollution-related Health Concern (PHC); ³Reproductive Attitudes Scale (RAS); ⁴Environmental Concern Scale (ECS); ⁵Environmental Behaviour Scale (EBS)

*p* < 0.05, **p** < 0.01

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Note. ¹The Brandt Line is “a way of visualising the world that highlights the disparities and inequalities between the wealthy North and the poorer Global South” [59] [p.85]. It is critiqued for being outdated; however, it is still regarded as a useful way to visualise economic inequities in world politics.
3.1 Quantitative Results

3.1.1 Study Characteristics

Table 1 presents the study characteristics of five included quantitative studies. All studies were cross-sectional, used surveys, and were conducted in denominated Global North countries (Canada and 27 EU countries) (Fig 3). Measurement instruments were heterogeneous, with four different tools, and one single-item measure used to assess environmental concern. In total, 10,788 participants were included, none of whom identified as gender-diverse, defined as “people on the continuum between binary male and female” [60] [p.82] (although information on gender was unattainable for one study [49]).

3.1.2 Quality Appraisal

Two studies were deemed high quality and three medium quality using the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies [45] (Table 1; S5 Table). The rigour with which confounding factors were controlled for varied, ranging from two to seven identified variables between studies. Limitations were described in every study with a key commonality being the inability to infer causation owing to cross-sectional study designs. Only one study [49] reported any acknowledgment of bias, yet all studies used self-report surveys which are prone to social desirability bias and acquiescent responding [61].
3.1.3 Narrative Synthesis

A narrative synthesis was appropriate due to the heterogeneity in reported outcome measures. The studies are categorised into those investigating reproductive intentions (measured by ideal number of children) and reproductive attitudes (positive and negative evaluations towards having children). One study [48] reported on both outcomes and thus the findings were separated into both groups.

Reproductive Intentions

Three studies tested the relationship between environmental concerns and participants’ reproductive intentions, and the findings were contradictory. Arnocky, Dupois & Stroink [48] reported that stronger pollution-related health concerns correlated with diminished reproductive intentions, mediated by participants’ attitude towards reproduction. However, De Rose and Testa [49] found no significant association between climate change concerns and (additionally) intended number of children, although weak evidence suggested an association between stronger concerns for people with one existing child and a larger intended family size. Finally, Szczuka’s [51] findings were mixed in the fully-adjusted models; for a family generally, stronger environmental concerns were positively associated with lower reproductive intentions in Hungary, but negatively associated in Slovakia. For participants’ own preferred number of children, stronger environmental concerns were negatively associated with increased reproductive intentions in Slovakia, with weak evidence of a positive association in Czech Republic.
Reproductive Attitudes

Three studies explored the link between reproductive attitudes and climate change concerns. Across all three studies, stronger concerns were significantly associated with less favourable attitudes towards having children. Additional findings from Davis, Arnocky, & Stroink [38] were unique to their research aims as they disaggregated environmental concern into three subscales: egoistic (concern for the self), altruistic (concern for humanity), and biospheric (concern for the environment). Higher egoistic and altruistic concern positively correlated with pro-reproductive attitudes whilst an inverse correlation was found for biospheric concern, meaning the concerns of participants with positive attitudes towards having children were centred on the repercussions of climate change for themselves and their community, rather than for the environment itself.

3.2 Qualitative Results

3.2.1 Study Characteristics

Table 1 presents the study characteristics of six included qualitative studies. Four studies used IDIs and are therefore expected to have obtained richer data [62], but semi-structured interviews were suitable to the studies’ aims nonetheless. Supplementary tools were used in three cases including focus group discussions (FGDs) and auto-photography, strengthening the validity of the results by employing methodological pluralism [63]. Geographical location was diverse, with data obtained from six different countries: four in the Global North, and two in the Global South (Fig 3).
384 participants were recruited in total (in addition to 1,157 online comments), including 181
women, 140 men, and 5 gender-diverse participants (the gender of 58 participants is
unknown). Some studies recruited ‘young adults’ aged 18-35, whilst others included older
individuals, in one case up to 59-years-old. This difference might be partially explained by the
ambiguity surrounding the end of ‘childbearing age’, but relevant justification was provided
for the age ranges selected.

3.2.2 Quality Appraisal

Three studies were deemed high quality and three medium quality using the CASP Qualitative
Checklist [46] (Table 1; S6 Table). Only two authors [53] [56] engaged in a critical examination
of reflexivity and their potential to be biased throughout the research process. Given this
topic is conducive to highly subjective opinions, the four studies failing to include this
reflection were weakened as a result.

3.2.3 Thematic Synthesis

The qualitative findings all sought to understand the motivating factors behind participants’
reproductive decision-making in light of their climate change-related concerns. These were
synthesised, grouped into themes, and are discussed in turn below.
Uncertainty of an Unborn Child’s Future

In four studies, participants were concerned about their child(ren)’s health and wellbeing in an uncertain future, confronted by the effects of climate change. This was reflected in reader comments from topical online news articles, with many predicting the quality of life for unborn children as ‘bleak’ or ‘doomed’ [52]. Projections of a ‘dire’ future were expressed in Smith et al. [56], with some participants feeling out of control of the future state of the planet and disappointment that the ability to enjoy aspects of nature such as “kayaking, or hiking, or snowboarding” [p.6] may no longer be accessible to future generations. In Nakkerud [36] and Krähenbühl [53], participants were concerned that societies were heading towards collapse and therefore did not want the responsibility of raising a child in their envisioned uninhabitable world.

Ecological Impact of Reproduction

Three studies highlighted environmentalist concerns related to the ecological contributions of reproduction to overpopulation and overconsumption. In Helm, Kemper, and White [52], a number of commentators believed that refraining from having children was the best course of action for reducing one’s carbon footprint. Participants in Krähenbühl [53] differentiated between concerns of the direct (overpopulation) and indirect (overconsumption) impacts of children on the environment, with the latter situated in their rejection of capitalist society and its materialist values. A unique finding in Nakkerud [36] was participants’ concerns for the “flourishing of non-human species” [p.203], aside from the environment as a whole.

Meeting Family Subsistence Needs
In Zambia [54] and Ethiopia [55], participants’ concerns centred around their families’ ability to subsist in a context of seasonal droughts and dependence on rain-fed agriculture. The dominant narrative in both studies was that smaller families are better positioned to support themselves during adverse environmental conditions, meaning participants desired fewer children to meet their household’s essential needs. This led to heightened demand for family planning services in these areas. However, the direction of this relationship was diametric in Rosen et al. [54] as some respondents noted that a greater number of children is an asset as they provide agricultural and pastoral labour that can be used to acquire more resources. This emerged as a secondary theme with only a few male participants still holding this view.

3.3 Mixed-Methods Results

3.3.1 Study Characteristics

Table 1 presents the study characteristics of two included mixed-methods studies. Both studies utilised the same dataset from the US, albeit for responding to different research aims, and thus the characteristics are homogeneous aside from the reproductive focus and key findings. Participants were disproportionately represented by women (n=446), followed by men (n=131), and gender-diverse people (n=30).

3.3.2 Quality Appraisal
Mixed-methods studies were appraised using the MMAT [47] and both deemed high quality (Table 1; S7 Table). Mixed-methods were appropriate as the quantitative multiple-choice questions captured discrete answers, whilst the open-ended qualitatively designed questions provided further detail for answering the research question. A key limitation was the non-randomised selection of participants, resulting in an inability to generalise findings to all Americans factoring climate change into their reproductive plans. Additionally, the use of self-report measures leads to the same response biases as previously discussed [61].

3.3.3 Narrative Synthesis

Given only two mixed-methods studies were acquired, it was not necessary to categorise them into distinct groups. However, the findings are discussed in turn due to heterogeneous research aims and findings. Participants in Schneider-Mayerson and Leong [58] were primarily concerned about the impacts of climate change on the health and wellbeing of their existing and/or hypothetical children, with concerns related to the carbon footprint of procreation emerging as a secondary finding. In Schneider-Mayerson [57], findings were divided between respondents who were already parents and/or planning to have children versus those who were environmentally childfree or undecided. The former group believed that parents are more invested in environmental politics due to their connections to a distant future, on the part of their children, and viewed their (future) parenting as contributing to a better world through supporting their children to become environmentalists. On the other hand, the latter group commented on the opportunity cost of parenting, meaning the energy required for raising a child would be taken “from the project of fighting climate change”
Additionally, reproduction was viewed as a socio-political tool that could be leveraged to influence environmental attitudes among family members specifically.

4. Discussion

4.1 Summary of Evidence

Thirteen studies detailing how climate change-related concerns link to reproductive decision-making were narratively synthesised. The majority of studies (12/13) reported that stronger environmental concerns are associated with less favourable reproductive attitudes and a diminished desire and intention to have children. However, weaker evidence from four studies suggested climate change concerns may be associated with increased reproductive intention for some. Four key areas of concern were identified: uncertainty of an unborn child’s future, ecological impact of reproduction, meeting family subsistence needs, and contributing to environmental politics. The qualitative, quantitative, and mixed-methods findings are consolidated in this section, and contextualised in relation to other literature, to answer the research question and objectives of this review.

4.2 Complex Relationship between Climate Change Concerns and Reproductive Decision-Making
The findings revealed a complex relationship between climate change-related concerns and reproductive decision-making. In all but one study, stronger concerns were associated with a desire for a smaller number of children or simply none at all. This accords with a recent cross-country study [64] involving 10,000 18–25-year-olds reporting that four in ten participants were hesitant to have children as a result of climate change. Additionally, these concerns sparked the inception of political movements such as BirthStrike, with Blythe Pepino, the founder of this collective stating, “we feel too afraid to have kids because we feel that we’re heading toward civilization breakdown as a result of the environmental crisis” [35] [p.2].

However, results were mixed; two quantitative studies in EU countries [49] [51] suggested that climate change concern may be associated with an increased desire for children for some. These studies, however, used a single item measure of concern as opposed to the NEP, and dichotomised environmental concern on a binary scale from ‘strong concerns’ to ‘no strong concerns’. This ignores the continuous nature of mental health issues and meant a considerable amount of this variable’s information was lost, reducing its statistical power [65]. However, one qualitative study [54] found that some Zambian men desire more children during times of environmental degradation, and in one mixed-methods study [57] environmental concerns were justified as a reason to have children. To explain these contradictory findings, it is important to discuss the various concerns that motivate these shifts in reproductive decision-making.
4.3 Explanations for Factoring Climate Change Concerns into Reproductive Decision-Making

Participants’ climate change concerns factoring into their reproductive decisions are divided into four themes. Firstly, participants worried about the quality of their child(ren)’s life in a future affected by climate change. These are altruistic environmental concerns, according to Davis, Arnocky, and Stroink [38], as they consider the impacts to others, in this case one’s children, and embody a “degree of nature-self overlap” [p.95] by placing them within an interdependent environment. This narrative is echoed in Dow’s [66] conceptualisation of an ecological ethic of reproduction which encourages prospective parents to look beyond their individual nuclear family to the broader environment, representing the conditions into which a child will be born.

Dow’s [66] theory also naturally intersects with the second theme, participants’ concerns of their ecological impact, as it proposes a reconsideration of “bring[ing] future generations into a world with stretched and unequally distributed resources” [p.653]. Participants feared that having children would contribute to overpopulation and overconsumption, which corresponds to recent calculations of the ecological cost of reproduction. Wynes and Nicholas [67], for example, concluded that having one fewer child is the highest impact action one can take to reduce personal emissions. Interestingly however, these concerns were not expressed by participants in the Global South, which may reflect their relatively negligible involvement in overconsumption practices [1]. Whilst the fertility rate in many Global South countries has historically been higher than their Global North counterparts,
focussing on overpopulation discourses has been critiqued as reductive and racist as consumption, aggravated by a capitalist way of living, is considered the primary anthropogenic driver of climate change [68].

The third and fourth themes were reported to a lesser extent, in two studies each. In Zambia and Ethiopia, participants desired fewer children to meet subsistence needs during periods of declining agricultural productivity. However, this competed with the lived reality of shortages in contraception provision which epitomises the distinction between ‘desire’ and ‘intention’ in Miller’s [31] T-D-I-B model. Given this finding was unique to the studies from the Global South, this may imply that the transition from desires to intentions is more challenging in these countries with generally weaker sexual and reproductive health (SRH) service provision, and where reproductive rights is, at times, still a taboo subject [69]. Contextualising this within broader discourses of reproductive freedom, it is important to remember that many people may not have the ability or privilege to choose whether, or how many children they have. Consequently, this highlights the highly situated nature of environmentally childfree behaviour as organised along social class hierarchies that are prevalent both within and between Global North and Global South settings [53].

The final theme explored environmental political concerns in some individuals’ decisions to restrict their reproduction. Participants in Schneider-Mayerson [57] believed that the energy required for parenting would detract from their personal endeavours to mitigate climate change. This parallels Blackstone’s [34] research suggesting that childfree individuals wish to “leave a legacy” [p.76] by making a positive mark on the world through philanthropic work, civic engagement, and in this case, climate change activism. Reproduction was also seen as a
socio-political tool in participants’ private lives, although interestingly only two participants
across all studies reported their refusal to have children on a more public scale, as a method
of ‘striking’ until systemic change was enacted. This is surprising given the prominence of
BirthStrike, Conceivable Future, and No Future No Children that had this notion at the very
core of their movements.

These final two themes were also articulated in participants’ intentions for a greater number
of children within two studies. Firstly, participants in Zambia were concerned about their
ability to support their family without the household labour provided by additional children.
This idea supports demand theories of fertility previously mentioned and is observed in other
Global South countries including Bangladesh and Nepal where children are seen as “helping
hands during difficult times” [70] [p.105] to support with domestic work as well as water and
fuel wood collection [71]. These concerns may also be reasonably linked to demographic
theories of ‘insurance’ births, whereby women in unfavourable environmental conditions
have more children to compensate for the risks to child mortality [72]. Regarding
environmental politics, participants responses were reflective of a political fertility gap in the
US, with statistics from the 2006 General Social Survey highlighting a 41% increase in
numbers of children had by ‘conservative’ adults than ‘liberal’ adults [73]. Participants feared
that this gap would widen if they, as liberal and environmentally conscious individuals, chose
to have fewer children which could further exacerbate the climate crisis.

These studies have therefore highlighted a complex and multidimensional relationship
between climate change concerns and reproductive decision-making. This contrasts with an
oversimplified depiction of this relationship within the media that has typically only
highlighted people’s concerns of the quality of a child’s life in a climate-changed future as a factor in their reproductive decisions. Additionally, important distinctions were found between, as well as within, Global North and Global South counties, adding further complexity to the relationship as climate change concerns and their impact on reproductive decision-making were not generalisable on a global scale.

4.4 Recommendations

4.4.1. Recommendations for Research

Due to the incipient nature of this topic, this review has a number of suggestions for future research directions. Firstly, greater attention should be paid to the impact of climate change concerns on reproductive timing to provide a comprehensive view on reproductive decision-making as a whole according to the T-D-I-B model. Given concerns of overpopulation featured as a dominant theme, age at first birth as well as birth spacing may be an additional reproductive consideration, warranting further inquiry. Secondly, this topic ought to be investigated further within Global South settings. Differences in structural constraints from the Global North have been highlighted and are expected to predict heterogeneous responses to environmental concerns and reproductive decisions between, as well as within, this binary geographical divide. Additionally, greater efforts to recruit and retain gender-diverse participants are needed as they are particularly vulnerable to both the effects of climate change and adverse mental health [74] [75]. Finally, with respect to study design,
longitudinal cohort studies would be advantageous to explore causality of this relationship and whether it is subject to change over an individual’s life course.

4.4.2 Recommendations for Policy and Practice

The wider implications of this review highlight some important recommendations for policy and practice. Firstly, evidence has shown that public concern towards climate change in the UK has grown considerably over the last decade [76] [77]. Acknowledging this suggests an evident need for increased resource investment into mental health service provision and policymakers should endeavour to use co-production methods that consult mental health service users and acknowledge their lived experience expertise. Additionally, greater prioritisation of climate change within political agendas may help mitigate public anxiety and relieve some of the burden on mental healthcare providers. Further research is required to explore the trend in public concern towards climate change in countries outside of the UK. Secondly, promotion of family planning services coupled with subsidised, readily available access to contraception presents a key opportunity for fostering climate resilience within the Global South, allowing individuals to control their own reproductive trajectories. Finally, as researchers and policymakers continue to seek ways to curb the environmental consequences of climate change, understanding the reasons why some people choose to adjust their reproductive intentions may prove instrumental for shaping public policy. At the very least, this review underscores a need for collaboration among policymakers to incorporate local-level environmental concerns within national and international climate change, mental health, and SRH policies.
4.5 Limitations

This review has identified a gap in the literature and provided key recommendations to be taken forward into the field, however, some limitations remain. Firstly, only English language papers were eligible for inclusion meaning relevant studies may have been omitted. Additionally, the inclusion of different study designs resulted in inconsistencies in the quality appraisal as three separate tools had to be used. However, not limiting by study design was justified as it facilitated methodological pluralism which is useful for viewing a singular phenomenon through different lenses [78]. The narrative synthesis approach is often critiqued for lacking transparency [79] and an in-depth description of the process was beyond the scope of this review. However, synthesis was conducted in line with Popay et al. [43] and we have provided detailed information on the review’s methods to ensure utmost transparency and reproducibility of findings. This detail was also provided to offset the risk of selection bias resulting from the single screening of articles as much as possible [80].

The included studies were all appraised as either high (n=7) or medium quality (n=6), enhancing the strengths of the conclusions drawn. However, there was significant variability in sample sizes with three qualitative studies recruiting only 7, 14, and 20 participants, resulting in low statistical power. All quantitative studies were cross-sectional, leading to an inability to infer a temporal relationship or to evaluate any changes prospectively. However, confounding factors were identified and adjusted for, and the qualitative and mixed-methods studies supported a directional relationship from climate change concern (exposure) to
reproductive decision-making (outcome), making it unlikely that the inverse was true for the quantitative studies. Finally, there was significant geographical homogeneity in the data, with 85% (n=11) of studies conducted in Global North countries, limiting the generalisability of these findings to the Global South.

5. Conclusions

This review has revealed a complex relationship between climate change-related concerns and reproductive decision-making. The findings support anecdotal evidence that climate change is factoring into people’s reproductive decision-making, with the majority of studies suggesting that many people are choosing to forego childbearing or reduce the number of children they have as a result. However, a relatively simplistic overview of this relationship, grounded in environmental ethics, is illuminated in public discourse. This review has revealed a more intricate account of how and why people are beginning to reconsider their childbearing and child-number decisions based on their climate change concerns. Whilst many participants’ narratives were rooted in ethical considerations, including concern for their child(ren) in an uncertain future and the ecological impact of reproduction, other considerations that do not appear so readily in public discourse were environmental political considerations and meeting family subsistence needs. These two concerns were also justified, albeit to a lesser degree, as reasons for a greater number of children, further complicating the relationship. The lack of Global South representation in the literature is highlighted as one among a number of gaps still remaining in the field with others including a
relative absence of gender-diverse participants’ voices and no consideration of the effect of climate change concern on reproductive timing. Given the multidisciplinary implications of this research for public health policy and environmental politics, these all represent necessary avenues for future research. This review therefore serves as a call to action for greater research into the climate change, mental health, and reproductive decision-making nexus.

Acknowledgements

We would like to thank Ms. Heather Chesters, the Deputy Librarian at the UCL Great Ormond Street Institute of Child Health Library, for supporting with the identification of appropriate search terms for this review. We would also like to thank Dr. Ilan Kelman, Professor of Disasters and Health at the UCL Institute for Risk and Disaster Reduction, for his feedback in the initial stages of the conceptualisation of this study.

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Supporting Information

S1 Table. Search terms for search strategy conducted on WOS database
S2 Table. MeSH terms used for search strategy
S3 Table. Inclusion/exclusion criteria for study selection
S4 Table. PRISMA Checklist 2009
S5 Table. Quality appraisal for quantitative studies using the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies
S6 Table. Quality appraisal for qualitative studies using the CASP Qualitative Checklist
S7 Table. Quality appraisal for mixed-methods studies using the MMAT
Fig 1. PRISMA diagram of study selection

- Records identified through database searching (n = 434):
  - WOS (126), ProQuest Central (97), Global Health (45), PsycINFO (13), Medline (138), GreenFILE (14)

- Additional records identified through other methods (n = 12):
  - Backward Snowballing (6), Forward Snowballing (3), Google Scholar (3)

- Total Potential Papers (n = 446)

- Titles and abstracts screened (n = 342)

- Duplicates excluded (n = 104)
  - EndNote de-duplication tool (64), manual de-duplication (40)

- Records excluded (n = 313)
  - Full text articles excluded (n = 16)
    - No mental health (10)
    - No climate change (4)
    - No reproductive decision-making (2)

- Full text screened for eligibility using inclusion/exclusion criteria (n = 29)

- Studies included in the review (n = 13)
  - Quantitative (5), Qualitative (6), Mixed-Methods (2)
Fig 2. A model of reproductive decision-making combining the T-D-I-B model with climate change concerns (modified from Miller, 1994; 2011)
Fig 3. A map showing the geographical distribution of included studies.