



**Prevalences of mental health disorders among low- and lower middle-income countries' children and adolescents exposed to extreme weather events:
A systematic review and meta-analysis**

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DECLARATION

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TABLE OF CONTENTS

1	DECLARATION	2
2	ACKNOWLEDGEMENTS	3
3	PART A: JOURNAL MANUSCRIPT	6
4	Abstract	6
5	1. Background	7
6	2. Methods	8
7	2.1. Eligibility criteria	8
8	2.2. Information sources and search strategy	9
9	2.3. Selection process.....	9
10	2.4. Data items and extraction.....	10
11	2.5. Risk of bias quality assessment.....	10
12	2.6. Data synthesis and analysis.....	10
13	2.7. Sensitivity analysis.....	11
14	2.8. Publication bias assessment	11
15	3. Results	11
16	3.1. Search results	11
17	3.2. Key characteristics	12
18	3.3. Risk of bias quality assessment.....	16
19	3.4. Findings of mental health disorder prevalences.....	17
20	3.4.1. Prevalence of PTSD	17
21	3.4.2. Prevalence of depression.....	17
22	3.4.3. Prevalence of anxiety	18
23	3.4.4. Prevalence of distress, sleeping disorders, and suicidal ideation.....	18
24	3.5. Subgroup analysis	18
25	3.5.1. Subgroup by extreme weather event.....	20
26	3.5.2. Subgroup by age.....	20
27	3.5.3. Subgroup by region.....	21
28	3.5.4. Subgroup by time point measured	22
29	3.5.5. Subgroup by measurement tool.....	22
30	3.6. Sensitivity analysis.....	24
31	3.7. Publication bias.....	25
32	4. Discussion	27
33	4.1. Key findings.....	27
34	4.2. Factors influencing prevalence	28
35	4.3. Strengths and limitations.....	31

36	5. Conclusion	32
37	5.1. Implications.....	32
38	6. List of abbreviations	33
39	7. Declarations	34
40	8. References	34
41	9. Supplementary materials	41
42	Supplementary file 1: Subgroup analysis forest plots.....	41
43	Supplementary file 2: Sensitivity analysis forest plots	43
44	Supplementary file 3: Influence diagnostic tests	44
45	Supplementary file 4: Leave-one-out analysis forest plots	45
46	Supplementary file 5: Doi plot and funnel plot of depression and PTSD studies.....	46
47	10. Appendices	47
48	Appendix A: BMC Public Health author guidelines for systematic reviews	47
49	Appendix B: Search strategy	49
50	Appendix C: Data extraction items list.....	51
51	Appendix D: Hoy et al. risk of bias tool	51
52	Appendix E: List of excluded studies with reasons	53
53	Appendix F: Data extraction chart.....	60
54	Appendix G: Ethics waiver letter.....	64
55	Appendix H: Research protocol.....	65
56	1. Introduction	69
57	2. Methods	77
58	3. Ethics	82
59	4. Conclusion	82
60	5. References	84
61	6. Appendices	90

PART A: JOURNAL MANUSCRIPT

62

63 **Title:** Prevalence of mental health disorders among low- and lower middle-income countries' children
64 and adolescents exposed to extreme weather events: A Systematic review and meta-analysis

65 **Target Journal:** *BMC Public Health* (see [Appendix A](#) for Author Guidelines and Authors' Contributions)

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73

74 **Abstract**

75 **Background:** Research concerning the disproportionate health consequences of climate change is still unexplored,
76 specifically in one of the most vulnerable populations: children and adolescents living in low- and lower middle-
77 income countries (LLMICs). At present, there is a gap in current literature on how prevalent LLMIC youth mental
78 health burdens are following climate-induced extreme weather events (EWEs). This systematic review serves to
79 uncover these mental health burdens in response to the EWEs projected to intensify in the near future.

80 **Methods:** The Context Condition Population (CoCoPop) framework for prevalence studies was used to identify
81 eligible studies. Mental health disorders were the condition of interest, in the context of LLMICs under the
82 population of children and adolescents (1 to 19 years of age) who had experienced at least one EWE. MEDLINE via
83 PubMed, PsychINFO, Web of Science Core Collection, Scopus, and CINAHL were databases retrieved using the
84 search strategy. All searches were done in June 2024. Two researchers screened and three extracted the data. Meta-
85 analyses were conducted using R (4.2.3).

86 **Results:** Twenty-seven studies met the eligibility criteria with a total sample population of 14239 participants. The
87 most prevalently reported mental health disorders identified were anxiety (32.7% 95% CI: 7.1-65.6), depression
88 (33.2% 95% CI: 17.0-51.8), and post-traumatic stress disorder (PTSD) (50.4% 95% CI: 36.7-64.1). Heterogeneity
89 was high in all groups ($I^2 = >90\%$). Subgroup analyses were conducted, grouped by type of EWE, age, region, time-
90 point measured, and measurement tool standardization.

91 **Conclusions:** This review provides critical insights into the mental health burdens LLMIC youth face after
92 experiencing EWEs. Anxiety, depression, and PTSD are commonly found prevalent, influenced by factors such as
93 the type of EWE, age, region, different time points measured, and measurement tools' standardization. The high
94 heterogeneity observed across studies highlights the challenges in standardizing mental health measurements,
95 especially in LLMIC settings. Influential factors must be considered to fully comprehend and address the
96 complexities of the vulnerable group's mental health states. LLMIC stakeholders must not only acknowledge mental
97 health disorder repercussions from EWE exposures but also translate such evidence into palpable interventions.

98 **Registration:** PROSPERO International Prospective Register of Systematic Reviews (ID: CRD42024535106)

99 **Keywords:** Child and adolescent health, Extreme weather events, Prevalence, Mental disorders

100 **1. Background**

101 Extreme weather events (EWEs) have intensified in number and severity over the last decade, a major
102 indicator of climate change's repercussions [1, 2]. Concerningly, the extremities in forms of EWEs such
103 as floods, landslides, droughts, heatwaves, cyclones, and hurricanes are projected to progressively worsen
104 over time [2-4]. Notably, trends of fluctuating weather events that have been studied over a long period
105 show increased precipitation in parts of North and South America, North and Central Asia, and Northern
106 Europe. In contrast, the Southern and Sahel regions of Africa, the Mediterranean, and Southern Asia have
107 recorded dryer climates [5]. In response to such changes in the environment, numerous international non-
108 governmental organizations have emphasized the need to urgently address climate change, warning that it
109 is one of the greatest health threats in the 21st century where no one is left out [3, 6, 7]. However, despite
110 affecting all, the consequences are experienced disproportionately by vulnerable populations, namely
111 low- and lower middle-income countries (LLMICs) [8-10].

112 EWEs can instantly cause destruction, rippling into a chain-reaction of damages, resulting in the
113 aggravated vulnerabilities that LLMICs already carry [11-14]. The inherently present insufficiencies in
114 LLMICs such as weak governance, frail infrastructures, inefficient health systems, lack of support
115 systems for disaster preparedness and limited resources are significantly challenged once hit with an EWE
116 [8, 9, 13, 15-17]. This results in immediate challenges such as displacement, inaccessible treatment
117 services, and limited recovery measures, as well as long-term effects such as financial strain and a
118 declining economy dependent on agricultural production [1, 8, 9, 15-21]. To further add to the
119 vulnerabilities unique to LLMICs, almost 50% of the population are under the age of 18 years old with an
120 overall 90% of the global youth living in low- and middle-income countries (LMICs) [7, 22, 23]. Children
121 and adolescents are defined as vulnerable populations by numerous organisations, with separate agendas
122 that prioritise their needs over others [1, 8, 24-26]. They are not just smaller versions of adults but hold
123 unique physical, physiological, and developmental characteristics, distinctive to adults [8, 27-31]. When
124 put together, LLMIC children and adolescents make up one of the most vulnerable populations in the
125 world [1]. The greatest paradox, however, is that LLMIC youth are the least accountable and yet the most
126 vulnerable, making the disproportionate spread of consequences unjustifiable [14, 23, 32, 33]. Children
127 born in 2020 are predicted to experience EWEs two to seven times more compared to those born in 1960
128 [34]. Adults contributing to emissions are neglecting the rights that children have to a sustainable and
129 healthy future [32]. Unlike adults, children and adolescents are only at the beginning stages of life with
130 endless opportunities ahead of them, and yet, are left to fight for their rights to a safe future, whilst
131 dealing with the damages from EWEs.

132 Furthermore, despite the gradually growing evidence in the past five years [8, 15, 16, 35-37], physical
133 health has always been prioritized and heavily studied over mental health consequences following EWEs
134 [8, 18]. However, in the last five years, an increasing number of studies have recognised the detrimental
135 effects on mental health, especially critical for children and adolescents [15, 16, 36, 38]. More specifically,
136 children who have experienced EWEs have reported emotions of fear for the uncertain future,
137 hopelessness, anger, sadness, and numbness [39]. To further add, numerous studies have shown that the
138 intensification of such negative emotions can lead to serious symptoms of panic attacks, sleeplessness,
139 and unrecognised distress [40, 41]. Anxiety, post-traumatic stress disorder (PTSD), depression, suicidal
140 ideation, and sleeping disorders are only some of the common mental health disorders LLMIC youth have
141 faced following EWEs [15, 37, 42-49]. This acceleration of findings has highlighted the importance of

142 recognizing EWEs as life-changing events critical to the brain during delicate stages of development,
143 further proving the cruciality of studying the vulnerabilities of the youth separately.

144 Although the linkages between mental health and EWEs are consistently reported [50], one of the key
145 gaps in literature on EWEs and LLMIC youth's mental health is the lack of information [7, 18, 47, 51].
146 The majority of literature on the topic is still centred around high-income countries (HICs) [4, 21, 39, 40,
147 52-57]. For under-resourced LLMICs, the major gaps in research that fail to uncover youth mental health
148 burdens have contributed to the inadequate and slow change [51]. More specifically, there is a gap in
149 current literature on the unavailable and inconsistent data of how prevalent the LLMIC youth mental
150 health burdens are [58]. There is an unsettling scarcity of mental health data in discussions of climate
151 change and EWEs, even in major international reports. For example, in both the Intergovernmental Panel
152 on Climate Change's (IPCC) special reports on climate change threats in 2018 and the IPCC Sixth
153 Assessment Report in 2022, mental health consequences were either overlooked or mentioned with
154 extreme vagueness [50, 59]. This lack of data ultimately translates to the limited progression of mental
155 health, resulting in LLMIC youth severely lacking treatment, policies, and understanding of the overall
156 burden of disease [7, 60-63]. As a result, recent studies on over the last two years have concluded with
157 concerns on the lack of research, encouraging for more rigorous evidence production and synthesis, such
158 as a systematic review [22, 48, 64]. With the evidence-based quality findings, critical information that
159 motivates stakeholders, governing bodies, and the public to act, can be produced [65-67]. More
160 specifically, research that identifies how prevalent a burden of disease is act as key drivers in pushing
161 policy and implementation [66, 68]. Without such data, LLMICs will continue to struggle with dismissive,
162 absent, and delayed action [61].

163
164 It is, therefore, imperative for LLMICs to identify the prevalence of mental health disorders, not only to
165 understand the overall magnitude and severity of mental health burdens faced, but to also progress in
166 mental health agendas for the youth [65]. LLMICs can use such evidence as guidelines to develop
167 contextually relevant policies and practices, allowing for the prioritization of youth mental health to be
168 argued upon sound research. At present, there has yet to be a systematic review calculating the overall
169 pooled prevalence estimates of LLMIC youth mental health disorders. By conducting a prevalence
170 systematic review, this review serves to answer the unknown measured burden to make practical
171 implications on policy, planning, decision-making, and future research on LMIC youth's mental health
172 alongside anticipated EWEs to come.

173

174 **2. Methods**

175 This systematic review was conducted in accordance with the most recently updated 2020 Preferred
176 Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. For best practice in
177 transparency and eliminating bias, the protocol has been registered in the PROSPERO International
178 Prospective Register of Systematic Reviews (ID: CRD42024535106).

179

180 **2.1. Eligibility criteria**

181 The main characteristics of a prevalence study from the recommended CoCoPop mnemonic are as follows:
182 condition, context, and population [68].

183 Condition: The condition of interest was mental health disorders and their prevalence estimates. Mental
184 health outcomes measured using standardised and operationalised methods were eligible for inclusion [42,
185 69]. Only researcher-administered interviews directly on participants and self-administered questionnaires
186 were included. In other cases, the most recent version of Diagnostic and Statistical Manual of Mental
187 Disorders (DSM-5) and the International Classification of Diseases (ICD-10) acted as the guidelines to
188 define mental disorders [46, 70]. Studies reporting prevalence or data where prevalence could be
189 calculated were included.

190 Context: The context was LLMICs as defined under the World Bank Country Classifications by Income
191 (June 2023) [71] which was the latest version at the time of the study's protocol.

192 Population: The population of interest was children and adolescents who have experienced at least one
193 EWE. Children were defined as ages 1 to 10 and adolescents were defined as 11 to 19 [72, 73].
194 Identification of EWEs experienced followed the Peril Classification and Hazard Glossary (2014) [74].
195 Specifically, only EWEs listed under geophysical, hydrological, meteorological, and climatological
196 categories were included due to the nature of defining climate-induced weather events. Earthquakes
197 categorized under geophysical were also excluded for the same reasons.

198 Other criteria: Quantitative and mixed methods studies were included. Cross-sectional studies reporting
199 prevalence were included. Various types of publication were open for inclusion, including original studies,
200 full-text articles, conference data, and thesis publications. Only English studies were eligible for inclusion
201 with no limitations on published dates.

202

203 ***2.2. Information sources and search strategy***

204 The following electronic databases were used to retrieve studies using the search strategy: MEDLINE via
205 PubMed, PsychINFO, Web of Science Core Collection, Scopus, and CINAHL. Reference lists of included
206 studies were also screened after included studies were identified. Additional searches for unpublished
207 literature such as conference materials and theses repositories were searched on the ProQuest
208 Dissertations & Theses Citation Index and the Preprint Citation Index via Web of Science. These included
209 databases of BioRxiv and MedRxiv. Additionally, the first 20 pages of Google Scholar using keywords,
210 were hand-searched. All searches were done on June 6th, 2024, and are available in [Appendix B](#).

211

212 ***2.3. Selection process***

213 Database searches were conducted by the primary author (EC). Retrieved studies were imported into
214 Rayyan where duplicates were hand-removed. Screening followed two steps: first through titles and
215 abstracts, then, through full texts. Both stages were done by two reviewers (EC, ACS) independently and
216 blinded, then, through discussion to resolve any conflict. Any disagreements thereafter were resolved in
217 discussion with an intervening third reviewer (ME).

218 Two studies from the database searches were not available despite requesting it from corresponding
219 authors. Eight studies had insufficient data to calculate the prevalence of mental health disorders among
220 LLMIC children. The data was not stratified in line with this study's inclusion criteria (i.e. age group went
221 over 19 or tsunami and war conflict were grouped together). Corresponding authors for inaccessible and
222 insufficient articles were contacted for further information. Authors were emailed twice with at least two-

223 week intervals between. No responses were classified as “no author response” under [Appendix E](#)
224 alongside other reasons for exclusion.

225

226 **2.4. Data items and extraction**

227 A data extraction form ([Appendix C](#)) was developed in an excel sheet with five main headings: 1) Study
228 characteristics, 2) Population characteristics, 3) EWE exposure, 4) Mental health impacts & results, and 5)
229 Risk of Bias assessment. Data extraction was done blinded by the primary author and two reviewers (EC,
230 ACS, KR). Any disagreements thereafter were resolved with an intervening fourth reviewer (ME).

231

232 **2.5. Risk of bias quality assessment**

233 Risk of Bias (ROB) was assessed using the tool developed for prevalence studies by Hoy et al. (2012)
234 ([Appendix D](#)) to rate the internal and external validity of individual studies [75]. Studies were scored zero
235 points for “high risk” and one point for “low risk”, with an overall score out of ten. ROB assessments
236 were conducted by the primary author and two reviewers independently, blinded (EC, ACS, KR). Any
237 disagreements were resolved in discussion with an intervening fourth reviewer (ME).

238

239 **2.6. Data synthesis and analysis**

240 A meta-analysis was done using the statistical software R (version 4.2.3) and R studio (Windows 10+
241 version 2024.09.0+375). Prevalence estimates were pooled using a random effects model as high
242 heterogeneity was expected from variations in measuring mental health disorders. The Freeman Tukey
243 arcsine transformation was applied to stabilize the variance of unadjusted prevalence estimates and reduce
244 any impact of extreme values on the pooled estimates [76]. A pooled prevalence with 95% confidence
245 intervals was computed using the statistical software. Data was computed and presented in a forest plot
246 using the *meta* and *metafor* packages. A threshold of $p < 0.05$ was applied to all statistical tests to
247 determine significance.

248 Subgroups were stratified by age groups, types of EWEs, geographical region, time-points measured, and
249 standardization of measurement tools. Measurements were deemed standardized if the tool, usually in
250 forms of questionnaires or interviews, referenced or used DSM or ICD guidelines during the
251 measurement. Both guidelines were included as mental health measurements were predicted to use either
252 or. Prevalences were pooled by specific mental health disorders to avoid double counting sample
253 populations in studies where more than one disorder was reported. This was to address the possibilities in
254 over-weighing one study over others, treating any extreme influences on effect sizes and false positives,
255 especially prone when heterogeneity is high in subgroup analyses.

256 Heterogeneity between studies were identified by Higgins test for I^2 statistic and Cochran’s Q statistics. I^2
257 scores of 25%, 50%, and 75% were interpreted as low, moderate, and high heterogeneity respectively.
258 Where heterogeneity was present, sensitivity analyses were conducted to assess the impact of outlying
259 study results on the overall effect.

260

261 **2.7. Sensitivity analysis**

262 A leave-one-out test and influence diagnostics test were done to identify outliers and influential studies on
 263 the overall estimates. The influence diagnostics test assessed studies with potentially unusual or extreme
 264 estimates on 1) externally standardised residuals, 2) difference in fits values (DFFITs), 3) Cook’s distance,
 265 4) covariance ratios, 5) difference in fits of beta (DFBETAS), 6) leave-one-out statistics, and 7) hat values
 266 and weights [77]. A Baujat plot was created to identify studies contributing to the overall heterogeneity
 267 while also influencing the overall prevalence estimate.
 268

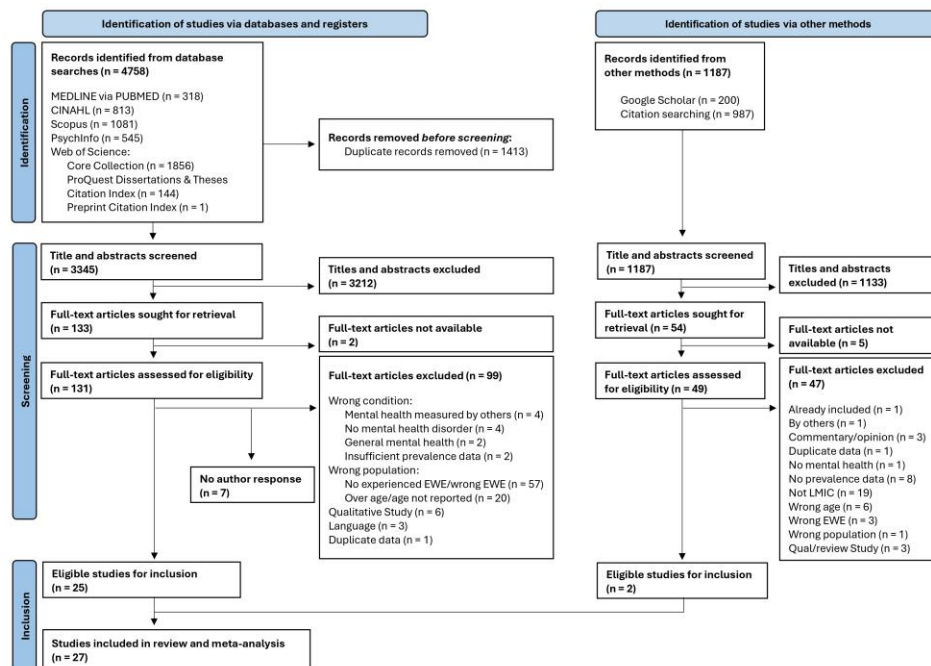
269 **2.8. Publication bias assessment**

270 Publication bias was considered in the screening stages by not limiting the searches to academic databases
 271 only and including non-peer reviewed articles in the screening stages. In the results stage, publication bias
 272 was addressed, as recommended by Wang (2018) and as previously done in other prevalence systematic
 273 reviews, through statistical tests of running Doi plots with LFK estimates and funnel plots with Egger’s
 274 test statistics ($p < 0.05$) [77-80].
 275

276 **3. Results**

277 **3.1. Search results and included studies**

278 The database searches yielded a total of 4758 articles, from which 1413 were removed following
 279 deduplication. Afterwards, 3345 titles and abstracts were screened, resulting in 131 articles assessed for
 280 full-text screening. With 99 articles excluded and seven without author responses, 25 articles were
 281 included. Other-source searches yielded an additional 1187 articles of which 49 were assessed for full-text
 282 screening and two studies were eligible for inclusion. Combined, a total of 27 studies (25 from database
 283 and two from other sources) were eligible for inclusion (Fig. 1).



284 **Fig. 1 PRISMA flow chart of study searches**
 285

286 **3.2. Key characteristics**

287 A summary of the included studies is shown in Table 1, with the full data extraction chart available under
 288 [Appendix F](#). Studies included were published between 2001 and 2024, and more than half were published
 289 in 2010 and onwards (74.1%).

290

291 **Table 1.** Summary of Key Characteristics of Included Studies by Mental Health Disorders

Author/Year	Country ¹	Regional Classification	Sample Size (n)	Age Range (years)	Extreme Weather Event	Measurement Tools	Risk of Bias Rating
Studies reporting PTSD							
Agustini et al., 2011 [81]	Indonesia	EAP	482	11-19	Tsunami	Child Post-Traumatic Stress Reaction Index	Low
Ahmad et al., 2011 [82]	Pakistan	South Asia	522	10-16	Flood	Impact of Event Scale-Revised	Low
Chung et al., 2017 [83]	Pakistan	South Asia	30	13-18	Flood	Posttraumatic Stress Diagnostic Scale (meets DSM-IV criteria)	Moderate
Dass-brailsford et al., 2022 [84]	Haiti	LAC	77	14-17	Hurricane	The University of California at Los Angeles PTSD Reaction Index for children and adolescents (meets DSM-5 criteria)	Moderate
Dawson et al., 2014 [85]	Indonesia	EAP	110	7-13	Tsunami	Children’s Revised Impact Event Scale-13 (meets DSM-IV criteria)	Low
Exenberger et al., 2019 [86]	India	South Asia	164	8-17	Tsunami	Children’s Revised Impact Event Scale-13 – Tamil version (meets DSM-IV criteria)	Moderate
Goenjian et al., 2001 [87]	Nicaragua	LAC	158	11-13	Hurricane	Child PTSD-Reaction Index (meets DSM-IV criteria)	Low
Irwanto et al., 2015 [88]	Indonesia	EAP	262	7-13	Tsunami	Child PTSD Symptom Scale & diagnosis using DSM-IV	Low
John et al., 2007 [89]	India	South Asia	502	5-18	Tsunami/flood	Child Behaviour Checklist Post Traumatic Stress Disorder Scale - Tamil Revised and Impact of Events Scale 8-item version (meets DSM-IV criteria)	Low
Kar & Bastia, 2006 [90]	India	South Asia	108	14-16	Super-cyclone	Mini International Neuropsychiatric Interview for children and adolescents & diagnosis using DSM-IV	Low
Kar et al., 2007 [91]	India	South Asia	447	7-17	Super-cyclone	Interview with psychiatrist, ICD-10-DCR questionnaire	Low
Mathew et al., 2021 [92]	India	South Asia	670	15-18	Flood/landslides	Trauma Screening Questionnaire (meets DSM-IV criteria)	Low

Mordeno et al., 2016 [93]	Philippines	EAP	632	16-19	Typhoon	PTSD checklist for DSM-5	Moderate
Neuner et al., 2006 [94]	Sri Lanka	South Asia	173	8-14	Tsunami	The University of California at Los Angeles PTSD Reaction Index (meets DSM-IV criteria)	Moderate
Nisha et al., 2014 [95]	India	South Asia	268	13-16	Flood	Trauma Screening Questionnaire	Moderate
Ponnamperuma & Nicolson, 2016 [96]	Sri Lanka	South Asia	187	12-16	Tsunami	The University of California at Los Angeles PTSD Reaction Index for DSM-IV, adolescent version	Low
Sana & Khattak, 2014 [97]	Pakistan	South Asia	35	7-17	Flood	Post-Traumatic Stress Scale	Low
Shah et al., 2022 [98]	Pakistan	South Asia	100	9-11	Flood	Pre-tested questionnaire	Low
Siddik et al., 2024 [99]	Bangladesh	South Asia	53	14-17	Flood	PTSD-2	Low
Sitwat et al., 2015 [100]	Pakistan	South Asia	205	13-19	Flood	Psychologist diagnosis based on DSM-IV-TR criteria	Low
Soysa, 2013 [101]	Sri Lanka	South Asia	60	12-14	Tsunami	Harvard Trauma Questionnaire (meets DSM-IV criteria)	Low
Vijayakumar et al., 2006 [102]	India	South Asia	230	11-14	Tsunami	Child Post-Traumatic Stress Reaction Index	Low
Wickrama & Kaspar, 2007 [103]	Sri Lanka	South Asia	325	12-19	Tsunami	DSM-IV diagnostic interview items	Low
Wiguna et al., 2010 [104]	Indonesia	EAP	2094	4-18	Tsunami	Strength and Difficulties Questionnaire & DSM-IV criteria interview with psychiatrists	Low
Studies reporting depression							
Chung et al., 2017 [83]	Pakistan	South Asia	30	13-18	Flood	General Health Questionnaire-28	Moderate
Dass-brailsford et al., 2022 [84]	Haiti	LAC	77	14-17	Hurricane	Centre for Epidemiological Studies Depression Scale for Children	Moderate
Dawson et al., 2014 [85]	Indonesia	EAP	110	7-13	Tsunami	Short Mood and Feelings Questionnaire	Low
Goenjian et al., 2001 [87]	Nicaragua	LAC	158	11-13	Hurricane	Depression Self-Rating Scale (meets DSM-IV criteria)	Low
Kar & Bastia, 2006 [90]	India	South Asia	108	14-16	Super-cyclone	Mini International Neuropsychiatric Interview for children and adolescents & diagnosis using DSM-IV	Low
Kar et al., 2007 [91]	India	South Asia	447	7-17	Super-cyclone	Interview with psychiatrist, ICD-10-DCR questionnaire	Low

Prencipe et al., 2021 [45]	Tanzania	SSA	796	14-19	Flood/drought	10-item Centre for Epidemiological Studies Depression Scale	Low
Shah et al., 2022 [98]	Pakistan	South Asia	100	9-11	Flood	Pre-tested questionnaire	Low
Siddik et al., 2024 [99]	Bangladesh	South Asia	53	14-17	Flood	Patient Health Questionnaire-7	Low
Sitwat et al., 2015 [100]	Pakistan	South Asia	205	13-19	Flood	Psychologist diagnosis based on DSM-IV-TR criteria	Low
Wiguna et al., 2010 [104]	Indonesia	EAP	2094	4-18	Tsunami	Strength and Difficulties Questionnaire & DSM-IV criteria interview with psychiatrists	Low
Studies reporting anxiety							
Chung et al., 2017 [83]	Pakistan	South Asia	30	13-18	Flood	General Health Questionnaire-28	Moderate
Kar & Bastia, 2006 [90]	India	South Asia	108	14-16	Super-cyclone	Mini International Neuropsychiatric Interview for children and adolescents & diagnosis using DSM-IV	Low
Kar et al., 2007 [91]	India	South Asia	447	7-17	Super-cyclone	Interview with psychiatrist, ICD-10-DCR questionnaire	Low
Shah et al., 2022 [98]	Pakistan	South Asia	100	9-11	Flood	Pre-tested questionnaire	Low
Sitwat et al., 2015 [100]	Pakistan	South Asia	205	13-19	Flood	Psychologist diagnosis based on DSM-IV-TR criteria	Low
Vijayakumar et al., 2006 [102]	India	South Asia	230	11-14	Tsunami	Youth Self-Rating Form of the Child Behaviour Checklist Tamil version (meets DSM-IV criteria)	Low
Studies reporting distress							
Aneelraj et al., 2015 [105]	India	South Asia	300	5-19	Flood/landslides	Impact of Event Scale & diagnostic interviews using ICD-10	Moderate
Shah et al., 2022 [98]	Pakistan	South Asia	100	9-11	Flood	Pre-tested questionnaire	Low
Studies reporting suicidal ideation							
Kar et al., 2007 [91]	India	South Asia	447	7-17	Super-cyclone	Interview with psychiatrist, ICD-10-DCR questionnaire	Low
Randeniya, 2017 [106]	Sri Lanka	South Asia	50	14-16	Flood	Piloted questionnaire	Moderate
Studies reporting sleeping disorders							
Randeniya, 2017 [106]	Sri Lanka	South Asia	50	14-16	Flood	Piloted questionnaire	Moderate
Shah et al., 2022 [98]	Pakistan	South Asia	100	9-11	Flood	Pre-tested questionnaire	Low
Study reporting grief							
Dawson et al., 2014 [85]	Indonesia	EAP	110	7-13	Tsunami	Prolonged Grief Disorder-13 Child Version (meets DSM-IV)	Low

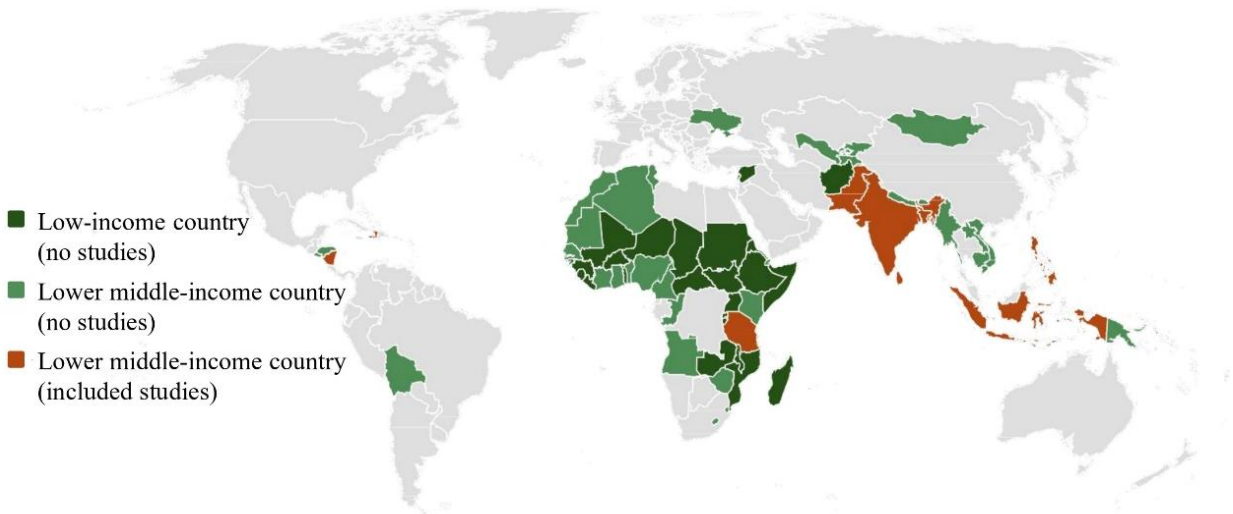
Study reporting stress							criteria)
Randeniya, 2017 [106]	Sri Lanka	South Asia	50	14-16	Flood	Piloted questionnaire	Moderate
¹ All studies were from lower middle-income countries and none from low-income countries. EAP: East Asia & Pacific; GAD: General anxiety disorder; LAC: Latin America & Caribbean; MDD: Major depressive disorder; PTSD: Post-traumatic stress disorder; SSA: Sub-Saharan Africa							

292

293 In summary, numerous studies reported more than one mental health disorder (44.4%). The most common
 294 were PTSD (88.9%), followed by depression (40.7%) and anxiety (22.2%). Distress, suicidal ideation,
 295 and sleeping disorders by two studies each (7.4%). Prolonged grief disorder and stress were reported
 296 separately by one study each (3.7%). Studies referencing a standardized mental health diagnostic
 297 classification guideline of either DSM or ICD in their measurement tools were 55.6%, whereas eight did
 298 not (29.6%). Four main EWEs were reported. From most to least reported, EWEs are as follows: 40.7%
 299 of studies on tsunamis, 29.6% on floods, 7.4% on flood/landslides, 7.4% on hurricanes, 7.4% on super-
 300 cyclones, and flood/drought and typhoon each accounting for 3.7%.

301 For age, six studies (22.2%) reported an age range falling in between childhood and adolescence (1 to 19
 302 years of age). Only four studies (14.8%) reported separately for children (1 to 10 years of age), whereas
 303 21 studies (77.8%) reported separately for adolescents (11 to 19 years of age). For measurement time-
 304 points, aside from the three studies (11.1%) that did not report, the most popular time point measurement
 305 was three to 11 months following an EWE (33.3%).

306 By region, 19 studies were from South Asia, followed by five from East Asia & Pacific (EAP), two from
 307 Latin America & Caribbean (LAC), and one from Sub-Saharan Africa (SSA). All studies were from lower
 308 middle-income countries, and none from low-income countries (LICs) (Fig. 2).



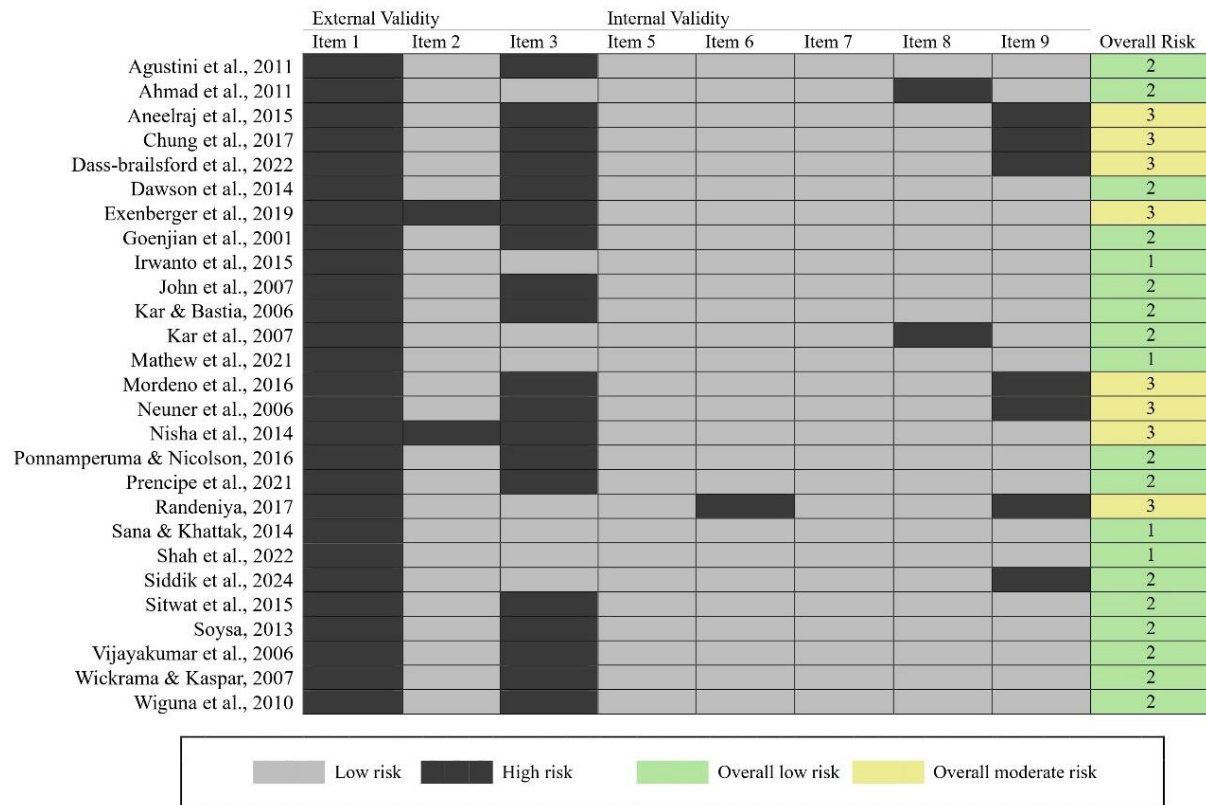
309

310 *Fig. 2 Map of study origins by country and World Bank Income Classifications (low- and lower middle-income*
 311 *countries only)*

312

313 **3.3. Risk of bias quality assessment**

314 Items four and ten from the Hoy et al. risk of bias tool were omitted due its lack of relevancy for the
 315 included studies. Studies scored between two and three on a range of one to eight, signifying moderate
 316 and low risk of bias (Fig. 3). In reference to other studies scoring methods, 0-2 was deemed low risk, 3-4
 317 as moderate risk, ≥ 5 as high risk.



From the Risk of Bias Tool by Hoy et al. (2012), items 4 and 10 have been omitted since they are not applicable to the included studies for this review.
 Overall grading: 0-2 = low risk, 3-4 = moderate risk, $5 \leq$ = high risk.

318
 319 **Fig. 3 Risk of bias of included studies**

320

321 Most studies were low risk (70.4%) and 29.6% were moderate risk. All studies collected directly from
 322 subjects (item 5) and used validated the instruments measuring disorders either through pre-testing,
 323 piloting, data-triangulation, referencing of standardized guidelines, and/or the referencing of previous
 324 studies where tools were already validated (item 7). All but one study had acceptable case definitions
 325 (96.0%; item 6), while 92.6% had a sampling frame representative to the target population (item 2) and
 326 used the same mode of data collection for all subjects (item 8).

327 In contrast, no studies had a target population representative of the national population (item 1), 70.4%
 328 did not use random selection (item 3), and 25.9% had prevalence periods that were not appropriate for the
 329 parameter of interest (item 9). For external and internal validity, items 1 to 3 measuring external validity
 330 showed 59.3% high risk compared to internal validity, measured by items 5 to 9 showing 7.4% high risk.

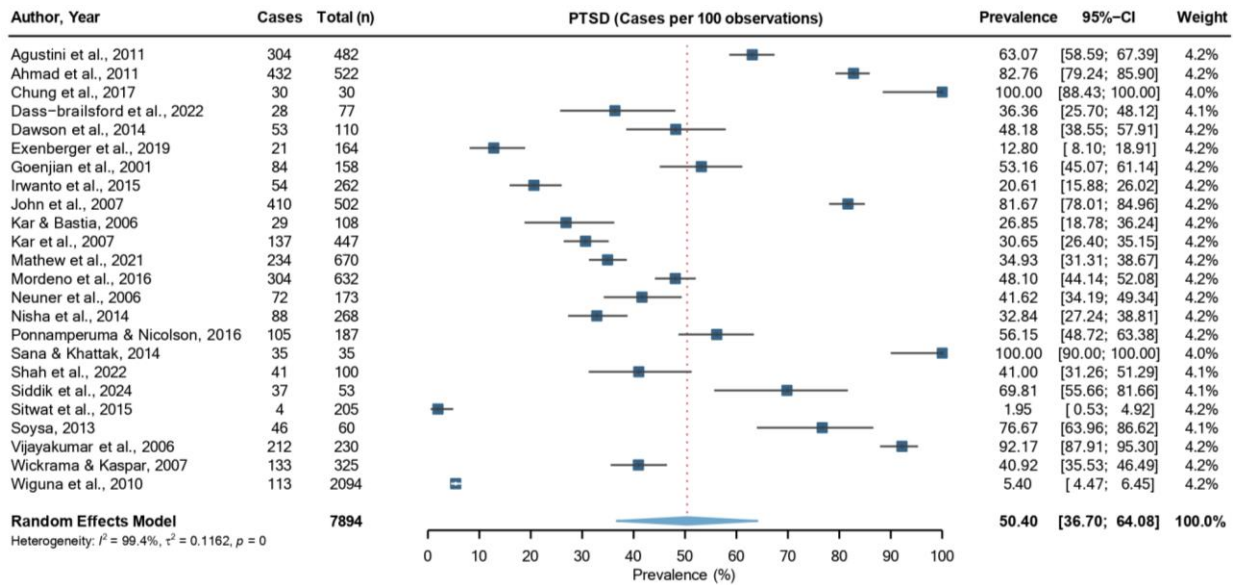
331 **3.4. Findings of mental health disorder prevalences**

332 All 27 studies (N = 14239) were included in the meta-analysis presenting 29 mental health outcome
 333 measurements. Grief and stress were only reported once and were excluded from the meta-analysis.

334

335 **3.4.1. Prevalence of PTSD**

336 PTSD was the most measured mental health outcome with 24 studies reporting the prevalence of PTSD in
 337 a total population of 7894 children and adolescents. The pooled prevalence was 50.4% (95% CI: 36.6-
 338 64.1) with high heterogeneity between studies ($I^2 = 99.4%$) as shown in Fig. 4.

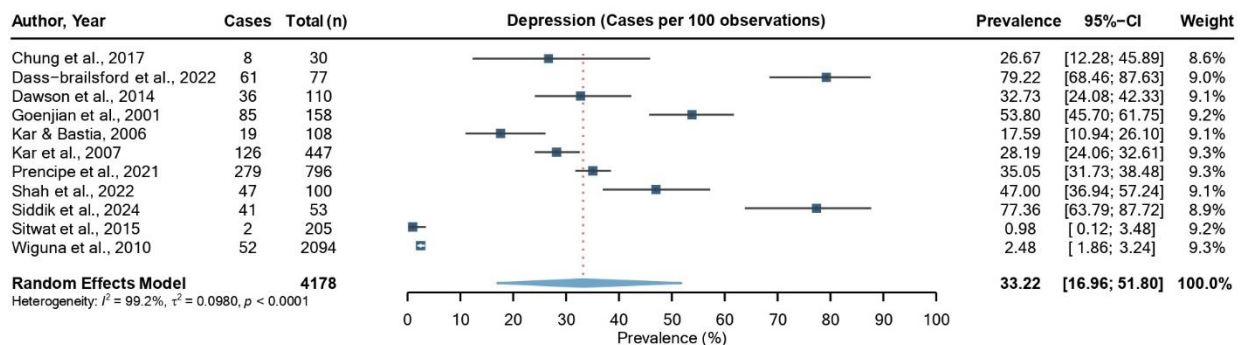


339 **Fig. 4 Forest plot of pooled prevalence of PTSD**

341

342 **3.4.2. Prevalence of depression**

343 Following PTSD, depression was the second-most reported mental health outcome with 4178 participants
 344 from 11 studies reporting the prevalence of 33.2% (95% CI: 17.0-51.8). Heterogeneity was also high at I^2
 345 of 99.2% (Fig. 5).

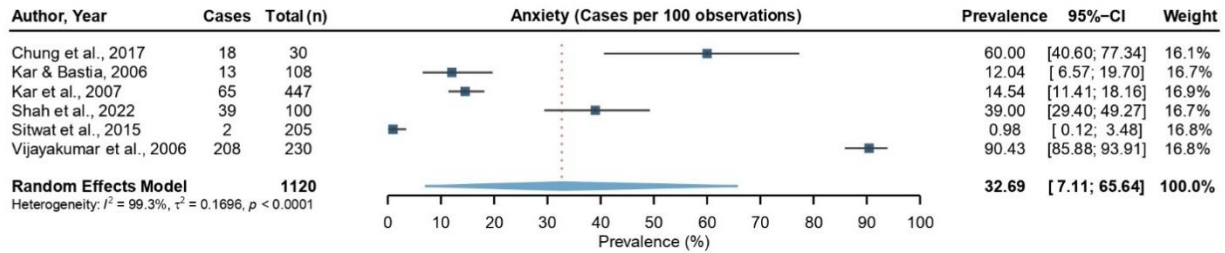


346 **Fig. 5 Forest plot of pooled prevalence of depression**

348

349 **3.4.3. Prevalence of anxiety**

350 Anxiety was prevalent in 32.7% (95% CI: 7.1-65.6) of 1120 participants reported from six studies (Fig. 6).
 351 Heterogeneity was significantly high ($I^2 = 99.3\%$).

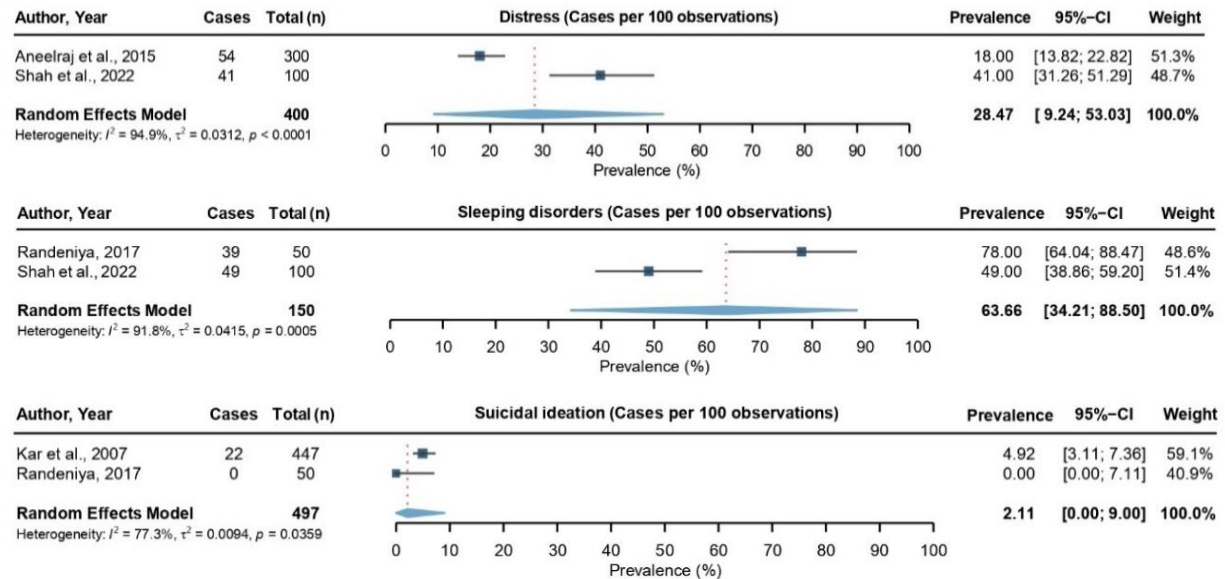


352
 353 **Fig. 6** Forest plot of pooled prevalence of anxiety

354

355 **3.4.4. Prevalence of distress, sleeping disorders, and suicidal ideation**

356 Mental health outcomes of distress, sleeping disorders, and suicidal ideation had each two studies.
 357 Amongst the three outcomes, sleeping disorders had the highest prevalence of 63.7% (95% CI: 34.2-88.5;
 358 $I^2 = 91.8\%$) (Fig. 7). In a population of 400, 28.5% had distress (95% CI: 9.2-53.0; $I^2 = 94.9\%$). Lastly,
 359 suicidal ideation had the lowest prevalence of 2.1% among a population of 497 (95% CI: 0.0-9.0; $I^2 =$
 360 77.3%).



361
 362
 363
 364 **Fig. 7** Forest plots of pooled prevalence of distress, sleeping disorders, and suicidal ideation

365

366 **3.5. Subgroup analysis**

367 Sub-group analyses were conducted for anxiety, depression, and PTSD. The summary of statistics from
 368 sub-group analyses is in Table 2. Forest plots of subgroup analyses by type of EWE and time point
 369 measured are available in [Supplementary file 1](#).

370

371 **Table 2.** Summary of statistics from sub-group analyses

Sub-groups		N of studies	Sample size	Cases	Prevalence % (95% CI)	Heterogeneity		Test for sub-group differences	
						p-value	I ² (%)	X ²	p-value
Anxiety									
<i>Age</i>	-	-	-	-	-	-	-	-	-
<i>Extreme weather event</i>	Flood	3	335	59	27.06 (0.32 - 71.59)	<0.01	98	0.50	0.48
	Super-cyclone	2	555	78	13.97 (11.18 - 17.00)	0.54	0		
<i>Region</i>	-	-	-	-	-	-	-	-	-
<i>Measurement tool</i>	Standardized	4	990	288	25.34 (0.00 - 72.60)	<0.01	100	0.77	0.38
	Non-standardized	2	130	57	47.96 (28.13 - 66.12)	0.04	75		
<i>Time point measured</i>	-	-	-	-	-	-	-	-	-
Depression									
<i>Age</i>	-	-	-	-	-	-	-	-	-
<i>Extreme weather event</i>	Flood	5	1184	377	33.72 (9.06 - 64.32)	<0.01	98	10.04	0.02
	Hurricane	2	235	146	66.80 (40.50 - 88.51)	<0.01	93		
	Super-cyclone	2	555	145	23.30 (13.92 - 34.22)	0.02	81		
	Tsunami	2	2204	88	13.76 (0.00 - 53.99)	<0.01	99		
<i>Region</i>	East Asia & Pacific	2	2204	88	13.76 (0.00 - 53.99)	<0.01	99	6.42	0.04
	Latin America & Caribbean	2	235	146	66.80 (40.50 - 88.51)	<0.01	93		
	South Asia	6	943	243	29.57 (9.44 - 54.99)	<0.01	98		
<i>Measurement tool</i>	Standardized	5	3012	284	16.25 (2.29 - 39.01)	<0.01	99	5.11	0.02
	Non-standardized	6	1166	472	50.01 (31.35 - 68.67)	<0.01	95		
<i>Time point measured</i>	1-2 months	2	83	49	52.86 (8.03 - 94.97)	<0.01	95	1.52	0.68
	3-11 months	2	363	87	20.04 (0.00 - 84.63)	<0.01	99		
	1 year	3	3337	457	18.92 (2.50 - 45.49)	<0.01	100		
	> 1 year	2	218	55	24.79 (11.63 - 40.86)	0.01	85		
PTSD									
<i>Age</i>	1 to 10	3	498	97	19.34 (15.95 - 22.97)	0.59	0	15.32	<0.01
	11 to 19	18	5049	2112	48.38 (33.65 - 63.25)	<0.01	99		
<i>Extreme weather event</i>	Flood	8	1883	901	60.84 (29.12 - 88.26)	<0.01	99	9.88	0.02
	Hurricane	2	235	112	45.21 (29.26 - 61.67)	0.02	83		
	Super-cyclone	2	555	166	29.86 (26.10 - 33.75)	0.45	0		
	Tsunami	11	4589	1523	48.44 (29.72 - 67.38)	0	100		
<i>Region</i>	East Asia & Pacific	5	3580	828	34.75 (14.28 - 58.71)	<0.01	100	2.01	0.37
	Latin America & Caribbean	2	235	112	45.21 (29.26 - 61.67)	0.02	83		
	South Asia	17	4079	2066	55.86 (38.05 - 72.94)	<0.01	99		
<i>Measurement tool</i>	Standardized	17	6204	1857	41.10 (26.68 - 56.34)	0	99	5.12	0.02
	Non-standardized	7	1690	1149	72.31 (49.95 - 90.05)	<0.01	98		

<i>Time point measured</i>	1-2 months	4	758	494	74.26 (43.78 - 95.65)	<0.01	95	4.89	0.18
	3-11 months	9	2745	1466	56.98 (31.75 - 80.43)	<0.01	99		
	1 year	3	2771	462	41.62 (0.84 - 93.21)	<0.01	100		
	> 1 year	6	1313	566	36.94 (20.83 - 54.69)	<0.01	85		
PTSD: Post-traumatic stress disorder									

372

373 **3.5.1. Subgroup by extreme weather event**

374 For studies reporting anxiety outcomes, EWE subgroups were stratified into flood, tsunami, and super-
 375 cyclone. Variability in flood studies was high with prevalences ranging from 1.0% to 60.0%. In contrast,
 376 for studies reporting after super-cyclones, heterogeneity between two studies was 0% with a lower
 377 prevalence of 14.0% (95% CI: 11.2-17.0). Test for subgroup differences showed no significant differences
 378 between prevalences of anxiety following floods vs. super-cyclones ($x^2 = 0.5$, $p = 0.48$).

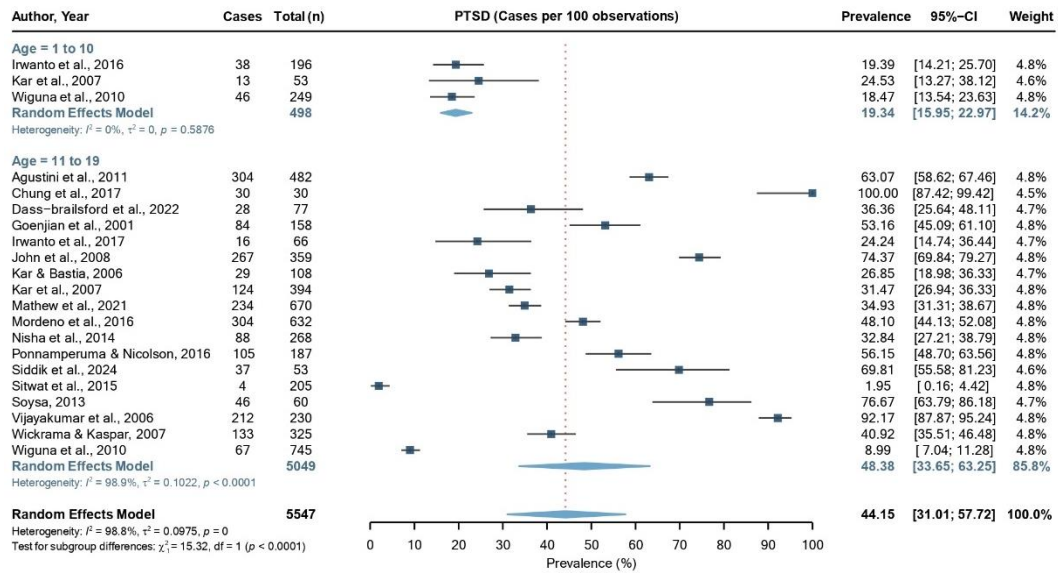
379 Among populations reporting depression, hurricanes had a significantly high prevalence of depression at
 380 66.8% (95% CI: 40.50-88.51). In contrast, prevalences for floods, tsunamis, and super-cyclones were
 381 similar at 33.7% (95% CI: 9.1-64.3), 25.4% (95% CI: 1.8-62.9), and 23.3% (95% CI: 13.9-34.2)
 382 respectively. Heterogeneity was significantly high at I^2 of 99.1%. Subgroup differences were present with
 383 x^2 of 10.04 and p-value of 0.02.

384 Among populations reporting PTSD, the pooled prevalence was the highest in the flood subgroup with
 385 60.8% prevalent with PTSD (95% CI: 29.12-88.26). Flood was followed by tsunami (48.4%), then
 386 hurricane (45.2%), and lastly, super-cyclones (29.9%). Heterogeneity in all sub-groups were significantly
 387 high above 90% except for the 2 super-cyclone studies where no heterogeneity was present. PTSD
 388 showed subgroup differences with x^2 of 9.9 and p-value of 0.02.

389

390 **3.5.2. Subgroup by age**

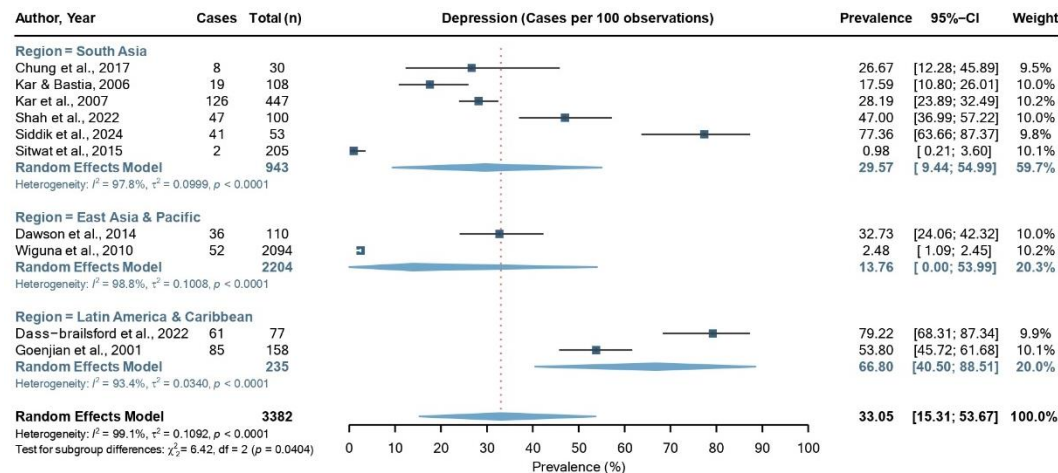
391 PTSD was the only mental health disorder stratified by age (Fig. 8). Ages were divided into two groups:
 392 children vs. adolescents. PTSD was prevalent in 19.3% of children (95% CI: 16.0-23.0) and 48.4% of
 393 adolescents (95% CI: 33.7-63.3). Among the three studies reporting PTSD in children, there was no
 394 heterogeneity present. In contrast, the 18 studies reporting PTSD in adolescents, heterogeneity was
 395 significant at 98.9%. The test for subgroup showed significant differences with x^2 of 15.3 and p-value of
 396 <0.0001.



397
398 **Fig. 8** Forest plot of subgroup analysis on PTSD outcomes associated with age
399

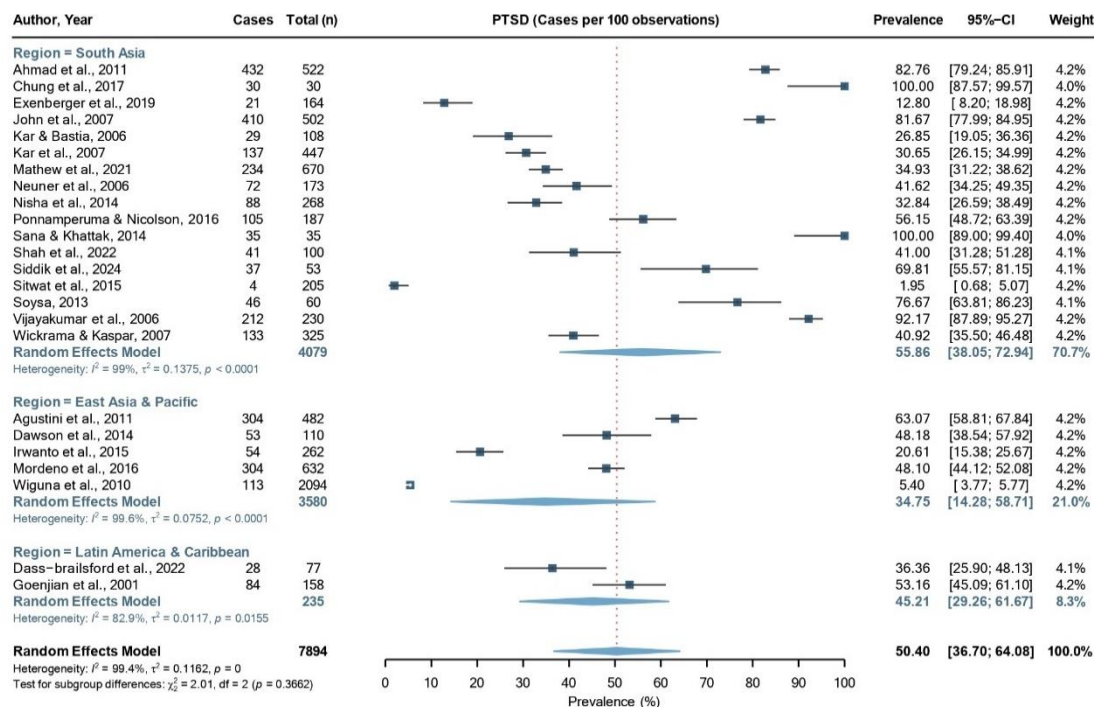
400 3.5.3. Subgroup by region

401 Subgroup analyses for regions were conducted for depression (Fig. 9) and PTSD (Fig. 10). Depression
402 was prevalent in 66.8% of LAC studies (95% CI: 40.5-88.5), 29.6% of South Asian studies (95% CI: 9.4-
403 55.0), and 13.8% of EAP studies (95% CI: 0.0-54.0). Heterogeneity was significant in all subgroups ($I^2 =$
404 $>90\%$). Subgroups were also significantly different with χ^2 of 6.4 and p-value of 0.04.



405
406 **Fig. 9** Forest plot of subgroup analysis on depression outcomes associated with region
407

408 The pooled prevalence of PTSD in South Asian studies was 55.9% (95% CI: 38.1-72.9), followed by 45.2%
409 of LAC studies (95% CI: 29.3-61.7), and 34.8% of EAP studies (95% CI: 14.3-58.7). Heterogeneity was
410 significant in all three groups ($I^2 = >80\%$). There were no significant differences found ($\chi^2 = 2.0$, $p =$
411 0.37).



412
413 **Fig. 10** Forest plot of subgroup analysis on PTSD outcomes associated with region

414
415 **3.5.4. Subgroup by time point measured**

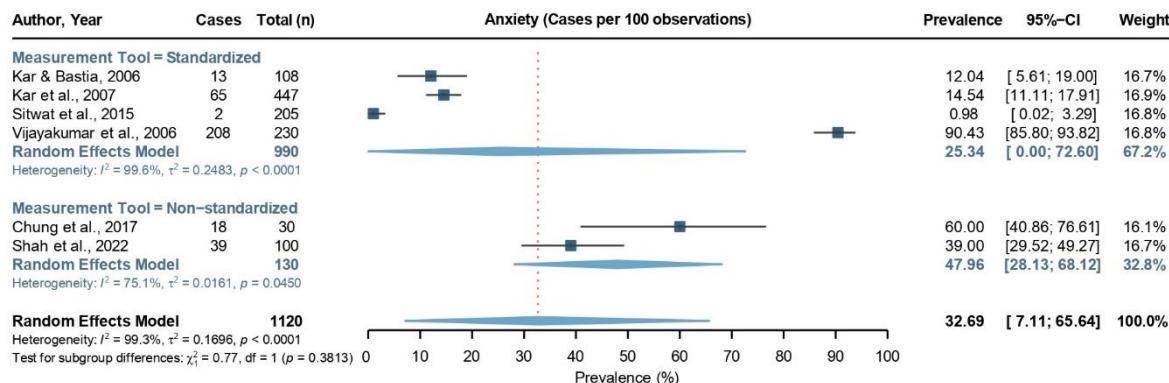
416 Depression and PTSD were analysed on time point measurements. One study was omitted in both
417 depression and PTSD subgroups due to an extensively wide time frame (EWE exposures ranging from
418 five to ten years ago were accounted for). Highest prevalences for depression were recorded at
419 measurement points of one to two months following EWEs at 52.9% (95% CI: 8.0-95.0). The lowest
420 prevalence of depression was recorded one year after EWEs with a prevalence of 18.9% (95% CI: 2.5-
421 45.5). Heterogeneity was high at I^2 of 100.0%. There were no differences between subgroups ($\chi^2 = 1.5$,
422 $p = 0.68$).

423 The highest prevalence for PTSD was also recorded one to two months following EWEs at 74.3% (95%
424 CI: 43.8-95.7). Prevalences decreased as measurement time points increased. Three to 11 months
425 following EWEs recorded a prevalence of 57.0% (95% CI: 31.8-80.4), followed by measurements after
426 one year resulting in a prevalence of 41.6% (95% CI: 0.8-93.2), and measurements taken over a year after
427 resulting in the lowest prevalence of 36.9% (95% CI: 20.8-54.7). Overall, heterogeneity was significantly
428 high at I^2 of over 95%. Subgroup differences were not present ($\chi^2 = 4.9$, $p = 0.18$).

429
430 **3.5.5. Subgroup by measurement tool**

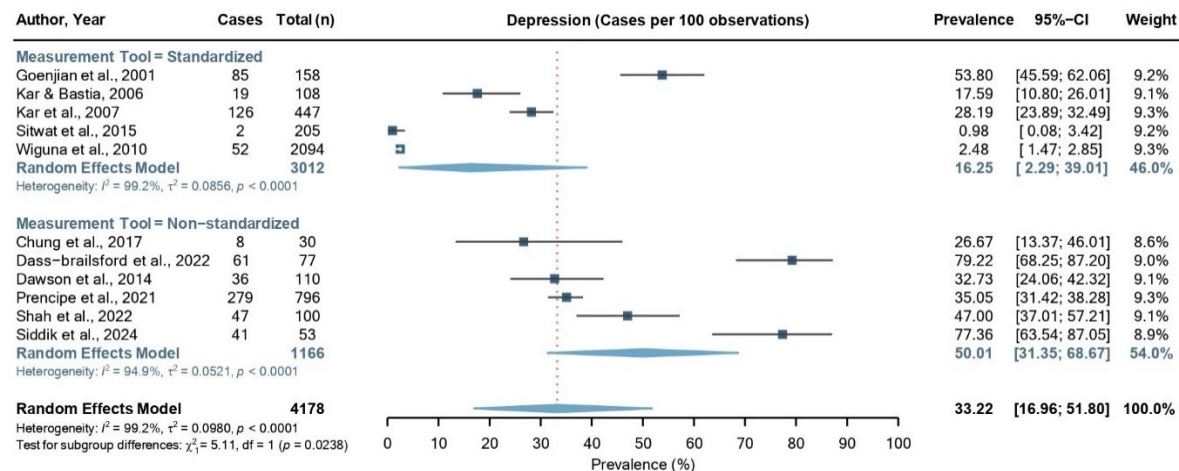
431 Out of six studies measuring anxiety, four used measurement tools that had standardized guidelines (ICD
432 and DSM) and two did not. The pooled prevalence for using standardized tools was 25.3% (95% CI: 0.0-
433 72.6) (Fig. 11). Given the wide confidence interval, heterogeneity was significantly present at 99.6%.
434 Studies that had non-standardized measurements resulted in a pooled prevalence of 48.0% (95% CI: 28.1-

435 68.1), and heterogeneity was lower in this subgroup, but still high at 75.1%. No significant subgroup
 436 differences were detected ($\chi^2 = 0.8, p = 0.38$).



437
 438 **Fig. 11** Forest plot of subgroup analysis on anxiety outcomes associated with measurement tool standardization
 439

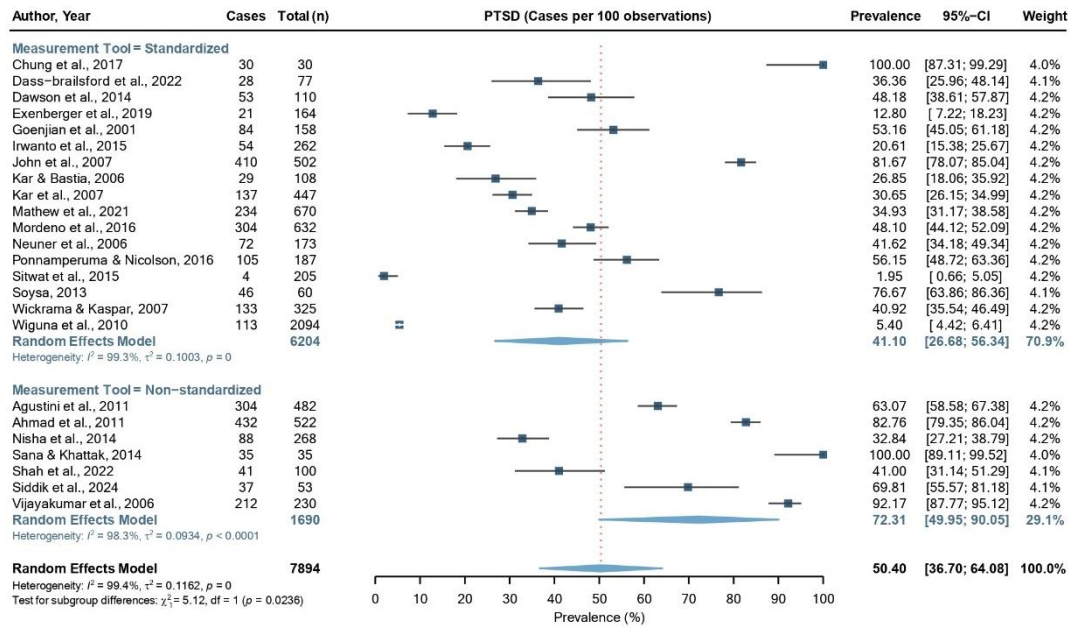
440 Out of 11 studies measuring depression, five studies used measurement tools with standardized guidelines
 441 and six did not. Studies that had standardized guidelines to support their measurement tools had a pooled
 442 prevalence of 16.3% (95% CI: 2.3-39.0), whereas studies that were non-standardized had a pooled
 443 prevalence of 50.0% (95% CI: 31.4-68.9) (Fig. 12). Heterogeneity was significant in both standardized
 444 and non-standardized groups, resulting in an I^2 of 99.2% and 94.9% respectively. The pooled prevalence
 445 of depression from non-standardized studies was more than three times higher than standardized studies.
 446 Notably, subgroup differences were present with χ^2 of 5.1 and p-value of 0.02.



447
 448 **Fig. 12** Forest plot of subgroup analysis on anxiety outcomes associated with measurement tool standardization
 449

450 Out of 24 studies measuring PTSD, 17 studies used measurement tools with standardized guidelines and 7
 451 did not. A total of 41.1% prevalence of PTSD was pooled for standardized studies (95% CI: 26.7-56.3),
 452 and 72.3% was pooled for non-standardized studies (95% CI: 50.0-90.1) (Fig. 13). Heterogeneity was
 453 significantly high in both groups, 99.3% and 98.3% respectively. Likewise, to the prevalences of anxiety
 454 and depression, PTSD also showed lower prevalences in the standardized group vs. the non-standardized

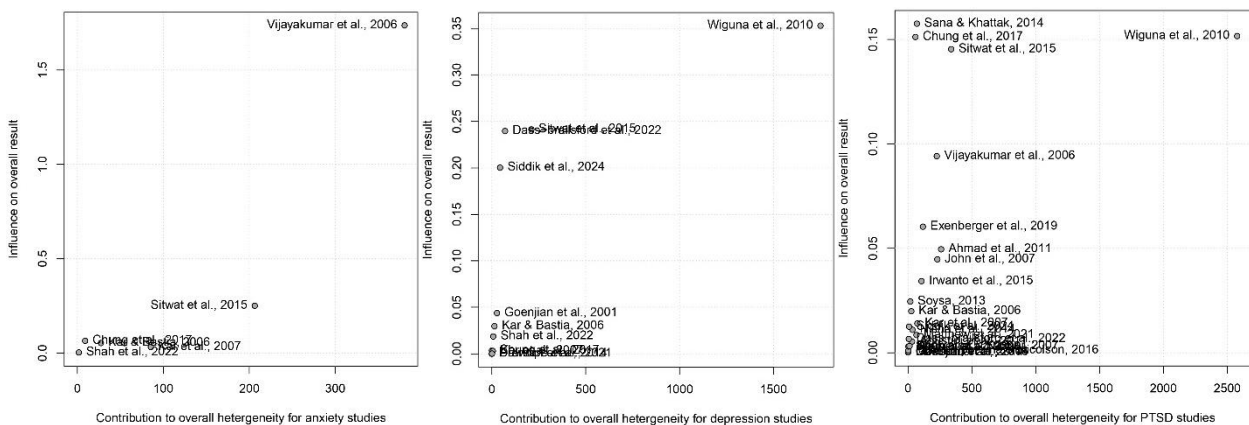
455 group. For PTSD, the non-standardized studies' prevalence was almost double the standardized studies'
 456 prevalence. As a result, subgroup differences were present with χ^2 of 5.1 and p-value of 0.02.



457
 458 **Fig. 13** Forest plot of subgroup analysis on PTSD outcomes associated with measurement tool standardization

459
 460 **3.6. Sensitivity analysis**

461 A sensitivity analysis on risk of bias (Supplementary file 2) showed no differences between low risk vs.
 462 moderate risk. Heterogeneity was consistently significant in all subgroups of low and moderate risk for all
 463 analyses for anxiety, depression, and PTSD. Outlier studies identified from Baujat plots (Fig. 14),
 464 influence diagnostic tests (Supplementary file 3), and leave-one-out analyses (Supplementary file 4) were
 465 removed (table 3) and heterogeneity remained high ($I^2 > 89\%$). Post-hoc analysis was conducted on the
 466 outlier studies to evaluate contributing factors to the high heterogeneity. Additional analyses were done on
 467 whether studies' measurements were diagnosis-based vs. symptomatic based, whether they were small
 468 sample size studies (<50), and whether studies reported varying symptom severity levels (i.e. moderate or
 469 severe) vs. presence or absence of disorders.



470
 471 **Fig. 14** Baujat plots for anxiety, depression, and PTSD

472 **Table 3.** Summary of results from plots and statistical tests identifying outliers and influential studies

	Baujat Plot	Influence Diagnostic Test (z-score = 2.0)	Influence Diagnostic Test (z-score = 1.5)	Leave1Out Analysis
Anxiety	Vijayakumar [102]	Vijayakumar [102]	Vijayakumar [102]	Vijayakumar [102]
Depression	Wiguna [104]	-	Wiguna [104]	Wiguna [104]
	Sitwat [100]	-	Sitwat [100]	Sitwat [100]
	Dass-brailsford [84]	-	Dass-brailsford [84]	Dass-brailsford [84]
	Siddik [99]	-	Siddik [99]	Siddik[99]
PTSD	Wiguna [104]	-	Wiguna [104]	Wiguna [104]
	Sana [97]	Sana [97]	Sana [97]	Sana [97]
	Chung [83]	Chung [83]	Chung [83]	Chung [83]
	Sitwat [100]	Sitwat [100]	Sitwat [100]	Sitwat [100]
	Vijayakumar [102]	-	Vijayakumar [102]	Vijayakumar [102]

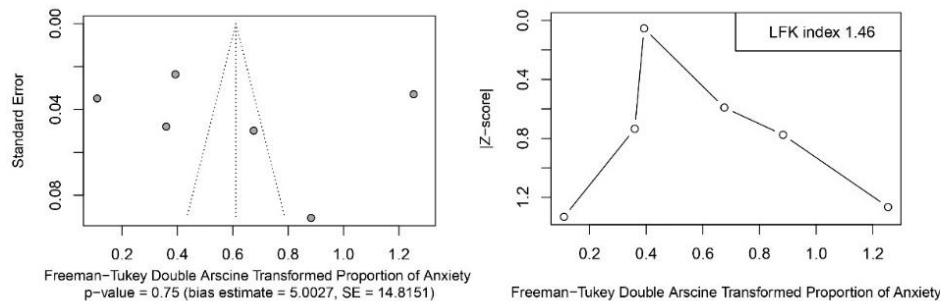
473

474 Several studies had high prevalences when inclusion was broadened to moderate and severe, instead of
 475 only severe cases [83, 97, 102]. Other studies also had combined prevalences that were not identified as
 476 outliers, and therefore, outlier studies did not have enough reason for exclusion in further analyses.
 477 Additionally, two studies reporting lower prevalences mentioned that mental disorders were based on
 478 clinical diagnosis [100, 104]. Other studies reported that cases were based on symptomatic/probable
 479 diagnosis or were measured using tools that had diagnostic purposes. Lastly, two studies had no particular
 480 reason found [84, 99].

481

482 **3.7. Publication bias**

483 Two outlier studies that had diagnostic differences were removed in tests for publication bias [100, 104].
 484 Tests were conducted first on the original data, then again with the outliers removed to observe the
 485 differences. For anxiety, no studies were excluded, and publication bias was not detected (Fig. 15). The
 486 funnel plot showed no asymmetry with a p-value of 0.75. The Doi plot showed moderate asymmetry, with
 487 a high LFK index of 1.5, showing potential risks to publication bias. A trim-and-fill method was applied
 488 to estimate potentially missing studies due to publication bias. However, no studies were added,
 489 confirming the absence of publication bias.

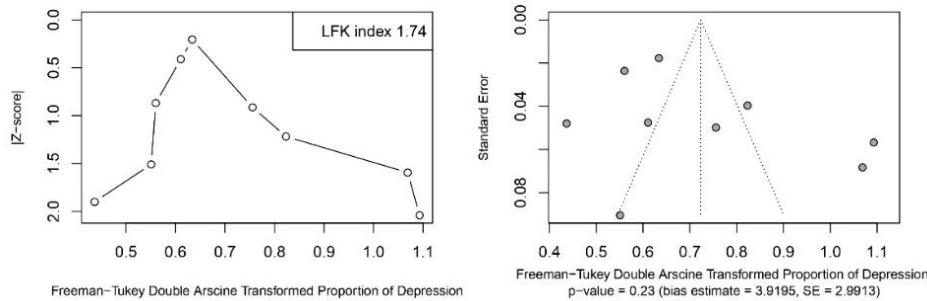


490
 491 **Fig. 15** Doi plot and Funnel plot of anxiety studies

492

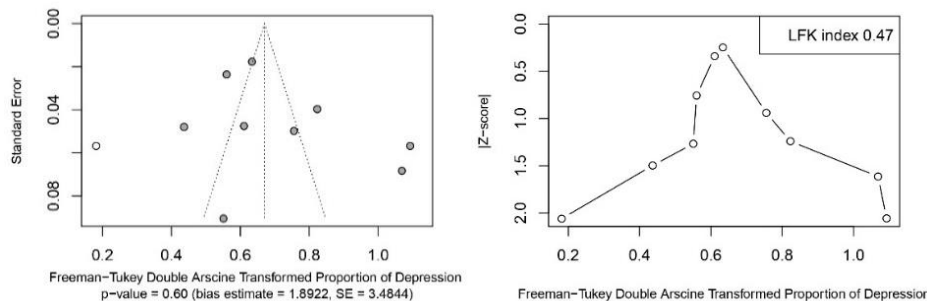
493 For depression and PTSD, without the removal of outliers, significant publication bias was detected. Both
 494 Doi and funnel plots showed asymmetry. The LFK index for depression was 3.6 with an Egger’s statistic
 495 of 0.03. For PTSD, the LFK index was 2.6 with an Egger’s statistic of 0.03 ([Supplementary File 5](#)).

496 In response, two outlier studies were excluded. For depression, the new LFK index was 1.7 with an
 497 Egger's statistic of 0.2 (Fig. 16). Although the Egger's statistic showed no presence of publication bias, a
 498 high LFK index showed potential risks to publication bias.



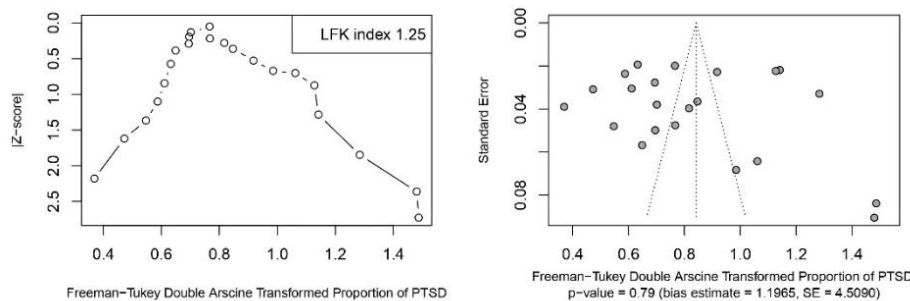
499
 500 **Fig. 16** Doi plot and funnel plot of depression studies after removal of outlier studies

501
 502 The trim-and-fill resulted in an addition of one study, altering the prevalence from 43.7% (95% CI: 32.7-
 503 55.1) to 38.5% (95% CI: 26.9-50.7), which is 5.3% higher than the original pooled prevalence of 33.2%.
 504 With the trim-and-fill the Doi plot was redone, resulting in a LFK index of 0.5. The new p-value with the
 505 trim-and-fill method was 0.60 with a bias estimate lower than the standard error, further validating the
 506 symmetry of no publication bias present (Fig. 17).



507
 508 **Fig. 17** Doi plot and funnel plot of depression studies after trim-and-fill method

509
 510 For PTSD, the exclusion of outlier studies resulted in an LFK index of 1.3 with an Egger's statistic of
 511 0.79 (Fig. 18). No studies were added in the trim-fill-method. The removal of the two outlier studies
 512 resulted in an increase of the original pooled prevalence of 50.4% to 55.7%.



513
 514 **Fig. 18** Doi plot and funnel plot of PTSD studies after removal of outlier studies

515 4. Discussion

516 4.1. Key findings

517 In response to the growing recognition of the mental health burdens LLMIC youth face following EWEs,
518 this review is the first to offer compelling evidence on how prevalent mental health disorders are among
519 the vulnerable population. PTSD, depression, and anxiety have been identified as the most reported and
520 prevalent, aligning with findings from previous LMIC studies [48, 107-114]. As reported in a 2019 study
521 on the global burden disease, 20% of youth experience mental health disorders, while a wide prevalence
522 range of 0-87% was observed from a LMIC youth review [111, 115]. In the LMIC youth review by
523 Yatham and colleagues, anxiety was prevalent up to 27%, depression up to 28%, and PTSD up to 87%
524 [109]. Conversely, this review's findings showed markedly higher rates of mental health disorders
525 compared to both youth's mental health burdens reported in the global and LMIC context. PTSD was
526 prevalent up to 100%, depression up to 79%, and anxiety up to 90% in this study assessing the same
527 youth but, only this time, on even more vulnerable LLMIC youth with the addition of EWEs. To add,
528 PTSD prevalences following floods in this review's findings were twice as prevalent (61%) compared to a
529 review with only UK studies (30%) [116] and another, with mostly studies from upper-middle-income
530 countries (29%) [117]. Notably, in contrast to previous findings, the significantly high prevalences found
531 in this study highlight the disproportionate impacts EWEs have on the mental health of LMIC youth.

532 As anticipated, heterogeneity was consistently high in this review, similar to previous systematic reviews
533 on mental health prevalences [117, 118]. Potential reasons for this may be attributed to the high variability
534 of mental health measurements which remain unstandardized, especially in LLMIC settings [119].
535 Although analyses were conducted to assess heterogeneity in the differences of measuring mental health
536 (i.e. looking at whether studies referenced standardized guidelines, measured diagnosis-based vs.
537 symptomatic-based, or reported varying symptom severity levels vs. presence/absence of disorders, etc.),
538 heterogeneity remained high. This shows the complexities in variability, not only in measurements of
539 mental health but also in the overall challenges to pooling mental health prevalences, especially in larger
540 settings like LLMICs. The high amount of variability arising from differing mental health measurements
541 alongside numerous influential factors and vulnerabilities may contribute to heterogeneity. To mitigate the
542 anticipated heterogeneity, it is worth noting that exploring various characteristics such as the varying
543 methods of measuring mental health disorders, is essential. Furthermore, despite such variabilities, it is
544 worth conducting research to face such challenges to identify directions future research must take.

545 Analyses of sub-groups showed the presence of influential factors that may exacerbate mental health
546 disorders, particularly when combined with the vulnerabilities unique to LLMIC youth. For example, this
547 review has identified notable findings of age and the type of EWE affecting PTSD, where PTSD
548 prevalences were higher among adolescents compared to children and floods compared to tsunamis,
549 super-cyclones, and hurricanes. For depression, higher prevalences were found following hurricanes and
550 among the LAC youth. Studies that referenced DSM or ICD when measuring mental health disorders
551 reported lower prevalences in anxiety, depression, and PTSD. Further explanations are described in the
552 following sections.

553
554
555

556 **4.2. Factors influencing prevalence**

557 ***Types of extreme weather events***

558 Although depression was the only disorder found to be significantly influenced by the types of EWEs,
559 most prevalent mental health disorders differed with each EWE. For example, depression was
560 significantly higher when following hurricanes, whereas among studies reporting PTSD and anxiety,
561 floods had the highest prevalence. Parallel to such findings, other studies have reported PTSD as most
562 prevalent compared to anxiety and depression when followed by flood exposures [116, 120]. In contrast,
563 reasons why depression is most prevalent following hurricanes is not as linearly found. Literature is still
564 limited between the three variables of hurricanes, LAC, and depression, and therefore, research is
565 encouraged to assert stronger associations. Nonetheless, a notable reason may be due to the long-lasting
566 repercussions of hurricanes which have been found to aggravate depressive symptoms. Previous studies
567 have reported associations between depression and the indirect damages from hurricanes such as
568 displacement, food insecurity, and inaccessible services [121-123]. Out of these, displacement is
569 especially critical to fostering healthy childhood experiences as it hinders feelings of adjustment and
570 belonging. This may further trigger depressive symptoms like hopelessness, helplessness, and sadness.

571 Tracy and colleagues even noted that these longer-term stressors had stronger associations with
572 depression over PTSD [124], explaining why unlike PTSD, over time depression prevalences do not
573 decrease, but stay the same, as found in this review in addition to numerous others [84, 87, 124-126]. It is,
574 therefore, inevitable for distinctive characteristics of EWEs to influence certain mental health disorders
575 differently. Understanding how such factors influence disorders can aid in addressing the appropriate
576 responses catered to each EWE and its most prevalent mental health outcome.

577 There was a lack of drought studies included in this review with only one study reporting the prevalence
578 of PTSD followed by droughts or floods combined [45] Likewise, insufficient inclusion of drought
579 studies has been observed in other systematic reviews. [109, 127]. In contrast to the lack of drought
580 studies in reviews, past literature has reported the associations between mental disorders and the
581 exposures to droughts with notable linkages of extreme heat and suicidal behaviours [52, 128].
582 Consequently, there was both a lack of drought studies and studies reporting suicidal behaviours in this
583 review. However, it is understandable why research on droughts is lacking. Unlike other EWEs, it is
584 difficult to identify the start of the extreme weather as it is not an “event” like immediate shocks like
585 floods, tsunamis, and hurricanes [46]. As a result, data collection is difficult and complex resulting in the
586 lack of, also presented in this review. Limitations in conducting drought studies may be addressed through
587 conducting highly detailed research on methodologies of how droughts were defined, how the event’s
588 start and finish were determined, and what thresholds were set to conclude a drought was taking place. In
589 doing so, drought studies may be able to survey quantitative data on certain outcomes like mental health
590 disorders.

591

592 ***Age***

593 A key finding in this review was the significantly higher prevalences of PTSD were found among
594 adolescents (48%) compared to children (19%). Similar observations have been reported in a global study
595 where higher mental health prevalences were found among adolescents (12%) compared to children (7%)

596 [115]. In contrast, a review in 2024 concluded that children are at higher risk to mental health disorders,
597 namely PTSD [129]. However, higher potential in successful treatments, building resilience, and reducing
598 future mental health risks has been observed among children at earlier developmental stages [130]. On the
599 other hand, adolescents faced with decreased neuroplasticity result in higher susceptibility to the mental
600 health risks or disorders [130]. Nonetheless, despite the differing findings, it is evident that children and
601 adolescents are impacted differently [91, 104], especially relevant in the context of traumatic events like
602 EWEs.

603 The symptoms of mental health disorders are also observed to vary greatly between children and
604 adolescents. Children are more likely to experience emotions of fear, worry, and anxiety whose lives are
605 still yet centred on education, whereas adolescents experience more complex or intensified emotions in
606 line with the complex societal pressures they are increasingly surrounded with [130]. A major difference
607 is that adolescents have more awareness of their surroundings and recognise the long-term impacts of
608 EWEs like homesickness from displacement, compromised education and financial instability [121].
609 Serious symptoms of mental health disorders such as the development of attachment problems, substance
610 use, poor sleep quality, and feelings of hopelessness or loss of purpose can be intensified when met with
611 adolescents' hormonal changes and growing psychosocial independence [130].

612 Consequently, traumatic weather events may aggravate the existing stresses from societal, parental, and
613 peer pressures, result in long-lasting effects. Previous literature has noted that adolescents who experience
614 EWEs are more susceptible to violence and alcoholism in adulthood [121, 131]. Such vulnerabilities
615 unique to adolescents explain how EWEs affect the group differently, putting them at higher risk to
616 mental health disorders. As the findings of this review suggest, it is therefore crucial to not only
617 understand the vulnerabilities of youth, but also further recognize the risks distinctive to children and
618 adolescents.

619

620 *Region*

621 Depression was significantly prevalent in LAC compared to other regions, as reported in two studies, both
622 following hurricanes. Despite being conducted over 15 years apart, both studies reported prevalences
623 above 50%. Notably, depression recorded among LAC youth was double the prevalences from South Asia,
624 and quintuple compared to the EAP region. Linkages between hurricanes and depression, and hurricanes
625 and the LAC region have been observed in past literature [122, 132]. As reported by the United Nations
626 Office for Disaster Risk Reduction, LAC is the second most EWE-prone region in the world after EAP,
627 also explaining why most studies in this review originated from EAP [122]. More specifically, the
628 subregions Central America and Caribbean, where most LAC LMICs are concentrated in, is also the area
629 most affected by hurricanes [122]. This may explain why the included hurricane studies of this review all
630 originated from the LAC region.

631 A significant lack of SSA studies was also found when stratified by region. This gap is critical in making
632 assertions on not only LLMICs but also on young populations. SSA makes up 69% of LLMICs and 86%
633 of LICs, in addition to 90% of the youth worldwide live in LMICs [7, 22, 23, 71]. This scarcity of data in
634 SSA has already been reported in past systematic reviews [46, 57]. In particular, a review on SSA mental
635 health outcomes among LMIC youth following EWEs only included two studies [47]. Despite the
636 anticipation that a pooled prevalence may be calculated from a thorough search strategy, only one SSA

637 study and none from LICs were eligible for inclusion. This reinforces the need for researchers to study the
638 effects of EWEs on the mental health of LLMIC youth living in the SSA region. Filling this research gap
639 is essential for depicting a complete picture of youth's mental health burdens in the most vulnerable
640 settings.

641

642 *Time point measured*

643 No subgroup differences were detected in both subgroup analyses done for depression and PTSD.
644 However, a handful of studies have consistently found decreasing PTSD prevalences overtime [113, 125,
645 126]. Similar decreasing trends were found in this review with the highest prevalences reported at the
646 shortest time point measured at one to two months and the lowest prevalences reported at the longest time
647 point measured at >1 year. More specifically, significant drops were observed past the one-to-two-month
648 time-point measurement. For depression, 53% has depression at 1-2 months after EWEs, then dropped
649 more than half to 20% when measured 3-11 months after. For PTSD, 74% has PTSD at 1-2 months, then
650 dropped to 57% at 3-11 months. In a review done by Wang and authors looking at mental health disorder
651 following typhoons and hurricanes, PTSD was higher when measured >12 months compared to <12
652 months [79]. In another study, it was noted that children were most susceptible to mental disorders in the
653 first six months following EWEs [108]. The more recent a traumatic event may be, the more vivid the
654 memories will be, which may contribute to higher risk of feeling stronger symptoms. Despite no subgroup
655 differences, such paralleled findings indicate the influence of prevalences depending on when it is
656 measured following EWEs. Researchers should consider time point measurements as a crucial variable to
657 study when assessing the impacts of EWEs. A separate sub-group analysis and interpretation is highly
658 encouraged, given the significant differences varying time point measurements can affect prevalence rates.

659

660 *Standardization of measurement tools*

661 Although no subgroup differences were present for anxiety, the pooled prevalence was nearly twice as
662 high in studies measuring with no reference to standardized tools (48%) compared to those referencing
663 standardized tools (25%). The same was observed for PTSD and depression where subgroup differences
664 were found due to significant prevalence differences.

665 The trend showed lower prevalences recorded from measurement tools that referenced standardized
666 guidelines compared to no references. Similar to the trends observed in standardization vs. non-
667 standardization of measurements, diagnostic vs. screening tools also had the same results as in other
668 studies. In general, for stricter measurements that referenced guidelines, used standardized tools, or
669 diagnosed disorders, conservative estimates were pooled, showing in lower prevalence estimates [133]. In
670 contrast, tools that screened for disorders and assessed probable disorders from symptoms were more
671 likely to be high in sensitivity, detecting more and therefore, resulting in higher prevalence estimates
672 [133]. However, such distinctions, as proven in the subgroup differences, must be identified and
673 recognized for correct interpretation. Although screening tools may aid in predicting early cases at early
674 ages, type 1 error with false positives are more likely to happen, which may also be a major limitation as a
675 measurement tool. Relevant to this review, measurement differences had significant influence on the
676 overall prevalence of PTSD and depression. The result, must therefore, recognise the influences the

677 measurement tools have on the prevalence to be interpreted appropriately. Researchers must note that
678 higher prevalences may rise from non-referenced studies measuring disorders from probable symptoms,
679 whereas diagnosis-based measurements may result in lower prevalences, but higher certainty.

680 A key observation in this review was that most studies used measurement which have been developed and
681 are practiced by HICs. All measurement tools that were used more than once, namely the Centre for
682 Epidemiological Studies Depression Scale, Child Post-Traumatic Stress Reaction Index, Child Behaviour
683 Checklist, Trauma Screening Questionnaire, and Children’s Revised Impact Event Scale, Impact of Event
684 Scale, and the University of California at Los Angeles PTSD Reaction Index were tools developed in
685 HICs. Such tools do not consider socio-economic or culture-specific factors that are unique or commonly
686 found in LLMICs which may interfere with the results of mental health measurements. For example,
687 compared to HICs, LLMICs still struggle with mental health stigma. This can trigger participants into
688 being dishonest with their answers if questionnaires inhibit judgemental or assertive wording. The idea of
689 being diagnosed with a mental disorder can also induce feelings of disapproval and discontent if
690 surrounded by stigma. In response to potential unresolved stigmatization in certain areas, reference tools
691 made specific for LLMICs should be based on symptoms and probable diagnosis rather than a confirmed
692 diagnosis [134]. Locally developed and piloted measurements that address socio-economic and cultural
693 aspects are encouraged to be utilized more to accurately measure the mental health burdens in stigmatized
694 LLMIC settings.

695 Additionally, future studies on children and adolescents’ mental health should measure using
696 measurement tools specifically designed for the youth. Among the included studies, there were several
697 that used the same base questionnaire; however, some used the youth version over the original/adult
698 version. For example, there were studies that used the UCLA PTSD-RI vs. the adolescent version and the
699 Impact of Event Scale (IES-8) vs. the Children’s Revised Impact Event Scale (CRIES). However, many
700 times children and adolescent versions are made bridging off from the original questionnaire with
701 modifications. For example, CRIES was initially created due to several studies reporting children
702 misinterpreting the original IES questionnaire [135]. Such creations of tools catered to younger
703 populations prove age as an influential factor in measuring mental health. As a result, using age-
704 appropriate measurement tools are critical to understanding the unique characteristics of the youth,
705 especially relevant to assessments that rely heavily on self-reported experiences like mental health
706 assessments done following EWEs.

707

708 ***4.3. Strengths and limitations***

709 As commonly reported in prevalence systematic reviews, high heterogeneity was significantly present in
710 this review. Two reasons were identified for studies with extreme results. For one, studies with extremely
711 low prevalences identified disorders based on stricter clinical diagnoses. On the other hand, small sample
712 size studies with extremely high results (i.e. prevalences of 100%) identified both moderate and severe
713 symptoms as prevalent disorders, broadening the inclusion and, thus, increasing prevalence. Such studies
714 were not excluded since there were other studies that also reported the inclusion of both moderate and
715 severe disorders but were not identified as outliers. These variabilities identified in post-hoc assessments
716 may have limited the highly influential studies and high heterogeneity to be better addressed. Nonetheless,
717 no studies were excluded to avoid additional bias, in addition to a thorough investigation of publication

718 bias addressed using adjustments from the trim-and-fill methods. Most importantly, we believe that the
719 transparent reporting throughout the entire review process increased the validity of this review.

720 Despite efforts to increase the robustness of the evidence provided in this review, there exist several
721 limitations. Prevalence systematic reviews highly depend on the quality of included studies, which affects
722 the quality of the overall pooled prevalences. However, most studies fell short on a risk of bias question
723 (item 3) concerning random sampling. As a result, the data reported lacks random sampling which is a
724 critical component to ensuring high-quality evidence. Studies were also limited in availability as the
725 context of this review was to obtain and report on under-resourced, and sometimes under-represented
726 LLMIC research. Cultural stigma may have also played a role in having only one study being reported
727 from SSA, resulting in no prevalence rates to be calculated for that region. Another major limitation was
728 the language restrictions made on the inclusion criteria. Limiting the search to English only may have
729 hindered the accessibility of French studies, as commonly used in LLMICs. Although some French
730 studies' abstracts were reviewed and excluded due to the inclusion criteria, searches may have been more
731 abundant if searches were done with French terms in addition to English.

732 There were numerous subgroup analyses that did not have enough studies, and therefore, were not able to
733 be calculated. Many subgroup analyses also had less than five studies included, which may reduce the
734 precision and reliability of pooled estimates. Ultimately, there was not adequate power in some subgroups.
735 Lastly, PTSD and depression had the most abundant data, with some for anxiety, and extremely limited
736 for others like distress, suicidal ideation, sleeping disorders, stress, and grief. As a result, aside from the
737 major ones like PTSD, depression, and anxiety, no subgroup analyses were able to be conducted. The
738 abundant variety of terminology to define mental health disorders and symptoms may have resulted in
739 missing some articles for inclusion. Such is also applicable for defining EWEs. During the preliminary
740 search stages, numerous articles were found to include country specific titles instead of mentioning
741 LLMICs, which was why all LLMICs were individually included in the search terms. With the thorough
742 search strategy and terms used in this review, we hope that future reviews can also continue to further add
743 on to open the scope of minimizing missing studies for both mental health disorders and EWEs.

744

745 **5. Conclusion**

746 This review provides compelling evidence on the significant detrimental effect of EWEs on mental health
747 disorders among the vulnerable population of LLMIC youth. Furthermore, the evidence from this review
748 addresses the failed attempts of previous reviews at conducting meta-analyses on the prevalence of mental
749 health disorders in this vulnerable group following EWE exposures. Our findings are essential to
750 discussions around the rising climate change-induced EWEs, and thus, several key implications emerge
751 for the prioritization of children and adolescents' mental health who have experienced detrimental EWEs
752 in the starting stages of their lives.

753

754 ***5.1. Implications for practice, policy, and future research***

755 This review stresses that interventions must be given timely the evidence for prevalences of mental health
756 disorders peaking at one to two months following EWEs. Particular attention must be paid to the
757 components of interventions to ensure age-appropriate application thereof. This is especially critical since

758 for younger populations, the brain goes through vast and rapid developmental changes, already putting
759 them in a time-sensitive state. If not prioritized, although it may not intensify, delayed or neglected mental
760 health disorders can hinder critical stages of growth, ultimately carrying into adolescence and adulthood.

761 This study warrants a review of policies relating to youth mental health service provisions given that, in
762 most LLMICs, no specific and clear guidelines for actions or services are present [61-63, 136]. In a recent
763 UNICEF report (The State of the World's Children 2021), statistics showed that Africans are left to pay
764 41% out-of-pocket for mental health services, whereas 98% of Europeans were insured, with only 20% of
765 costs being out-of-pocket [7]. Policymakers should not only advocate for heightened attention on mental
766 health burdens in general, but also for funding towards mental health provisions to provide treatment
767 immediately after EWEs. This, in turn, will facilitate ensuring that existing policies and guidelines are
768 kept up to date incorporating current best evidence, given the rapidly changing scenarios within climate
769 change-induced EWEs.

770 Additionally, there are several implications regarding future research endeavours. Firstly, there is an
771 urgent need to evaluate the generalizability of current diagnostic frameworks within diverse LLMIC
772 settings. As found in this review and others [137], measurements that reference standardized guidelines
773 like DSM or ICD, present lower prevalences, potentially depicting an under-representation of the reality.
774 In response, future studies on mental health disorders are encouraged to extract and conduct sub-group
775 analysis on diagnosis vs. symptom-based measures. Secondly, given the unique vulnerabilities
776 adolescents face, as shown through the significant prevalence differences in this review, future studies
777 assessing the impacts of EWEs should conduct separate analyses for the two age groups (1 to 10 years of
778 age vs. 10 to 19 years of age). Lastly, our review highlights the dearth of data on specific variables such
779 as children, droughts, LICs, and less popular mental health disorders like suicidal ideation, sleeping
780 disorders, and distress. Researchers are encouraged to navigate future studies in filling these gaps where
781 under-representation lies, continuously building upon defining mental health burdens in the context of
782 EWEs. Taken together, we believe the recommendations presented will contribute to alleviating the
783 inequities faced by vulnerable LLMIC children and adolescents who need the world's care and attention.

784

785 **6. List of abbreviations**

786 DFBETAS – Difference in Fits of Beta; DFFITS – Difference in Fits; DSM – Diagnostic and Statistical
787 Manual of Mental Disorders; EM-DAT – Emergency Events Database; EWE – extreme weather events;
788 HIC – high-income country; ICD - International Classification of Diseases; IPCC - Intergovernmental
789 Panel on Climate Change; IRDR - Integrated Research on Disaster Risk; LIC – low-income country;
790 LLMIC – low- and lower middle-income country; LMIC – low- and middle-income country; PRISMA –
791 Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PTSD – post-traumatic stress
792 disorder; ROB – risk of bias, SSA – Sub-Saharan Africa, UNICEF – United Nations International
793 Children's Emergency Fund

794

795

796 **7. Declarations**

797

798 *Ethics Approval and Consent to Participate*

799 This study has been approved by the University of Cape Town's School of Public Health Departmental
800 Research Committee. The ethics waiver form is available in Appendix G.

801

802 *Consent for publication*

803 Not applicable.

804

805 *Consent for Publication*

806 Not applicable

807

808 *Competing interests*

809 The authors declare no competing interests.

810

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812 There was no funding involved.

813

814 *Authors' Contributions*

815 EC wrote the initial draft of the proposal and the main manuscript, conducted database searches,
816 screening in both stages, extracted data, performed quality assessment, meta-analyses, sensitivity analyses,
817 interpretation of data, and made all figures and tables. HAR and ME participated in the conceptualization
818 of the research, supervised the entire project, and revised subsequent drafts. HAR acted as the primary
819 supervisor and overlooked the protocol, literature view, and main manuscript. ME resolved conflict
820 during for all screening stages, supervised the meta-analyses, interpretation of data, and making of figures.
821 ACS and KR acted as the second and third reviewers during the screening stages and extracted the data of
822 included studies.

823

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9. Supplementary materials

Supplementary file 1: Subgroup analysis forest plots

Fig. 1 Subgroup analysis on a) anxiety outcomes and b) depression, and c) PTSD outcomes associated with extreme weather events

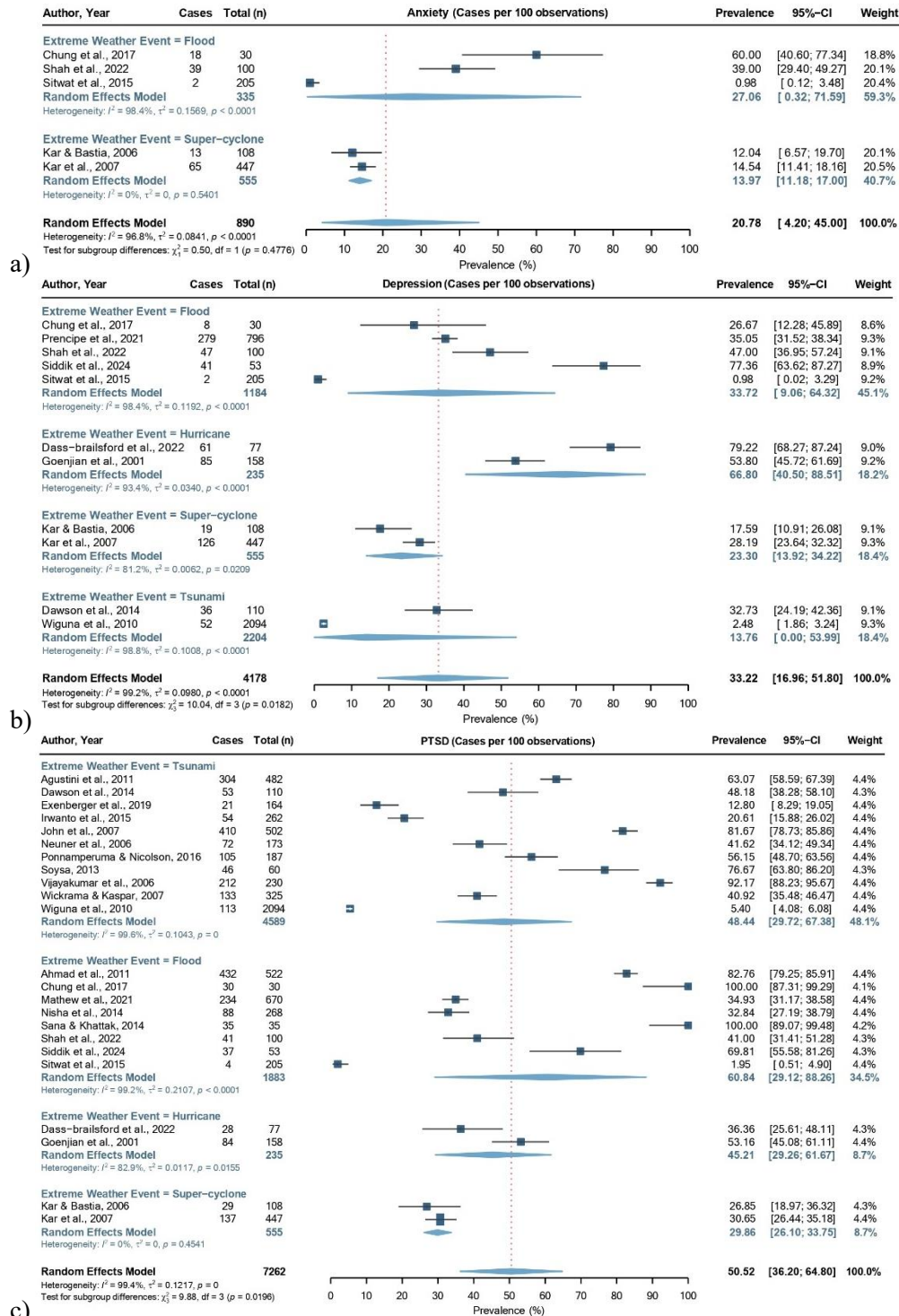
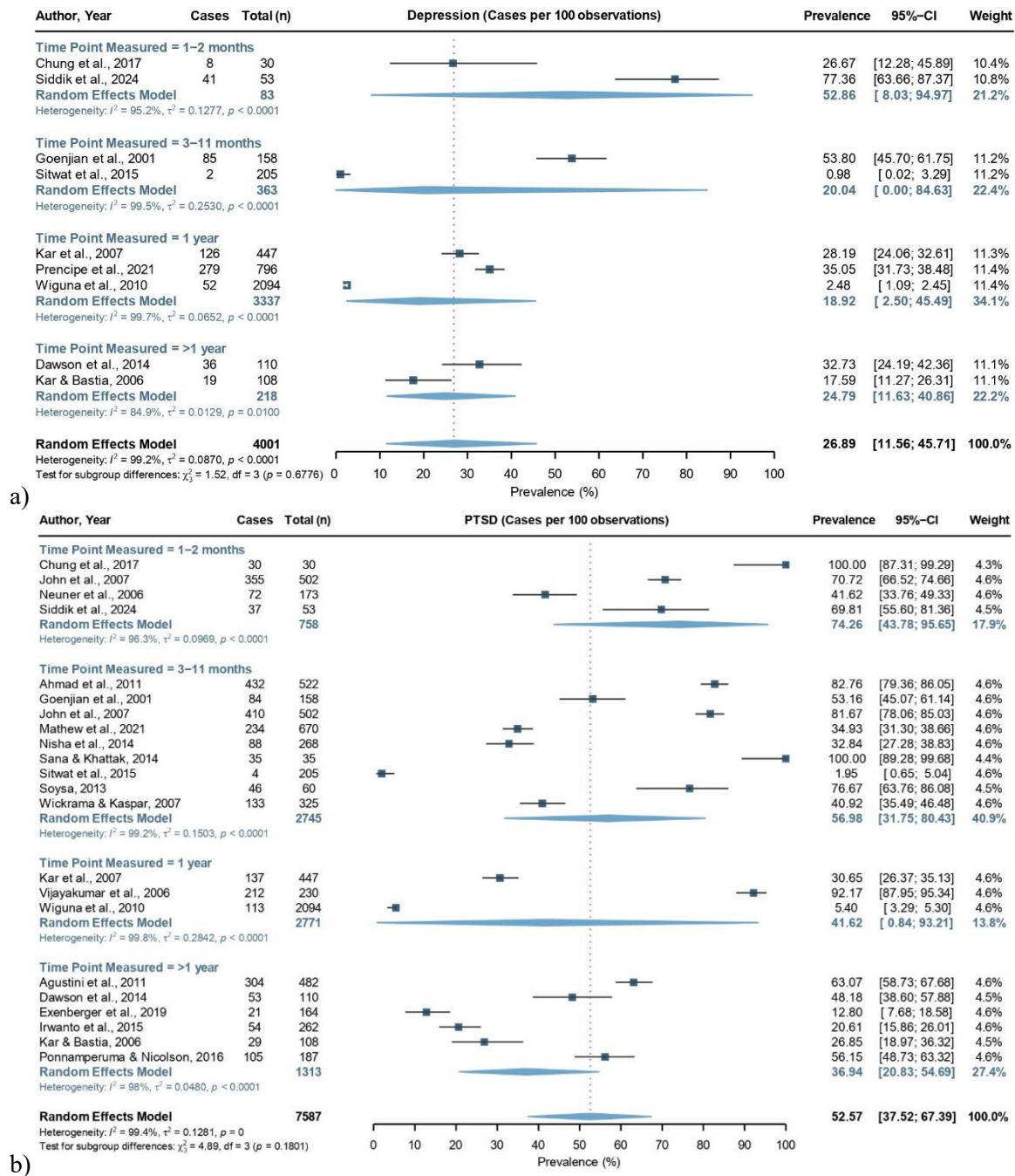
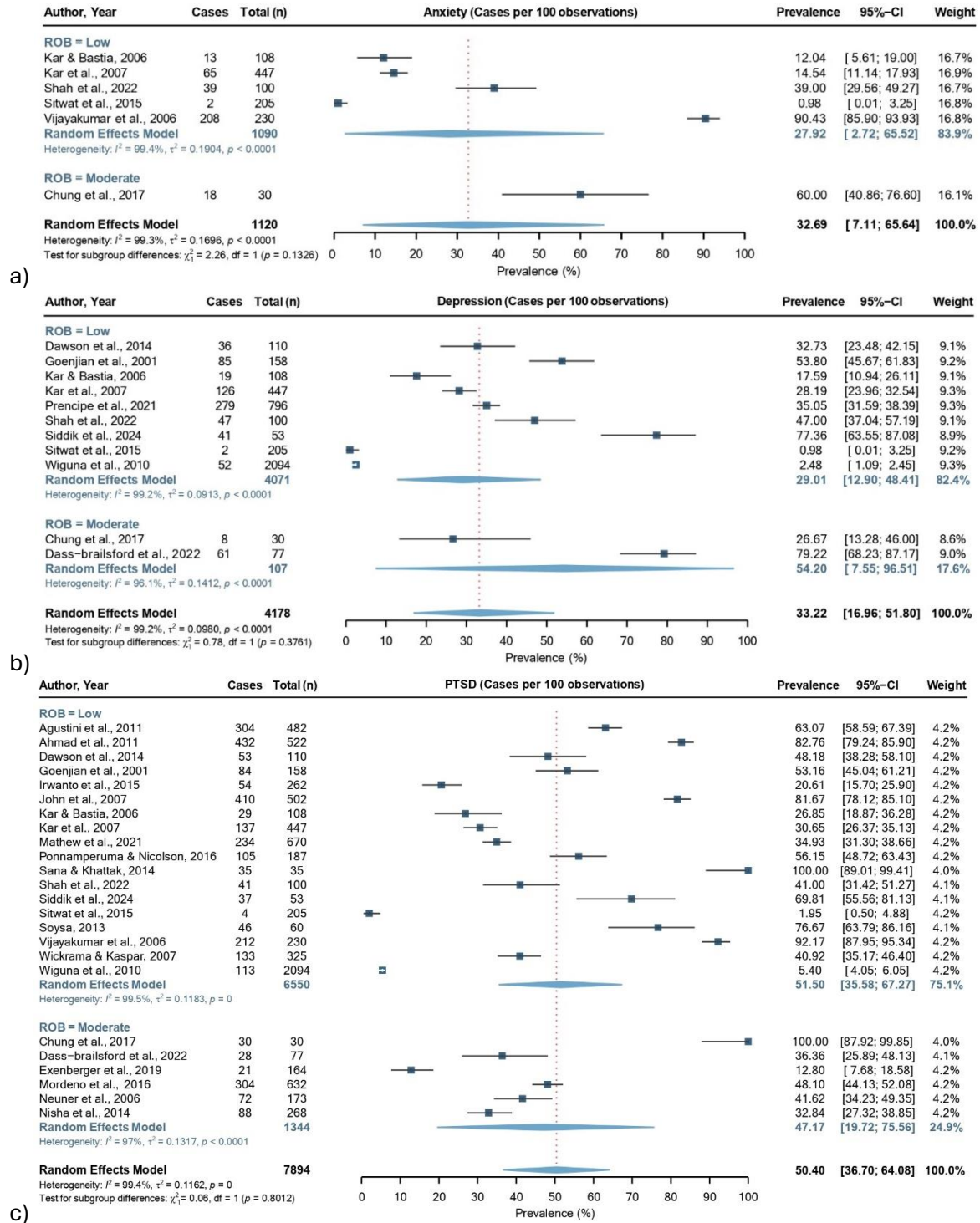


Fig. 2 Subgroup analysis on a) depression and b) PTSD outcomes associated with time point measured



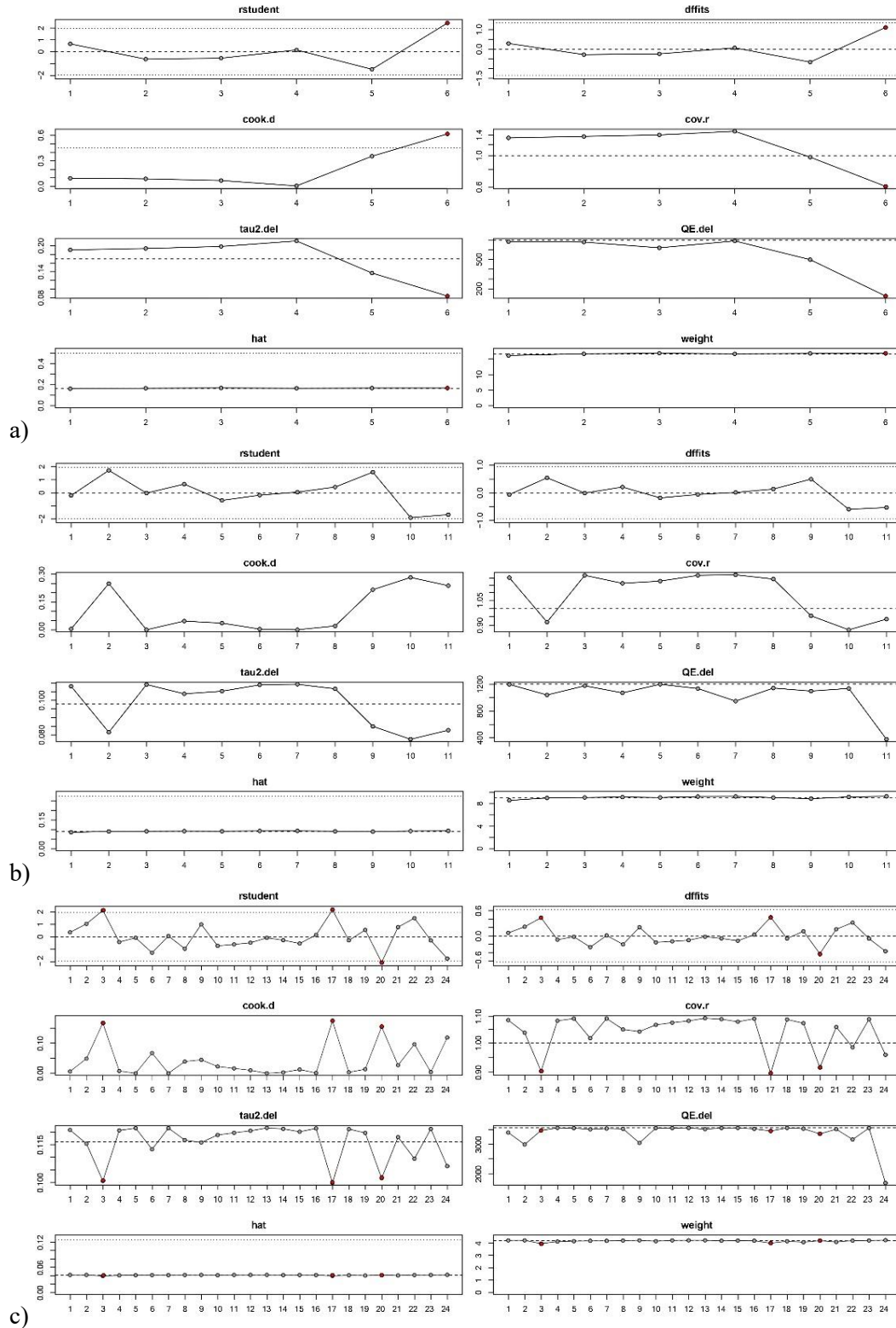
Supplementary file 2: Sensitivity analysis forest plots

Fig. 1 Sensitivity analysis for a) anxiety, b) depression, and c) PTSD on risk of bias levels



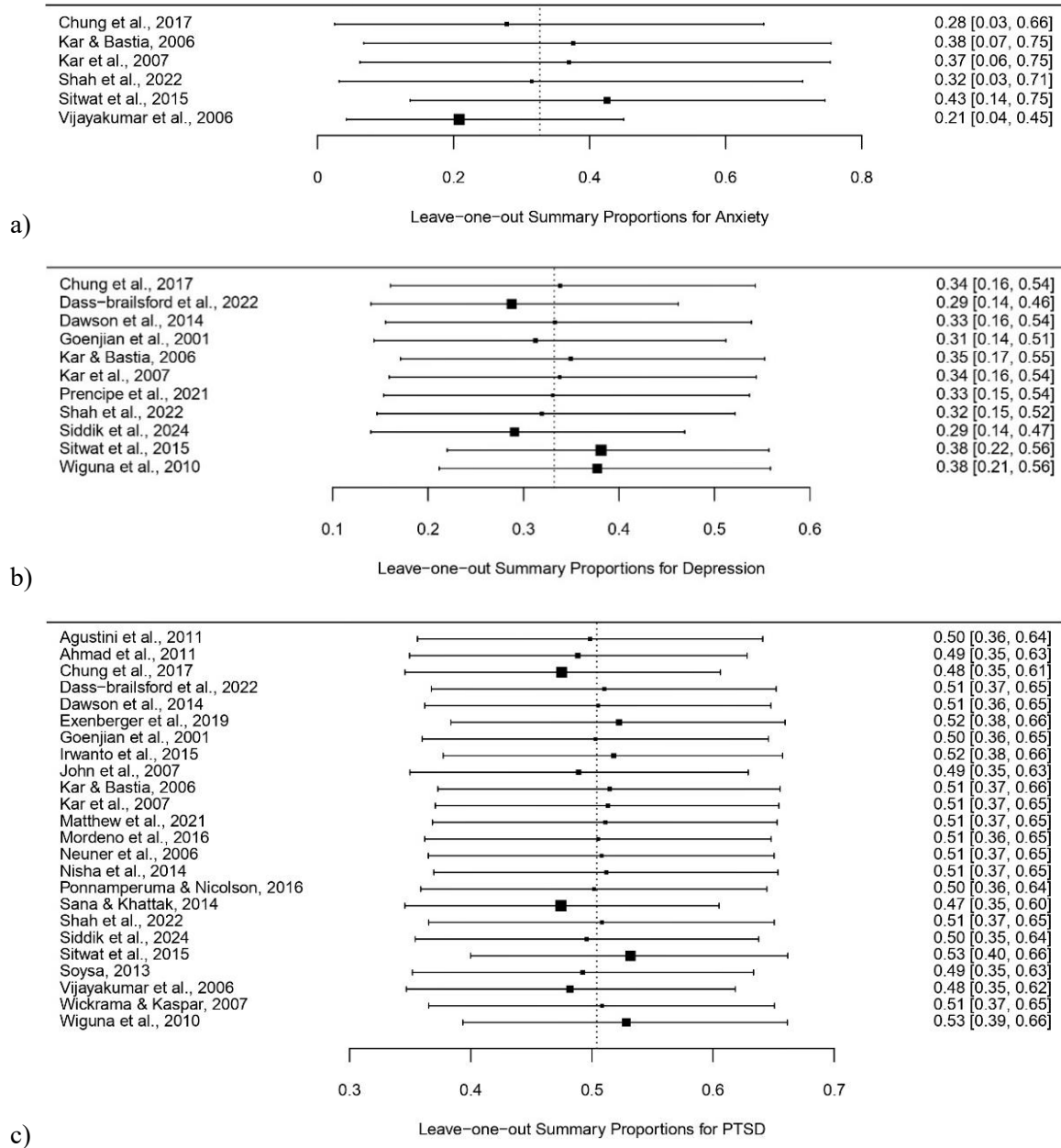
Supplementary file 3: Influence diagnostic tests

Fig. 1 Influence diagnostic test for a) anxiety, b) depression, and c) PTSD studies



Supplementary file 4: Leave-one-out analysis forest plots

Fig. 1 Leave-one-out analysis for a) anxiety, b) depression, and c) PTSD studies



Supplementary file 5: Doi plot and funnel plot of depression and PTSD studies

Fig. 1 Doi plot and funnel plot of depression studies

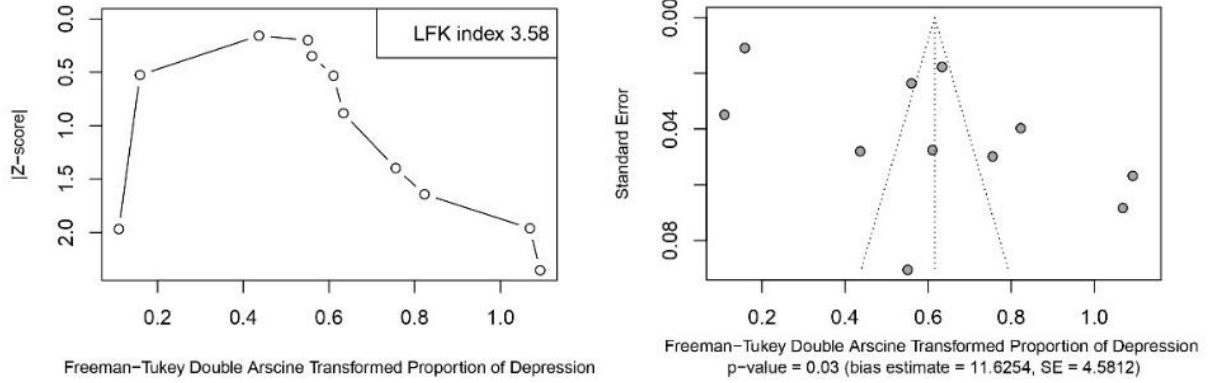
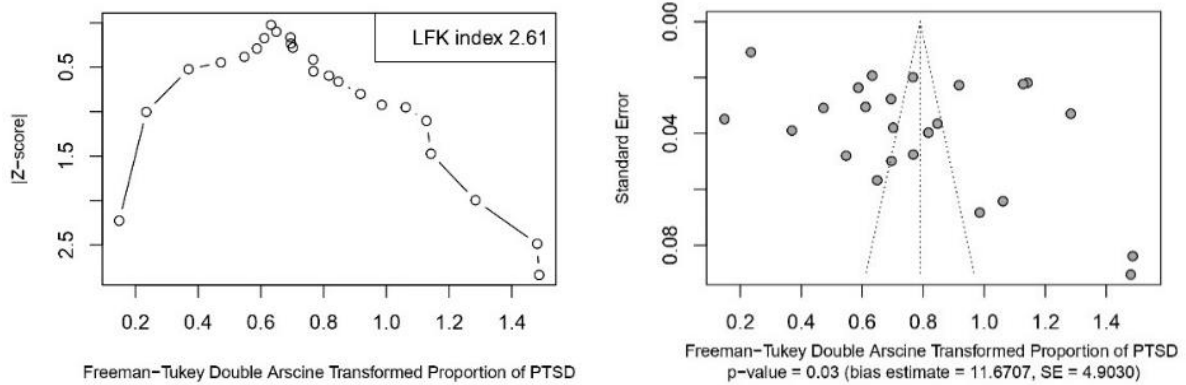


Fig. 2 Doi plot and funnel plot of PTSD studies



10. Appendices

Appendix A: BMC Public Health author guidelines for systematic reviews

Systematic Review
Criteria
Systematic reviews articles should describe meta-analyses, systematic reviews, scoping reviews or umbrella reviews that synthesize published research. We strongly encourage the use of the appropriate reporting guideline , including PRISMA . Please note that non-commissioned pooled analyses of selected published research and bibliometric analysis will not be considered. Registration of systematic reviews BMC supports the prospective registration of systematic reviews and encourages authors to register their systematic reviews in a suitable registry (such as PROSPERO). Authors who have registered their systematic review should include the registration number as the last line of the manuscript abstract. We do not publish protocols for systematic reviews. Data sharing <i>BMC Public Health</i> strongly encourages that all datasets on which the conclusions of the paper rely should be available to readers. We encourage authors to ensure that their datasets are either deposited in publicly available repositories (where available and appropriate) or presented in the main manuscript or additional supporting files whenever possible.
Preparing your manuscript
The information below details the section headings that you should include in your manuscript and what information should be within each section. Please note that your manuscript must include a 'Declarations' section including all of the subheadings (please see below for more information).
Title page
The title page should: <ul style="list-style-type: none">• present a title that includes, if appropriate, the study design e.g.:<ul style="list-style-type: none">○ "A versus B in the treatment of C: a randomized controlled trial", "X is a risk factor for Y: a case control study", "What is the impact of factor X on subject Y: A systematic review"○ or for non-clinical or non-research studies a description of what the article reports• list the full names and institutional addresses for all authors<ul style="list-style-type: none">○ if a collaboration group should be listed as an author, please list the Group name as an author. If you would like the names of the individual members of the Group to be searchable through their individual PubMed records, please include this information in the "Acknowledgements" section in accordance with the instructions below○ Large Language Models (LLMs), such as ChatGPT, do not currently satisfy our authorship criteria. Notably an attribution of authorship carries with it accountability for the work, which cannot be effectively applied to LLMs. Use of an LLM should be properly documented in the Methods section (and if a Methods section is not available, in a suitable alternative part) of the manuscript.• indicate the corresponding author
Abstract
The Abstract should not exceed 350 words. Please minimize the use of abbreviations and do not cite references in the abstract. Reports of randomized controlled trials should follow the CONSORT extension for abstracts. The abstract must include the following separate sections: <ul style="list-style-type: none">• Background: the context and purpose of the study• Methods: how the study was performed and statistical tests used• Results: the main findings• Conclusions: brief summary and potential implications• Trial registration: If your article reports the results of a health care intervention on human participants, it must be registered in an appropriate registry and the registration number and date of registration should be stated in this section. If it was not registered prospectively (before enrollment of the first participant), you should include the words 'retrospectively registered'. See our editorial policies for more information on trial registration
Keywords
Three to ten keywords representing the main content of the article.
Background
The Background section should explain the background to the study, its aims, a summary of the existing literature and why this study was necessary or its contribution to the field.
Methods
The methods section should include: <ul style="list-style-type: none">• the aim, design and setting of the study• the characteristics of participants or description of materials• a clear description of all processes, interventions and comparisons. Generic drug names should generally be used. When

<ul style="list-style-type: none"> proprietary brands are used in research, include the brand names in parentheses the type of statistical analysis used, including a power calculation if appropriate
Results
This should include the findings of the study including, if appropriate, results of statistical analysis which must be included either in the text or as tables and figures.
Discussion
This section should discuss the implications of the findings in context of existing research and highlight limitations of the study.
Conclusions
This should state clearly the main conclusions and provide an explanation of the importance and relevance of the study reported.
List of abbreviations
If abbreviations are used in the text they should be defined in the text at first use, and a list of abbreviations should be provided.
Declarations
<p>All manuscripts must contain the following sections under the heading 'Declarations':</p> <ul style="list-style-type: none"> Ethics approval and consent to participate Consent for publication Availability of data and materials Competing interests Funding Authors' contributions Acknowledgements Authors' information (optional) <p>Please see below for details on the information to be included in these sections. If any of the sections are not relevant to your manuscript, please include the heading and write 'Not applicable' for that section.</p> <p>Ethics approval and consent to participate</p> <p>Manuscripts reporting studies involving human participants, human data or human tissue must:</p> <ul style="list-style-type: none"> include a statement on ethics approval and consent (even where the need for approval was waived) include the name of the ethics committee that approved the study and the committee's reference number if appropriate <p>Studies involving animals must include a statement on ethics approval and for experimental studies involving client-owned animals, authors must also include a statement on informed consent from the client or owner. See our editorial policies for more information. If your manuscript does not report on or involve the use of any animal or human data or tissue, please state "Not applicable" in this section.</p> <p>Consent for publication</p> <p>If your manuscript contains any individual person's data in any form (including any individual details, images or videos), consent for publication must be obtained from that person, or in the case of children, their parent or legal guardian. All presentations of case reports must have consent for publication. You can use your institutional consent form or our consent form if you prefer. You should not send the form to us on submission, but we may request to see a copy at any stage (including after publication). See our editorial policies for more information on consent for publication. If your manuscript does not contain data from any individual person, please state "Not applicable" in this section.</p> <p>Availability of data and materials</p> <p>All manuscripts must include an 'Availability of data and materials' statement. Data availability statements should include information on where data supporting the results reported in the article can be found including, where applicable, hyperlinks to publicly archived datasets analysed or generated during the study. By data we mean the minimal dataset that would be necessary to interpret, replicate and build upon the findings reported in the article. We recognise it is not always possible to share research data publicly, for instance when individual privacy could be compromised, and in such instances data availability should still be stated in the manuscript along with any conditions for access. Authors are also encouraged to preserve search strings on searchRxiv https://searchrxiv.org/, an archive to support researchers to report, store and share their searches consistently and to enable them to review and re-use existing searches. searchRxiv enables researchers to obtain a digital object identifier (DOI) for their search, allowing it to be cited.</p> <p>Competing interests</p> <p>All financial and non-financial competing interests must be declared in this section. See our editorial policies for a full explanation of competing interests. If you are unsure whether you or any of your co-authors have a competing interest please contact the editorial office. Please use the authors initials to refer to each authors' competing interests in this section. If you do not have any competing interests, please state "The authors declare that they have no competing interests" in this section.</p> <p>Funding</p> <p>All sources of funding for the research reported should be declared. If the funder has a specific role in the conceptualization, design, data collection, analysis, decision to publish, or preparation of the manuscript, this should be declared.</p> <p>Authors' contributions</p>

The individual contributions of authors to the manuscript should be specified in this section. Guidance and criteria for authorship can be found in our [editorial policies](#).

Please use initials to refer to each author's contribution in this section, for example: "FC analyzed and interpreted the patient data regarding the hematological disease and the transplant. RH performed the histological examination of the kidney, and was a major contributor in writing the manuscript. All authors read and approved the final manuscript."

Acknowledgements

Please acknowledge anyone who contributed towards the article who does not meet the criteria for authorship including anyone who provided professional writing services or materials.

Authors should obtain permission to acknowledge from all those mentioned in the Acknowledgements section.

If you do not have anyone to acknowledge, please write "Not applicable" in this section.

Authors' information

This section is optional.

You may choose to use this section to include any relevant information about the author(s) that may aid the reader's interpretation of the article, and understand the standpoint of the author(s). This may include details about the authors' qualifications, current positions they hold at institutions or societies, or any other relevant background information. Please refer to authors using their initials. Note this section should not be used to describe any competing interests.

Footnotes

Footnotes can be used to give additional information, which may include the citation of a reference included in the reference list. They should not consist solely of a reference citation, and they should never include the bibliographic details of a reference. They should also not contain any figures or tables.

Footnotes to the text are numbered consecutively; those to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data). Footnotes to the title or the authors of the article are not given reference symbols.

Always use footnotes instead of endnotes.

References

Examples of the Vancouver reference style are shown below.

See our [editorial policies](#) for author guidance on good citation practice

Web links and URLs: All web links and URLs, including links to the authors' own websites, should be given a reference number and included in the reference list rather than within the text of the manuscript. They should be provided in full, including both the title of the site and the URL, as well as the date the site was accessed, in the following format: The Mouse Tumor Biology Database. <http://tumor.informatics.jax.org/mtbwi/index.do>. Accessed 20 May 2013. If an author or group of authors can clearly be associated with a web link, such as for weblogs, then they should be included in the reference.

Figures, tables and additional files

See [General formatting guidelines](#) for information on how to format figures, tables and additional files.

Appendix B: Search strategy

Population: Children and adolescents		
#1	MeSH terms:	Child; adolescent; infant; young adult;
#2	Text Word:	adolescent OR adolescents OR adolescence OR babies OR baby OR boy OR boys OR child OR children OR girl OR girls OR infant OR infants OR pediatric OR paediatric OR teen OR teenager OR teenagers OR teens OR toddler OR toddlers OR young adult or youth OR youths
#3	#1 OR #2	
Exposure: Extreme weather events		
#4	MeSH terms:	Extreme weather events; weather; climatic processes; disasters
#5	Text Word:	avalanche OR avalanches OR climate change OR cyclone OR cyclones OR cyclonic OR drought OR droughts OR El Nina OR La Nina OR El Nino OR La Nino OR El Nino-southern oscillation OR extreme cold OR extreme heat OR extreme precipitation OR extreme temperature OR flood OR floods OR flooding OR global warming OR heat wave OR heatwave OR heavy precipitation OR heavy rain OR heavy rainfall OR global warming OR hurricane OR hurricanes OR landslide OR landslides OR mudslide OR mudslides OR natural disasters OR storm OR storms OR tidal wave OR tidal waves OR tornado OR tornadoes OR tsunami OR tsunamis OR wildfires OR weather OR weather-driven
#6	#4 OR #5	
Condition: Mental health outcomes		
#7	MeSH terms:	Mental health, mental disorders
#8	Text Word:	alcohol use OR alcohol abuse OR anger OR anxiety OR attachment disorders OR cognition OR cognitive OR coping OR depression OR depressive OR drug use OR drug abuse OR emotion OR

		emotions OR emotional OR mental OR mood OR phobias OR post-traumatic OR posttraumatic OR PTSD OR psychological OR psychology OR psychosocial OR sleep disorders OR stress OR substance abuse OR substance use OR temperament OR trauma OR traumatic OR
#9	#7 OR #8	
Context: Low- and middle-income countries		
#10	MeSH terms:	Developing countries, low-income countries, middle-income countries, low-middle income countries
#11	Text Word:	Deprived Countries OR Deprived Population OR Deprived Populations OR Developing Countries OR Developing Country OR Developing Economies OR Developing Economy OR Developing Nation OR Developing Nations OR Developing Population OR Developing Populations OR Developing World OR LAMI Countries OR LAMI Country OR Less Developed Countries OR Less Developed Country OR Less Developed Economies OR Less Developed Nation OR Less Developed Nations OR Less Developed World OR Lesser Developed Countries OR Lesser Developed Nations OR LMIC OR LMICS OR Low GDP OR Low GNP OR Low Gross Domestic OR Low Gross National OR Low Income Countries OR Low Income Country OR Low Income Economies OR Low Income Economy OR Low Income Nations OR Low Income Population OR Low Income Populations OR Lower GDP OR lower gross domestic OR Lower Income Countries OR Lower Income Country OR Lower Income Nations OR Lower Income Population OR Lower Income Populations OR Middle Income Countries OR Middle Income Country OR Middle Income Economies OR Middle Income Nation OR Middle Income Nations OR Middle Income Population OR Middle Income Populations OR Poor Countries OR Poor Country OR Poor Economies OR Poor Economy OR Poor Nation OR Poor Nations OR Poor Population OR Poor Populations OR poor world OR Poorer Countries OR Poorer Economies OR Poorer Economy OR Poorer Nations OR Poorer Population OR Poorer Populations OR Third World OR Transitional Countries OR Transitional Country OR Transitional Economies OR Transitional Economy OR Under Developed Countries OR Under Developed Country OR under developed nations OR Under Developed World OR Under Served Population OR Under Served Populations OR Underdeveloped Countries OR Underdeveloped Country OR underdeveloped economies OR underdeveloped nations OR underdeveloped population OR Underdeveloped World OR Underserved Countries OR Underserved Nations OR Underserved Population OR Underserved Populations
#12	Text Word:	East Asia OR East Asia and Pacific OR Cambodia OR Indonesia OR Kiribati OR Democratic People's Republic of Korea OR Laos OR Micronesia OR Mongolia OR Myanmar OR Papua New Guinea OR Philippines OR Samoa OR Solomon Islands OR Timor-Leste OR Vanuatu OR Vietnam
#13	Text Word:	Europe OR Central Asia OR Kyrgyzstan OR Tajikistan OR Ukraine OR Uzbekistan
#14	Text Word:	Bolivia OR Caribbean OR El Salvador OR Haiti OR Honduras OR Latin America OR Nicaragua OR Venezuela
#15	Text Word:	Algeria OR Djibouti OR Egypt OR Iran OR Lebanon OR Middle East OR Morocco OR North Africa OR Syria OR Tunisia OR Palestine OR Gaza OR Yemen
#16	Text Word:	Afghanistan OR Bangladesh OR Bhutan OR India OR Nepal OR Pakistan OR South Asia OR Sri Lanka
#17	Text Word:	Angola OR Benin OR Burkina Faso OR Burundi OR Cabo Verde OR Cameroon OR Central Africa OR Chad OR Comoros OR Congo OR Republic of Congo OR Democratic Republic of Congo OR Cote d'Ivoire OR Eritrea OR Eswatini OR Ethiopia OR Gambia OR Ghana OR Guinea OR Guinea-Bissau OR Kenya OR Lesotho OR Liberia OR Madagascar OR Malawi OR Mali OR Mauritania OR Mozambique OR Niger OR Nigeria OR Rwanda OR Sao Tome and Principe OR Senegal OR Sierra Leone OR Somalia OR South Sudan OR Sub-Saharan Africa OR Sudan OR Tanzania OR Togo OR Uganda OR Zambia OR Zimbabwe
#18	#10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17	
#19	#3 AND #6 AND #9 AND #18	

Appendix C: Data extraction items list

Data Items for extraction

1) Study characteristics
Title, authors, year of publication, country, study design, regional classification (WHO guidelines)
2) Population characteristics
Country income status (by World Bank guidelines), sample size (n =), age range
3) EWE exposure
EWE experienced, duration time between experienced EWE and outcome for study (time point measured)
4) Mental health impacts & results
Mental health outcome(s), measurement (diagnostic instrument), prevalence of mental health disorder(s)
5) ROB assessment
Hoy et al. questions: <ol style="list-style-type: none"> i. Was the study's target population representative to national population? ii. Was the sampling frame representative of target population? iii. Was some form of random selection used to select the sample or was census undertaken? iv. Was the likelihood of non-response bias minimal? v. Were data collected directly from the subjects? vi. Was an acceptable case definition used in the study? vii. Was the study instrument measuring interest shown to have reliability and validity? viii. Was the same mode of data collection used for all subjects? ix. Was the length of the shortest prevalence period for the parameter of interest appropriate? x. Were the numerators and denominators for the parameter of interest appropriate?

Appendix D: Hoy et al. risk of bias tool

This tool is designed to assess the risk of bias in population-based prevalence studies. Please read the additional notes for each item when initially using the tool. Note: If there is insufficient information in the article to permit a judgement for a particular item, please answer **No (HIGH RISK)** for that particular item.

Risk of bias item	Criteria for answers (please circle one option)	Additional notes and examples
External Validity		
1. Was the study's target population a close representation of the national population in relation to relevant variables, e.g. age, sex, occupation?	<ul style="list-style-type: none"> • Yes (LOW RISK): The study's target population was a close representation of the national population. • No (HIGH RISK): The study's target population was clearly NOT representative of the national population. 	<p>The target population refers to the group of people or entities to which the results of the study will be generalised. Examples:</p> <ul style="list-style-type: none"> • The study was a national health survey of people 15 years and over and the sample was drawn from a list that included all individuals in the population aged 15 years and over. The answer is: Yes (LOW RISK). • The study was conducted in one province only, and it is not clear if this was representative of the national population. The answer is: No (HIGH RISK). • The study was undertaken in one village only and it is clear this was not representative of the national population. The answer is: No (HIGH RISK).
2. Was the sampling frame a true or close representation of the target population?	<ul style="list-style-type: none"> • Yes (LOW RISK): The sampling frame was a true or close representation of the target population. • No (HIGH RISK): The sampling frame was NOT a true or close representation of the target population. 	<p>The sampling frame is a list of the sampling units in the target population and the study sample is drawn from this list.</p> <p>Examples:</p> <ul style="list-style-type: none"> • The sampling frame was a list of almost every individual within the target population. The answer is: Yes (LOW RISK). • The cluster sampling method was used and the sample of clusters/villages was drawn from a list of all villages in the target population. The answer is: Yes (LOW RISK). • The sampling frame was a list of just one particular ethnic group within the overall target population, which

		comprised many groups. The answer is: No (HIGH RISK) .
3. Was some form of random selection used to select the sample, OR was a census undertaken?	<ul style="list-style-type: none"> • Yes (LOW RISK): A census was undertaken, OR some form of random selection was used to select the sample (e.g. simple random sampling, stratified random sampling, cluster sampling, systematic sampling). • No (HIGH RISK): A census was NOT undertaken, AND some form of random selection was NOT used to select the sample. 	<p>A census collects information from every unit in the sampling frame. In a survey, only part of the sampling frame is sampled. In these instances, random selection of the sample helps minimise study bias. Examples:</p> <ul style="list-style-type: none"> • The sample was selected using simple random sampling. The answer is: Yes (LOW RISK). • The target population was the village and every person in the village was sampled. The answer is: Yes (LOW RISK). The nearest villages to the capital city were selected in order to save on the cost of fuel. The answer is: No (HIGH RISK).
4. Was the likelihood of non-response bias minimal ?	<ul style="list-style-type: none"> • Yes (LOW RISK): The response rate for the study was $\geq 75\%$, OR an analysis was performed that showed no significant difference in relevant demographic characteristics between responders and non-responders • No (HIGH RISK): The response rate was $< 75\%$, and if any analysis comparing responders and non-responders was done, it showed a significant difference in relevant demographic characteristics between responders and non-responders. 	<p>Examples:</p> <ul style="list-style-type: none"> • The response rate was 68%; however, the researchers did an analysis and found no significant difference between responders and non-responders in terms of age, sex, occupation and socio-economic status. The answer is: Yes (LOW RISK). • The response rate was 65% and the researchers did NOT carry out an analysis to compare relevant demographic characteristics between responders and non-responders. The answer is: No (HIGH RISK). The response rate was 69% and the researchers did an analysis and found a significant difference in age, sex and socio-economic status between responders and non-responders. The answer is: No (HIGH RISK).
Internal Validity		
5. Were data collected directly from the subjects (as opposed to a proxy)?	<ul style="list-style-type: none"> • Yes (LOW RISK): All data were collected directly from the subjects. • No (HIGH RISK): In some instances, data were collected from a proxy. 	<p>A proxy is a representative of the subject. Examples:</p> <ul style="list-style-type: none"> • All eligible subjects in the household were interviewed separately. The answer is: Yes (LOW RISK). • A representative of the household was interviewed and questioned about the presence of low back pain in each household member. The answer is: No (HIGH RISK).
6. Was an acceptable case definition used in the study?	<ul style="list-style-type: none"> • Yes (LOW RISK): An acceptable case definition was used. • No (HIGH RISK): An acceptable case definition was NOT used. 	<ul style="list-style-type: none"> • For a study on low back pain, the following case definition was used: "Low back pain is defined as activity-limiting pain lasting more than one day in the area on the posterior aspect of the body from the bottom of the 12th rib to the lower gluteal folds." The answer is: Yes (LOW RISK). • For a study on back pain, there was no description of the specific anatomical location „back“ referred to. The answer is: No (HIGH RISK). • For a study on osteoarthritis, the following case definition was used: "Symptomatic osteoarthritis of the hip or knee, radiologically confirmed as Kellgren-Lawrence grade 2-4". The answer is: LOW RISK.
7. Was the study instrument that measured the parameter of interest (e.g. prevalence of low back pain) shown to have reliability and validity (if necessary) ?	<ul style="list-style-type: none"> • Yes (LOW RISK): The study instrument had been shown to have reliability and validity (if this was necessary), e.g. test-re-test, piloting, validation in a previous study, etc. • No (HIGH RISK): The study instrument had NOT been shown to have reliability or validity (if this was necessary). 	<ul style="list-style-type: none"> • The authors used the COPCORD questionnaire, which had previously been validated. They also tested the inter-rater reliability of the questionnaire. The answer is: Yes (LOW RISK). • The authors developed their own questionnaire and did not test this for validity or reliability. The answer is: No (HIGH RISK).

<p>8. Was the same mode of data collection used for all subjects?</p>	<ul style="list-style-type: none"> • Yes (LOW RISK): The same mode of data collection was used for all subjects. • No (HIGH RISK): The same mode of data collection was NOT used for all subjects. 	<p>The mode of data collection is the method used for collecting information from the subjects. The most common modes are face-to-face interviews, telephone interviews and self-administered questionnaires.</p> <p>Examples:</p> <ul style="list-style-type: none"> • All eligible subjects had a face-to-face interview. The answer is: Yes (LOW RISK). • Some subjects were interviewed over the telephone and some filled in postal questionnaires. The answer is: No (HIGH RISK).
<p>9. Was the length of the shortest prevalence period for the parameter of interest appropriate?</p>	<ul style="list-style-type: none"> • Yes (LOW RISK): The shortest prevalence period for the parameter of interest was appropriate (e.g. point prevalence, one-week prevalence, one-year prevalence). • No (HIGH RISK): The shortest prevalence period for the parameter of interest was not appropriate (e.g. lifetime prevalence) 	<p>The prevalence period is the period that the subject is asked about e.g. "Have you experienced low back pain over the previous year?" In this example, the prevalence period is one year. The longer the prevalence period, the greater the likelihood of the subject forgetting if they experienced the symptom of interest (e.g. low back pain).</p> <p>Examples:</p> <ul style="list-style-type: none"> • Subjects were asked about pain over the past week. The answer is: Yes (LOW RISK). • Subjects were only asked about pain over the past three years. The answer is: No (HIGH RISK).
<p>10. Were the numerator(s) and denominator(s) for the parameter of interest appropriate?</p>	<ul style="list-style-type: none"> • Yes (LOW RISK): The paper presented appropriate numerator(s) AND denominator(s) for the parameter of interest (e.g. the prevalence of low back pain). • No (HIGH RISK): The paper did present numerator(s) AND denominator(s) for the parameter of interest but one or more of these were inappropriate. 	<p>There may be errors in the calculation and/or reporting of the numerator and/or denominator.</p> <p>Examples:</p> <ul style="list-style-type: none"> • There were no errors in the reporting of the numerator(s) AND denominator(s) for the prevalence of low back pain. The answer is: Yes (LOW RISK). • In reporting the overall prevalence of low back pain (in both men and women), the authors accidentally used the population of women as the denominator rather than the combined population. The answer is: No (HIGH RISK).
<p>11. Summary item on the overall risk of study bias</p>		
<ul style="list-style-type: none"> • LOW RISK OF BIAS: Further research is <u>very unlikely</u> to change our confidence in the estimate. • MODERATE RISK OF BIAS: Further research is likely to have an important impact on our confidence in the estimate and may change the estimate. • HIGH RISK OF BIAS: Further research is <u>very likely</u> to have an important impact on our confidence in the estimate and is likely to change the estimate. 		

Appendix E: List of excluded studies with reasons

Wrong condition: mental health prevalence (13 studies)

General mental health

1. Agampodi TC, Agampodi SB, Fonseka P. Prevalence of mental health problems in adolescent schoolchildren in Galle District, Sri Lanka: eight months after tsunami. *Asia Pac J Public Health*. 2011;23(4):588-600. doi:10.1177/1010539509349866
2. Du YB, Lee CT, Christina D, et al. The living environment and children's fears following the Indonesian tsunami. *Disasters*. 2012;36(3):495-513. doi:10.1111/j.1467-7717.2011.01271.x

No mental health disorders mentioned

3. Aruta JJBR. Ecological Grief in Filipino Youth. *Journal of Loss and Trauma*. 2022;28(3):273–275. <https://doi.org/10.1080/15325024.2022.2108204>
4. Chatterjee P. Mental health care for India's tsunami survivors. *Lancet*. 2005;365(9462):833-834. doi:10.1016/S0140-6736(05)71023-0
5. Meynard JB, Nau A, Halbert E, Todesco A. Health indicators in children from Meulaboh, Indonesia, following the tsunami of December 26, 2004. *Mil Med*. 2008;173(9):900-905. doi:10.7205/milmed.173.9.900
6. Ratin Hestyanti Y. Children survivors of the 2004 tsunami in Aceh, Indonesia: a study of resiliency. *Ann N Y Acad Sci*. 2006;1094:303-307. doi:10.1196/annals.1376.039

Mental health measured by others (i.e. teachers or parents)

7. Bhushan B. & Kumar JS. Emotional distress and posttraumatic stress in children surviving the 2004 tsunami. *Journal of Loss and Trauma*. 2007;12(3), 245-257. <https://doi.org/10.1080/15325020600945996>
8. Dildar S. & Kausar R. Moderating role of attachment styles between stress appraisal and posttraumatic stress symptoms. *Pakistan Journal of Social and Clinical Psychology*. 2019;17(1):3–8.
9. Hané T, Gomula A, Nowak-Szczepanska N, Chakraborty R, Kozieł S. Prenatal and early postnatal exposure to a natural disaster and Attention-Deficit/Hyperactivity Disorder symptoms in Indian children. *Sci Rep*. 2022;12(1):16235. doi:10.1038/s41598-022-20609-6
10. Widyatmoko, C. S., Tan, E. T., Seyle, D. C., Mayawati, E. H., & Silver, R. C. (2011). Coping with natural disasters in Yogyakarta, Indonesia: The psychological state of elementary school children as assessed by their teachers. *School Psychology International*, 32(5), 484–497. <https://doi.org/10.1177/0143034311402919>

Insufficient data to calculate prevalence estimate

11. Hassan FU, Singh G, Sekar K. Children's Reactions to Flood Disaster in Kashmir. *Indian J Psychol Med*. 2018;40(5):414-419. doi:10.4103/IJPSYM.IJPSYM_571_17
12. Dewaraja R, Sato H, Ogawa T. Anxiety in tsunami-affected children in Sri Lanka measured by Revised Children's Manifest Anxiety Scale and Synthetic House–Tree–Person Test, International Congress Series. 2006;1287:74-78. <https://doi.org/10.1016/j.ics.2005.12.035>.

Wrong population: children and adolescents who have experienced an EWE (77 studies)

Not children or adolescent

13. Amstadter AB, Acierno R, Richardson LK, et al. Posttyphoon prevalence of posttraumatic stress disorder, major depressive disorder, panic disorder, and generalized anxiety disorder in a Vietnamese sample. *J Trauma Stress*. 2009;22(3):180-188. doi:10.1002/jts.20404
14. Caldera T, Palma L, Penayo U, Kullgren G. Psychological impact of the hurricane Mitch in Nicaragua in a one-year perspective. *Soc Psychiatry Psychiatr Epidemiol*. 2001;36(3):108-114. doi:10.1007/s001270050298
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Other reasons: (10 studies)

Wrong study design: qualitative

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Duplicate data of included study

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No access and no response from authors (2 studies)

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Appendix F: Data extraction chart

Author/ Year	Country	Region by WHO	World Bank Income Status	Study Design	Sample size (n)	Age range	EWE	Time point measured (months)	Mental Health Outcomes	Cases	Assessment Tool	ROB	
Agustini et al., 2011	Indonesia	EAP	LMIC	Cross- sectional	482	11-19	Tsunami	54	PTSD	304	CPTSD-RI (NS)	Low risk	
Ahmad et al., 2011	Pakistan	SA	LMIC	Cross- sectional	522	10-16	Flood	4	PTSD	432	IES-R (NS)	Low risk	
Aneelraj et al., 2015	India	SA	LMIC	Cross- sectional	300	5-19 (5-10 & 11-18)	Cloud bursts/ Flood/ landslides	1.5	Distress	54	IES, diagnostic interviews using ICD-10	Moderate risk	
Chung et al., 2017	Pakistan	SA	LMIC	Cross- sectional	30	13-18	Flood	1	PTSD	30	PDS (DSM-IV)	Moderate risk	
Dass- brailsford et al., 2022	Haiti	LAC	LMIC	Cross- sectional	77	14-17	Hurricane	NR	PTSD	8	UCLA PTSD-RI for children and adolescents (DSM-5)	Moderate risk	
										18			GHQ-28 (NS)
										28			61
Dawson et al., 2014	Indonesia	EAP	LMIC	Cross- sectional	110	7-13	Tsunami	60	PTSD	53	CRIES-13 (DSM-IV)	Low risk	
										36			SMFQ (NS)
										21			PG-13 child version (DSM-IV)
Exenberger et al., 2019	India	SA	LMIC	Cross- sectional	164	8-17	Tsunami	48	PTSD	21	CRIES-13 (DSM-IV)	Moderate risk	

Author/ Year	Country	Region by WHO	World Bank Income Status	Study Design	Sample size (n)	Age range	EWE	Time point measured (months)	Mental Health Outcomes	Cases	Assessment Tool	ROB
Goenjian et al., 2001	Nicaragua	LAC	LMIC	Cross-sectional	158	11-13	Hurricane	6	PTSD	84	CPTSD-RI (DSM-IV)	Low risk
									Depression	85	Depression Self-Rating Scale (DSM-IV)	
Irwantanto et al., 2015	Indonesia	EAP	LMIC	Cross-sectional	262	7-13 (7-10 & 11-13)	Tsunami	60	PTSD	54	CPSS, diagnosis using DSM-IV	Low risk
John et al., 2007	India	SA	LMIC	Cross-sectional	502	5-18	Tsunami/Flood	2	PTSD	355	CBCL-PTSD-TR, IES-8 to confirm (DSM-IV)	Low risk
								6		410		
Kar & Bastia, 2006	India	SA	LMIC	Cross-sectional	108	14-16	Super-cyclone	14	PTSD	29	MINI-KID, diagnosis using DSM-IV	Low risk
									MDD	19		
									GAD	13		
Kar et al., 2007	India	SA	LMIC	Cross-sectional	447	7-17 (7-10 & 11-17)	Super-cyclone	12	PTSD	137	Interview with psychiatrist, ICD-10-DCR questionnaire	Low risk
									Depression	126		
									Anxiety	65		
									Suicidal ideation	22		
Mathew et al., 2021	India	SA	LMIC	Cross-sectional	670	15-18	Flood/landslides	8	PTSD	234	TSQ (DSM-IV)	Low risk
Mordeno et al., 2016	Philippines	EAP	LMIC	Cross-sectional	632	16-19	Typhoon	NR	PTSD	304	PCLC-5 based on DSM-5	Moderate risk
Neuner et al., 2006	Sri Lanka	SA	LMIC	Cross-sectional	173	8-14	Tsunami	1	PTSD	72	UCLA PTSD-RI (DSM-IV)	Moderate risk

Author/ Year	Country	Region by WHO	World Bank Income Status	Study Design	Sample size (n)	Age range	EWE	Time point measured (months)	Mental Health Outcomes	Cases	Assessment Tool	ROB
Nisha et al., 2014	India	SA	LMIC	Cross-sectional	268	13-16	Flood	3	PTSD	88	TSQ (NS)	Moderate risk
Ponnamperuma & Nicolson, 2016	Sri Lanka	SA	LMIC	Cross-sectional	187	12-16	Tsunami	36	PTSD	105	UCLA-PTSD- RI adolescent version (DSM-IV)	Low risk
Prencipe et al., 2021	Tanzania	SSA	LMIC	Cross-sectional	796	14-19	Flood/ Drought	12	Depression	279	CES-D10 (NS)	Low risk
Randeniya, 2017	Sri Lanka	SA	LMIC	Cross-sectional	50	14-16	Flood	NR	Sleeping disorders	39	Piloted questionnaire (NS)	Moderate risk
									Stress	33		
									Suicide	0		
Sana & Khattrak, 2014	Pakistan	SA	LMIC	Cross-sectional	35	7-17	Flood	5	PTSD	35	PTSS (NS)	Low risk
Shah et al., 2022	Pakistan	SA	LMIC	Cross-sectional	100	9-11	Flood	5-10 years*	PTSD	41	Pre-tested questionnaire (NS)	Low risk
									Depression	47		
									Anxiety	39		
									Sleeping disorders	49		
									Distress	41		
Siddik et al., 2024	Bangladesh	SA	LMIC	Cross-sectional	53	14-17	Flood	1	PTSD	37	PTSD-2 (NS)	Low risk
									Depression	41	PHQ-7 (NS)	

Author/ Year	Country	Region by WHO	World Bank Income Status	Study Design	Sample size (n)	Age range	EWE	Time point measured (months)	Mental Health Outcomes	Cases	Assessment Tool	ROB
Sitwat et al., 2015	Pakistan	SA	LMIC	Cross- sectional	205	13-19	Flood	11	PTSD	4	Psychologist diagnosis based on DSM-IV-TR criteria	Low risk
									GAD	2		
									MDD	2		
Soysa, 2013	Sri Lanka	SA	LMIC	Cross- sectional	60	12-14	Tsunami	3	PTSD	46	HTQ based on DSM-IV	Low risk
Vijayakumar & Kaspar, 2007	India	SA	LMIC	Cross- sectional	230	11-14	Tsunami	12	PTSD	212	CPTSD-RI (NS)	Low risk
									Anxiety	208	YSR of CBCL Tamil version (DSM-IV)	
Wickrama & Kaspar, 2007	Sri Lanka	SA	LMIC	Cross- sectional	325	12-19	Tsunami	4	PTSD	133	DSM-IV diagnostic interview items	Low risk
Wiguna et al., 2010	Indonesia	EAP	LMIC	Cross- sectional	2094	4-18 (4-10 & 11-18)	Tsunami	12	PTSD	113	SDQ, DSM-IV criteria interview with psychiatrists	Low risk
									MDD	52		

Categories: EWE – extreme weather events; ROB – risk of bias; WHO – World Health Organization

Regions: EAP – East Asia & Pacific; LAC – Latin America & Caribbean; SA – South Asia

World Bank Income Status: LMIC – Lower middle-income country

Time point measured: NR – not reported

Mental Health Outcomes: GAD – general anxiety disorder; MDD – major depressive disorder; PTSD – post-traumatic stress disorder

Assessment Tool: (NS) – No reference to standardized guideline like DSM or ICD

Mental Disorder Measurement Tools: DSM – Diagnostic and Statistical Manual of Mental Disorders, CBCL-PTSD-TR – Child Behaviour Checklist Posttraumatic Stress Disorder Scale – Tamil Revised, CES-DC/DI10 – Center for Epidemiological Studies Depression Scale for Children, CPSS – Child PTSD Symptom Scale, CRIES-13 – Children’s Revised Impact of Event Scale, CPTSD-RI – Child Posttraumatic Stress Disorder Reaction Index, GHQ-28 – General Health Questionnaire, HTQ – Harvard Trauma Questionnaire, ICD – International Classification of Diseases, IES-R – Impact of Event Scale-revised, MINI-KID – Mini International Neuropsychiatric Interview for Children and Adolescents, PDS – Posttraumatic Stress Diagnostic Scale, PG-13 – Prolonged Grief – Child Version, PHQ-7 – Patient Health Questionnaire, PTSS – Posttraumatic Stress Scale, SDQ – Strengths and Difficulties Questionnaire, SMFQ – Short Mood and Feelings Questionnaire, TSQ – Trauma Screening Questionnaire, UCLA PTSD-RI – University of California at Los Angeles Posttraumatic Stress Disorder Reaction Index, YSR CBCL – Youth self-report form of the Child Behaviour

Appendix G: Ethics waiver letter



UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
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11 February 2025

HREC REF: 105/2025

Prof Hanna-Andrea Rother

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FHS

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Dear Prof Andrea-Rother

PROJECT TITLE: PREVALENCE OF MENTAL HEALTH DISORDERS AMONG LOW- AND MIDDLE-INCOME COUNTRIES' CHILDREN AND ADOLESCENTS EXPOSED TO EXTREME WEATHER EVENTS: A SYSTEMATIC REVIEW PROTOCOL- (MASTER CANDIDATE-PUBLIC HEALTH-MS ELIZABETH CHOI)

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

The HREC note that the proposed study is a systematic review project. As the systematic review and meta-analysis involves published literature available through publicly accessible electronic databases, research ethics review and approval is not required.

This is in accordance with Section 1.1.8 of the Department of Health's Ethics in Health Research: Principles, Processes and Structures (South African Department of Health, 2015), which states: *"Research that relies exclusively on publicly available information or accessible through legislation or regulation usually need not undergo formal ethics review. This does not mean that ethical considerations are irrelevant to the research."*

The HREC recommend that researchers refer to the PRISMA website, for the PRISMA statement and checklist, to facilitate the reporting of systematic reviews and meta-analyses. For more information, please refer to <http://www.prisma-statement.org/>.

Further, fundamental ethical principles for health-related research should be considered in the objectives and methods of the systematic review. See, for example, the Declaration of Helsinki (Fortaleza, Brazil, 2013) and the Department of Health's Ethics in Health Research: Principles, Processes and Structures (South African Department of Health, 2015).

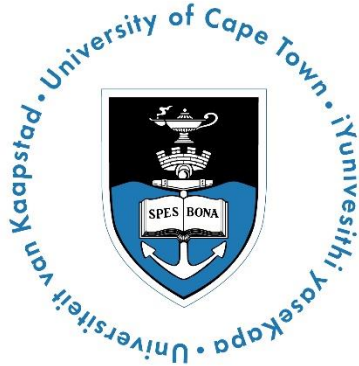
The HREC acknowledges that the following student is part of this project: Ms Elizabeth Choi.

Please quote the HREC REF 105/2025 in all your correspondence.

Yours sincerely

PROFESSOR MARC BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE

Appendix H: Research protocol



Prevalence of mental health disorders among low- and middle-income countries' children and adolescents exposed to extreme weather events: A systematic review protocol

Master of Public Health
Environmental Health Specialization
Mini-dissertation Research Protocol

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May 2024

Table of Contents

1. Introduction	69
1.1. Background	69
1.1.1. Climate change and extreme weather events	69
1.1.2. The impact of extreme weather events on low and lower middle-income country vulnerabilities	70
1.1.3. Low and lower middle-income country children and burden of disease	71
1.1.4. Defining children and adolescents: Children are not small adults	72
1.1.5. Climate change and children’s mental health	73
1.1.6. Gaps in literature	74
1.1.7. Rationale: Study justification	75
1.2. Objectives	76
1.2.1. Research aims	76
1.2.2. Research objectives	76
1.2.3. Review question	76
2. Methods	77
2.1. Eligibility criteria	77
2.2. Information sources	78
2.3. Search strategy	79
2.4. Study records	79
2.4.1. Data management	79
2.4.2. Selection process	79
2.4.3. Data collection process	80
2.5. Data items	80
2.6. Risk of bias in individual studies	80
2.7. Data synthesis	81
2.8. Meta-bias(es)	81
3. Ethics	82
4. Conclusion	82
4.1. Limitations	82
4.2. Timeline	83
5. References	84
6. Appendices	90
6.1. Appendix A: PRISMA 2020 checklist.....	90
6.2. Appendix B: PRISMA-P 2015 checklist.....	95
6.3. Appendix C: Integrated research on disaster risk: Peril classification and hazard glossary.....	97

6.4. Appendix D: Search strategy for PubMed and Scopus	98
6.5. Appendix E: Prisma 2020 flow diagram	99
6.6. Appendix F: Data management plan.....	100
6.7. Appendix G: Data extraction sheet	102
6.8. Appendix H: Hoy et al. risk of bias tool	103
6.9. Appendix I: Synthesis Without Meta-analysis (SWiM) reporting guideline.....	106

Glossary

Terms:	Definitions:
BOD	Burden of Disease
CCRI	Children’s Climate Risk Index
DMP	Data management plan
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders
EWE	Extreme weather event
GRADE	Grading for Recommendations, Assessment, Development, and Evaluations
HIC	High-income country
HIV/AIDS	human immunodeficiency virus/acquired immunodeficiency syndrome
ICD 10	International Classification of Diseases
IPCC	Intergovernmental Panel on Climate Change
IRDR	Integrated Research on Disaster Risk
LIC	Low-income country
LMIC	Lower middle-income country
MeSH	Medical Subject Heading
NCD	Non-communicable disease
NIEHS	National Institute of Environmental Health Sciences
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PTSD	Post-traumatic stress disorder
ROB	Risk of Bias
SSA	Sub-Saharan Africa
UMIC	Upper middle-income country
UNICEF	United Nations International Children’s Emergency Fund
WASH	Water, sanitation, and hygiene
WHO	World Health Organisation

1. Introduction

The health risks of climate change have transitioned from mere silent threats to palpable realities, marked by the tangible and destructive consequences [1, 2]. More concerning, the dire extremities in forms of extreme weather events (EWEs) are projected to worsen in the very near future [2, 3]. Repeated alerts from the latest international reports from the United Nations Intergovernmental Panel on Climate Change (IPCC), the United Nations, and the Lancet, assert climate change as the greatest health threat of the 21st century [2, 4, 5]. However, despite this assertion, research concerning the disproportionate health consequences of climate change is still unexplored, especially on one of the most vulnerable populations in the world: children and adolescents living in low and lower middle-income countries (LMICs) [6].

Furthermore, in contrast to the heavily prioritised research focus on identifying physical health impacts [3, 7], non-physical outcomes like mental health disorders have only gained attention in the last five years [3, 8]. Studies conducted in LMIC settings have shown negative associations between children and adolescent mental health and EWE experiences [9-13]. More specifically, mental health disorders such as anxiety, stress, post-traumatic stress disorder (PTSD), depression, distress, fear, hopelessness, and anger have been continuously reported [9, 14, 15]. Considering these findings, a striking number of studies conclude by expressing concerns on the lack of research, implementation, and prioritisation around LMIC children and their mental health impacts from EWE exposures [5, 7, 16, 17]. Yet, with only the consistent rise of concerns, progression is discouragingly slow and inadequate. As a result, there are continuous gaps in understanding the mental health impacts of EWEs on vulnerable populations like LMIC youth.

Over the last two years, scoping reviews on similar topics have pointed directions toward future research needs by calling for a systematic review of the literature to be done [18-21]. Although several scoping and systematic reviews exist in current literature on the topic [7, 19, 20, 22, 23], studies are found distributed disproportionately across geographical regions (e.g. Sub-Saharan Africa). For example, a recent systematic review by Rother and colleagues (2022) focusing on SSA youth, only identified two eligible studies for inclusion [16]. In contrast, a scoping review that focused on LMICs collectively, included a total of 23 studies of which 14 studies (61%) were from China, an upper-middle income country (UMIC) [20]. Consequently, there is a lack of available systematic reviews specific to LMIC children and adolescents.

To understand the mental health burden following EWEs, it is imperative to uncover the magnitude of the issue by identifying the frequency of mental health disorders [24]. However, there is a gap in current literature on the unavailable and inconsistent data of how prevalent the LMIC youth mental health burdens are [19]. Such is a barrier to understanding how severe, and therefore, urgent the disease is. To address this gap, prevalence systematic reviews are conducted to measure the disease burden within the unique population. With the evidence-based quality findings from systematic reviews, critical information in motivating stakeholders, governing bodies, and the public to act can be produced [24]. LMICs can, then, use the supported findings as guidelines to develop the most appropriate policies and practices. Most importantly, LMIC agendas can also be built upon sound research. Ultimately, by conducting a prevalence systematic review, this review serves to answer the unknown measured burden to make practical implications on policy, planning, decision-making, and future research on LMIC youth's mental health alongside anticipated EWEs to come.

1.1 Background

1.1.1 Climate change and extreme weather events

Anthropogenic greenhouse gas emissions, the major cause of climate change, have influenced changes in the ecosystem visibly resulting in higher temperatures, fluctuating rainfalls, sea level rise, acidifying oceans, and accelerated EWEs [2, 18]. As described by the most recent climate change indexes such as the 2021 Children's Climate Risk Index (CCRI) and the Climate Change and Human Health Glossary by

the National Institute of Environmental Health Sciences (NIEHS), EWEs are influenced by climate change both in frequency and intensity [3, 25]. The direct consequences of climate change have, therefore, translated into realities of EWEs experienced such as heatwaves, droughts, floods, monsoons, landslides, cyclones, hurricanes, and wildfires [3, 18, 25]. Indirect consequences include air pollution, open toxicant exposure, water scarcity, malnutrition, displacement, loss of economic assets, unpredictable vector transmissions, increased infectious diseases and cardiorespiratory illnesses, premature deaths, and overall, a collapsing ecosystem [3, 18, 26]. Trends of fluctuating weather events that have been studied over a long period show increased precipitation in parts of North and South America, North and Central Asia, and Northern Europe. In contrast, the Southern and Sahel regions of Africa, the Mediterranean, and Southern Asia have recorded dryer climates [27].

To define EWEs in the context of climate change-related events, this review will use the Integrated Research on Disaster Risk (IRDR) Peril Classification and Hazard Glossary (2014) as recommended and used by the International Disaster Database: EM-DAT [28]. Furthermore, if a scientific definition is needed to understand the EWEs from the above source, the list of explored EWEs in Chapter 11 of The Working Group I contribution to the IPCC Sixth Assessment Report (2021) and the in-depth descriptions will be referred to [29].

1.1.2 The impact of extreme weather events on low and lower middle-income country vulnerabilities

The greatest paradox of this climate crisis is the unfair pay of consequences that LMICs must suffer from, which HICs are most accountable for [30]. Most greenhouse gas emissions are produced by HICs compared to LMICs, but LMICs who produce the least amount are left to bear the damaging effects [30-33]. As a result, despite climate change affecting all persons, the damage is experienced disproportionately [3, 33]. Consequently, the unique vulnerabilities that LMICs carry are aggravated when combined with EWEs. Specifically, four major vulnerabilities have been identified which will be explored in this section: a) already present burden of disease (to be further discussed in section 1.1.4), b) insufficient resources, c) weak systems structures, and d) the economic dependency on agriculture which makes recovery harder due to the destructive damages of goods [3].

Already present and detrimental burden of disease

LMICs are known to experience multiple other disruptions to their realities, in addition to the effects of EWEs. The already present challenges are commonly in forms of other persistent and untreated health risks. A study in Nepal reported an increase in infectious diseases such as dengue, influenza, scrub typhus, and malaria alongside climate change and its related EWEs [34]. The increases in seasonal flooding, landslides, debris flows, droughts and their indirect causes of crop production loss, food insecurity, malnutrition, and injuries have been additional burdens to the already fragile population [34]. In Cambodia, strong associations between floods and increased diarrheal diseases have also been reported in two of the country's most vulnerable cities to climate change [35]. The increase of illness due to climate change means that such illnesses were present beforehand. In addition, a study in Pakistan has reported water insecurity due to corruption; a burden that was already present even before the damages of climate change were experienced [36]. Climate shocks like EWEs, therefore, strike LMICs with harsher damages than they would in HIC settings where the present burden of disease is less intense.

Lack of resources and capacity to recover

In addition, LMICs are commonly not as well advanced in sufficient resources which are crucial in capacity-building. This means that whether it may be technology, infrastructure, or human resources, most often LMICs are not shielded enough to prepare and protect themselves from EWEs [33, 37]. For example, sparse access to technology could result in limitations to communicating early warning signs of

disasters, and unavailable access to mitigative materials could prevent advancements in stronger infrastructures such as implementations of disaster-proof buildings [33]. The inevitable susceptibility to damage and costly recovery, therefore, are challenges unique to LMICs due to their impoverished state of limited resources and lack of adaptive capacity measures [33, 37].

Weak social, political and health system structures

Secure and well-structured service systems such as universal healthcare, equitable access to learning, acceptable quality of life, attainable standard living, proper housing, and good governance, can significantly alter the impact that the population experiences from EWEs [3, 9]. Inaccessible healthcare services, untreated injuries, broken water sanitation systems, declining economy, displacement, no adaptation measures implemented, and no alternative measures to support the population are results from the weak and failing structures that make LMICs most vulnerable to climate change and EWEs [3, 7, 9, 11, 33, 38]. Social factors like education can improve a population's capacity to prepare, respond, and recover [3]. The adaptation skills that communities feel empowered in are, therefore, commonly found among educated communities than not [3]. However, LMICs are commonly faced with limited resources to build support systems for preparedness, as well as limited human and material resources to treat the sick [6]. Political structures also add on to the barriers as insufficient proactivity from governing bodies are commonly disrupted by corrupt leadership [36]. Such vulnerabilities from the weak structures make EWEs distinctively relevant to LMICs.

Agriculturally dependent economy

The dependence on agricultural production adds to the vulnerable state of LMICs. The main repercussions of EWEs are the physical damage of tangible resources done to the environment. Environmental shocks can result in instantly destructive EWEs like floods and cyclones which ripple into a chain-reaction of damages. The initial shock is done to the environment, resulting in damaged crops and agricultural resources which are also economic goods. This can indirectly hinder agricultural markets, which results in lesser household incomes, eventually affecting the financial stability of families [3]. Gradually destructive EWEs like droughts and heatwaves also have the same effect. Long-term hinderance of profitable farming goods like crop failures results in unstable incomes and even competitive food prices [3].

Agricultural dependency can mean low economic diversification, meaning limited flexibility in having alternative methods to recover from damages. This increases the vulnerability of agricultural-dependent LMICs since once the sole source of profit is destroyed, there are no other means to find income. The lack of choices makes it difficult to adapt to the damaged state, ultimately delaying the ability to become economically stable again [3]. This contrasts the available resources that HICs put into measures for recovery in the form of credit and financial services. Insurance helps to compensate for unprepared losses, as with EWEs [3, 33]. Overall, multiple factors come together that characterize LMICs to be highly susceptible. For populations that are already at risk, living in LMICs creates further concern. One such population is children and adolescents.

1.1.3 Low and lower middle-income country children and burden of disease

A significant factor that highlights the substantial disparity of the youth in LMIC versus HIC populations is the proportion of the population that consists of children and adolescents. Approximately 90% of the global youth live in LMICs where almost 50% of the population are under the age of 18 years [5, 23, 26, 39, 40]. HICs, on the other hand, only accounted for 21%, less than double the amount. Studying the youth of LMICs, therefore, provides insight into the 90% of the world's youth who are at the forefront of experiencing the most destructive and damaging effects of climate change and EWEs. As the most vulnerable will bear the heaviest burdens, such is the fate that the population of LMIC youth are inescapable of [3, 41, 42].

Triple threat: climate change and low and lower middle-income country burden of disease

In the last decade, new terms describing the intertwined negative effects have been coined such as the double burden, triple burden, and triple threat. The ripple effect of damages that climate change and EWEs induce, results in a vicious cycle where the poor constantly experience the harshest realities one after another. Moreover, this increases their risks from the lack of adaptation measures, putting them in a situation worse than before [3, 43]. The double burden as described by numerous authors [18, 44-47], are the additional factors that limit a population's capacity to recover. Numerous aggregating factors like absent social systems and scarce resources are typical challenges faced by LMICs.

Additionally, the overwhelming prevalences of diseases make it harder to build adaptation measures and develop resilience [44-47]. Despite the decreasing trend of global child mortality rates recorded with HICs showing the largest decreases, SSA, a region where most countries are LMICs, has been the only exception [48]. Some of the major global burdens of disease that LMIC children and adolescents carry are vector- and water-borne diseases, cardiovascular diseases, malnutrition, and mental health illnesses [10, 42]. Moreover, unlike HICs, LMICs still struggle with critical infectious diseases such as HIV/AIDS, tuberculosis, malaria, and dengue fever [45]. Associations between EWEs and LMIC children's health problems including diarrhea, asthma, malaria, and even decreased height have also been recorded [49-53].

Similarly, findings on EWEs aggravating already present LMIC burdens were found in Xu and colleagues' study where the association between low-income youth's hospitalizations and heat exposure was found [54]. In the study, as age and socioeconomic status decreased, reported hospitalizations increased, showing a negative relationship [54]. Hajat and colleagues also replicated similar findings in their study looking at three cities of differing socioeconomic statuses [55]. When looking at mortality rates and climate burdens, children from the poorest city in the study, Delhi, reported the highest child mortality rates compared to the middle-income city, San Paulo, and the HIC city, London [55]. The study concluded that LIC children would suffer the greatest from climate repercussions [55]. Further findings confirm the higher risk that LMIC youth must face in comparison to HICs. They and colleagues have computed estimates that the 64 million children born between 2015 and 2020 in Europe and Central Asia will experience around four times more EWEs, whereas the 205 million children born in SSA will face an increase of almost six times more to be experienced in their lifetime [56]. Burgess and colleagues also report that the poorest children in the world have an increased likelihood of up to ten times being affected by climate change EWEs when compared to children living in higher-income settings [57].

In a March 2023 *Triple Threat* report by UNICEF, the deadly combination of the triple burden that children face was identified as the combinations of disease, climate risks, and unsafe water, sanitation, and hygiene (WASH) [8]. In a differing definition, Karn and colleagues referred to the LMICs' triple burden of disease as infectious diseases, non-communicable diseases, and injuries with the rise of climate change [34]. Nonetheless, regardless of what the combination of exacerbating factors are, the inescapable burdens are inevitably experienced by LMIC children. As a result, the disproportionate impacts of the climate crisis leave the vulnerable population trapped in a complicated and vicious cycle.

1.1.4 Defining children and adolescents: Children are not small adults

Children and adolescents are defined as vulnerable populations by numerous organisations, with separate agendas that prioritise their needs over others [3, 6, 43, 58]. They are not just smaller versions of adults but hold unique physical, physiological, and developmental characteristics, distinctive to adults [3, 59]. They are physically smaller, breathe twice as fast as adults and intake more amounts of air, drink more water, consume more food, and are more physically active in playing both indoors and outdoors [3, 60]. The nature of children's behaviours at earlier stages in life also make them more vulnerable, especially to the environment. Crawling, playing on the ground at lower levels, and bringing everything to their mouths from hand-to-mouth motions result in higher risks of being exposed to various harmful potentials [60]. Furthermore, children can be easily affected at greater risk even with smaller doses of exposure as

the impact is physiologically amplified in their smaller sized bodies compared to adults who are larger [3]. They are also less capable of lowering heat loss compared to adults. This makes it harder to thermoregulate their body temperatures to staying cool at times of extreme climates like heatwaves and droughts [59, 61]. Ultimately, children and adolescents live longer than adults and, therefore, the possibilities of seeing a harmful effect are also greater. Because the exposures they encounter are at the beginning stages of their lives, diseases that take time to develop with long latency periods have a higher chance to become present [3, 60, 62]. Mental health conditions are one example where disorders can take time to develop after being exposed to a triggering cause at early developmental stages. The delicate stages of development must, therefore, be taken care of with precaution. Such vulnerabilities prove the need for their own agendas to be made; to acknowledge their uniqueness in treating them differently to adults.

Children's climate crisis: Intergenerational injustice

The “children’s climate crisis” as announced by UNICEF, is an issue of intergenerational inequity and injustice [3, 39, 63]. The generational differences in the number of EWE experiences vary immensely. For example, in comparison to those born in 1960, children born in 2020 are predicted to experience a two to sevenfold increase in EWEs, especially for heatwaves [56]. To the young population, the disproportionate spread of suffering consequences from climate change and EWEs, is unjustifiable [39]. Adults contributing to emissions, are neglecting the rights that children have to a sustainable and healthy future. The indirect consequences that the climate crisis is intertwined with, such as destroyed housing, increased tensions and conflict, compromised education, and increased risks of morbidity and mortality, hinder the rights that the youth have to a safe and healthy life [3, 62]. More specifically, their violated rights to play, learn, and be given fair opportunity for career development are critical rights of freedom [3, 62, 63]. Unlike adults, children are only just at the beginning stages of life with endless opportunities ahead of them.

Furthermore, children and adolescents are not given the same rights to legitimacy and political participation [3, 58, 62]. This makes their voices harder to be heard, especially in legal and financial sectors [3, 58]. Youth participation is oftentimes not implemented nor prioritised, and they have no choice but to depend on adults with hopes of reliable and trustworthy representation [3]. However, the dynamic between adults and children is not always fair. Conflict of interests may arise, and adults may push for their own agendas such as economic profit over the preservation of the environment for future generations [3]. There can exist power imbalances where adults may not even take the younger population seriously [3]. Fortunately, in the last five years, efforts to incorporate youth participation have expanded, especially for climate change [3, 39, 62]. Through understanding their vulnerabilities, it is important to recognize the climate crisis as a children’s crisis. Collaborative initiatives must, therefore, continue and translate into future key agendas to come.

1.1.5 Climate change and children's mental health

Fear of an uncertain future, hopelessness, anger, sadness, numbness, and guilt are only some of the countless possibilities of emotions that children and adolescents are faced with as direct outcomes after experiencing EWE [15]. Intensified negative emotions could lead to serious symptoms of panic attacks, sleeplessness, problematic social and relational behaviour, and unrecognised distress recorded from young populations following EWE experiences, especially droughts [64, 65]. Repetitively, observations made on findings of distress, suicide and suicidal behaviour, and increased hospital psychiatric admissions were linked to increasing EWEs of hot temperatures like heatwaves and droughts [38, 66-68]. Anxiety and PTSDs were commonly identified for experienced floods and hurricanes [69-71] [72], and depressive disorders were present in both floods and droughts [71, 73]. On the contrary, a lower risk of experiencing floods was positively associated with good mental health, further supporting the strong associations

between the two [74]. Overall, the main mental health disorders that have been continuously recorded include PTSD, depression, anxiety, and suicidal ideation and suicide [10, 14, 15, 22, 65-67, 75-78].

Indirectly, limitations to accessing information, education, and support also act as barriers to understanding and making sense of the repercussions which induce anxiety, worry, and stress from the unknown [65]. When asked about the post-drought experiences to children living in rural Australia, they expressed worries about their family's mental health, having to compromise school for work, being isolated, and their future employment status [65]. Likewise, such concerns were also present among children in the Philippines following natural disasters [79]. Experiencing the burdens of carrying one's household financial responsibility and stress at an early age, not only induces immense anxiety, but also low self-perceived health and serious functional impairment [80]. Additionally, separation from displacement is another indirect consequence that inhibits mental health disorders such as anxiety and stress [3]. Separations not only happen from being forced to relocate, but also between families and communities, which further amplifies fear, abandonment, and missing nurtured support [3]. Undeniably, all influential factors, both direct and indirect consequences of climate change, hinder the mental health of children and adolescents who are still in key developmental stages.

Psychological maturity develops over time, and when children suffer from both direct and indirect repercussions of EWEs, they may not fully understand the logic behind how and why it happened [17, 40]. Adverse childhood experiences like physical and emotional abuse, neglect, conflict, and violence are all linked to the possible outcomes of EWEs which can alter and hinder the mind at critical stages of brain development [5, 44, 62, 63]. As concluded in Doherty and Clayton's study, the magnitude of effects depicts the expansive and intense mental health impacts that change the lives of victims following EWEs [81]. Such repercussions of health risks must not be dismissed simply because they are not visible or apparent.

1.1.6 Gaps in literature

Upon completing a preliminary search, the key gaps in research have been identified in three principal areas: 1) the lack of focus on mental health over physical health, 2) the limited numbers of LMIC-centered research despite their most detrimental vulnerabilities, and 3) the lack of quality-assessing quantitative reviews. Numerous studies published in the last ten years have expressed concerns about the continuous failure to address the issue of mental health [17, 38, 65, 82]. As mentioned in the introduction, most primary objectives in agendas remain concentrated on the biophysical impacts instead of the mental health, particularly within the context of climate change [5]. For example, in UNICEF's latest guidelines developed to address children's climate risks, mental health is mentioned three times with the lack of detail and urgency to address the issue [3]. In contrast, biophysical health risks such as malaria, dengue, pneumonia, diarrhoea, and injury were only some of the many listed and discussed with great prioritisation [5]. Likewise, in an IPCC special report on climate change threats, mental health was mentioned only four times out of five chapters to explain that due to its unknown and unpredictable climate risk factors, mental health problems were excluded in the discussion [83]. However, in the same report, physical health risks from climate-related morbidity and mortality were included and summarised [83]. The unsettling scarcity of mental health information and inclusion is further proven in the IPCC Sixth Assessment Report [29]. Among all the observed impacts of climate change on human health and systems, mental health had the least amount of assessed information, despite its significantly negative global impact and very high confidence in its attribution to climate change [29]. The overall sparse information and attention on mental health, especially on youth and climate change, highlights the need for further research focus and expansion.

Additionally, despite EWE's harsher repercussions impacting LMICs, most of the research has been focused on studying the detriments in HIC settings [15, 18, 26]. Barriers such as weak governance, frail

infrastructures, inefficient health systems, limited resources, and agriculturally centered economies contribute to the harsher conditions that LMICs must recover and adapt from compared to HICs [3, 9, 33, 34]. The unique vulnerabilities of LMIC youth as highlighted in [section 1.1.3](#), act as barriers to resilience against EWEs, giving even more reason to uncover and study over HICs. However, unfortunately, although its relevancy for research investments is evident, the preliminary search indicates otherwise. Even with the limited number of studies on children and adolescents' mental health outcomes, a great amount of them have been conducted in wealthier countries [65, 84-88]. Numerous reviews on climate change and mental health reflect this because most struggle to include studies from LMICs, and many unintentionally end up with only including studies from HICs [68, 88-90]. Consequently, a systematic review by Liu and colleagues on climate change and mental health included 53 studies, all of which were all from middle, middle-high, and HICs only [88]. Similarly, other systematic and scoping reviews have resulted in similar scarce inclusions of LMIC setting studies [18, 90-92]. This has resulted in studies to conclude on the noticeable differences and urge for research to be done in LMIC settings [19, 20, 38]. The lack of LMIC literature, especially relevant in the context of climate change and mental health, must therefore be filled to explore the unknown depth of the issue.

Lastly, although most of the primary studies done on children's mental health outcomes use quantitative research methods [18], reviews on the topic have mostly been qualitative in forms of scoping review [16, 18, 20, 89, 90, 93]. Qualitative scoping reviews are beneficial in their own ways (i.e. mapping of literature, answering broader questions, etc.), however, there are numerous limitations and risks to biases that only quantitative systematic reviews can address [94-96]. Rigorous research that can be duplicated with critical appraisals of studies are one of the strongest reasons behind conducting systematic reviews over scoping [96]. In doing so, systematic reviews bring together the dispersed information to compute evidence-based depth and quality findings [24]. Such may also be the supporting reasons behind why, over the last two years, numerous scoping reviews have raised the need for one to be done [21]. Moreover, to the best of the author's knowledge, there has been no systematic review measuring the prevalence estimates on this topic of LMIC children's mental health following EWEs. It is therefore timely to conduct a quantitative review to address the disease burden. Overall, all three gaps act as determinants to this review which aims to provide advancing research on mental health, LMIC settings, and quantitative data in the context of youth and climate change.

1.1.7 Rationale: Study justification

Given the three research gaps, understanding the burden of disease through prevalence is crucial for addressing mental health issues among LMIC youth who have experienced EWEs. This is because, without a measured estimate of burden, it is difficult to identify the severity of a concern. This can inhibit the underestimation of the problem, resulting in the inaction of policy and services. Limiting investments in further research impedes a society's potential to acknowledge, understand, and treat, as in the case for LMIC mental health issues.

Under-resourced settings, commonly found in LMICs, therefore, suffer the challenges to undermining present problems. This can be translated into social constructs like mental health stigmatization [94, 97, 98]. Such, mental health stigma is present in younger LMIC populations discussing their EWE experiences. For example, in India, children who experienced floods reported nightmares of being trapped in waters and were scared to return to school unless promised to be picked up after. However, families dismissed the possibility that such fear could be related and identified as mental health issues [98]. The failure to acknowledging mental health as a serious health problem resulted in children to be dismissed of any treatment opportunities. For these exact reasons, research plays a key role in targeting stigma. Identifying mental health burdens through distinct and undeniable measurements like prevalence estimates can help stigmatized minds to realise and acknowledge the problem. Recognizing mental health as a legitimate health concern will challenge the stigma to transition the neglect and shame into a collaborative initiation of supporting mental health care services.

Scarce LMIC setting research on youth mental health has also paralleled the lack of service provisions when compared to HICs. While 78% of HICs have policies enacted specifically for child and adolescent mental health, there are none present in LMICs [99]. Service provisions in most developing countries are already weak and lack extensively in mental health services, especially for children and adolescents [100, 101]. Even in South Africa, one of the more relatively developed LMICs, child and adolescent mental health has been discussed in superficial manners with no specific and clear guidelines for actions or services [102]. In the recent report (The State of the World's Children 2021) by UNICEF, statistics showed that Africans are left to pay 41% out-of-pocket for mental health services, whereas 98% of Europeans were insured, with only 20% of costs being out-of-pocket [5]. The comparative reality between HICs and LMICs further describes the current disparities that are led by the lack of interest and investment in research. The lack of evidence-based research findings goes hand in hand with dismissive, absent, and delayed action which LMICs have been grappling with. To push for policy and implementation, research to identify the prevalent burden is therefore crucial.

Estimating the prevalence will allow us to answer the question of how intensive and extensive the disease burden is which will further enable relevant stakeholders to identify where prioritisation of the issue truly lies. Measurements of disease of a certain population act as critical information that can inform decision-makers on needs, delivery, and services [95, 103]. Knowing to what extent the problem lies informs how to distribute and allocate resources to ensure enough adaptive coping capacity [103, 104]. As a result, to assess the present the health concern in the target population, concrete up-to-date evidence must be presented. Such information will inform critical decision makers such as governments, policy makers, and healthcare stakeholders including consumers, to understand better the seriousness of the burden in their own populations [24, 95, 96].

1.2 Objectives

1.2.1 Research aims

This review aims to document the burden of children and adolescent mental health following EWE experiences to inform LMIC agendas on policy, planning, decision-making, and directions for future research.

1.2.2 Research objectives

The following objectives to meet the aim are:

- To compute the prevalence estimate of mental health disorders among LMIC youth following EWE experiences.
- To identify and describe key sub-groups (e.g. country income status, geographical region, type of EWE, outcome measurement tools, and type of mental health disorder).
- To identify the unique burden of diseases per subgroup by computing prevalence estimates per characteristic accordingly where applicable.
- To inform relevant stakeholders like health policy makers, practitioners, decision-makers, governing bodies, and researchers on the burdens of mental health disorders among the target population to highly prevalent areas.

1.2.3 Review question

The main question for this review is: *What is the burden of disease (the prevalence of mental health disorders) among LMIC children and adolescents who have experienced EWEs?*

Secondary questions include:

- *What are the key characteristics of the studies that are associated with youth mental health prevalence rates in LMIC settings?*
- *What is the burden of disease (the prevalence of mental health disorders) among the target population when sub-grouped by key characteristics of included studies?*

2. Methods

In the past ten years, other types of systematic reviews have emerged looking to answer prevalence and incidence, which resulted into the development of review manuals like the JBI Manual for Evidence Synthesis and MOOSE (Meta-analysis of Observational Studies in Epidemiology) [96, 105]. Pooling a representative estimate of how prevalent a certain illness is in a particular population provides valuable information for describing varying distributions, especially between subgroups like income and age [95]. As identified in [section 1.1.7](#), the motive that systematic reviews have in practice is the reason a systematic review of prevalence was deemed appropriate for this study question. A systematic review will be conducted in accordance with the most recently updated 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline ([Appendix A](#)) [106]. This review protocol follows the PRISMA-Protocol guideline checklist for recommended items in reporting a systematic review protocol 2015 ([Appendix B](#)) [107] and has been registered in the PROSPERO International Prospective Register of Systematic Reviews (CRD42024535106).

2.1 Eligibility criteria

The eligibility of the study will be based on the main characteristics of a prevalence study from the recommended CoCoPop mnemonic: condition, context, and population [103]. Additional criteria to be considered for inclusion and exclusion are outlined in Table 1.

Condition

The condition of interest is mental health disorders and their prevalence. Major and frequently chosen mental health disorders in similar studies such as anxiety, depression, stress, PTSD and suicidal behaviour will be assessed. Only outcomes using standardised and operationalised measurements such as questionnaires, assessments, or diagnoses will be included [93, 108]. If not, Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) and International Classification of Diseases (ICD10) will jointly act as the basis for indications of whether the outcome is classified as a mental health disorder or not [22, 109]. Any studies reporting prevalence or data where the prevalence of the outcome can be calculated will be considered for inclusion.

Context

The context is LMICs as defined under the World Bank Country Classifications by Income (2022) which is the latest updated classification at the time of the study. Studies conducted in and/or published by HICs will also be included if deemed necessary and relevant (i.e. contains LMIC prevalence data) to the scope of this review [110].

Population

The population of interest is children and adolescents who have experienced at least one EWE. The age ranges of the population are to be defined by the World Health Organization and UNICEF [111, 112]. Although children and adolescents fall under two different age ranges 1 to <10 years old and 10-19 years old respectively, this review will regard them as one group to broaden the inclusion as possible. Any study

that defines children or adolescents between the ages of 1 and 19 will therefore fit the population of interest for inclusion.

EWEs will follow the definition provided by the IPCC and the Integrated Research on Disaster Risk (IRDR) Peril Classification and Hazard Glossary (2014), as recommended by the International Disaster Database: EM-DAT [28]. The full list is available in [Appendix C](#). Only perils categorised under geophysical, hydrological, meteorological, and climatological will be included due to the nature of defining climate change-related and weather events. Biological and extraterrestrial categories will be exempted.

Table 1. Summary of inclusion and exclusion criteria for screening

Inclusion Criteria	Exclusion Criteria
<p>Population:</p> <ul style="list-style-type: none"> Children and adolescents defined as between 1 to 19 years of age Children and adolescents who experienced at least one EWE¹ <p>Condition:</p> <ul style="list-style-type: none"> Studies that reported prevalence of mental health disorders² or studies that provide data where prevalence could be calculated <p>Context:</p> <ul style="list-style-type: none"> Population from LMIC countries as defined by the World Bank³ <p>Type of study:</p> <ul style="list-style-type: none"> Quantitative and mixed methods Observational studies: cross-sectional studies that report prevalence <p>Type of publication:</p> <ul style="list-style-type: none"> Original studies, full-text articles, conference data, thesis publications <p>Language:</p> <ul style="list-style-type: none"> English and foreign language articles with English abstracts <p>Timeline:</p> <ul style="list-style-type: none"> No date limitation 	<p>Population:</p> <ul style="list-style-type: none"> Studies defining children and adolescents as >19 years of age or without specific indication of age range Studies on children and adolescent experiences of non-climate change related factors and non-EWE-related events Studies on discussing general climate change with no links to EWEs <p>Condition:</p> <ul style="list-style-type: none"> Studies on general mental health effects and well-being Studies discussing mental health only qualitatively Studies on descriptive mental health without standardised definitions <p>Context:</p> <ul style="list-style-type: none"> Studies conducted on UMIC and HIC populations as classified by the World Bank³ <p>Type of study:</p> <ul style="list-style-type: none"> Systematic reviews, scoping reviews, literature reviews, letters, and comments <p>Type of publication:</p> <ul style="list-style-type: none"> Studies reporting on secondary data where primary and original data can be found <p>Language:</p> <ul style="list-style-type: none"> Non-English full-text articles
<p>¹ As defined by the IPCC and the Integrated Research on Disaster Risk (IRDR) Peril Classification and Hazard Glossary (2014) [28]; ² in reference to DSM-IV and ICD10 [109]; ³ World Bank Country Classifications by Income (2022) [110]</p>	

2.2 Information sources

Studies searches will be done through electronic databases, hand searching reference lists, and by using a “snowballing” method to find both published and unpublished studies [113]. The search strategy will be conducted in the following electronic databases: MEDLINE via PubMed, PsychINFO, Web of Science Core Collection, Scopus, and CINAHL. Reference lists of included studies will also be reviewed for screening after included studies have been identified. It will follow the same steps of screening as for database and grey literature screenings: title and abstract first, full-text second.

The additional searches for unpublished and grey literature, such as conference materials, theses repositories, BioRxiv, and MedRxiv will be conducted using the keywords outlined above on Google Scholar. The first 20 pages of searches will be reviewed for screened using the eligibility criteria [104].

2.3 Search strategy

The search strategy ([Appendix D](#)) was built upon two existing systematic review/protocol [19, 93] assessing similar topics of LMIC children's mental health following EWEs. From these similar studies [19, 93], the search strategy was adapted and developed further through consultation with experts in the field and senior health sciences librarians. The following keywords of Medical Subject Heading (MeSH) terms and additional Text Word search terms will be used for identified databases: infant; child; adolescent; young adult; young adult; weather; extreme weather; climatic process; climate change; disasters; mental health; mental disorders; mental illness; psychological; anxiety; stress; trauma; depression; developing countries; low income; lower middle income LMICs; East Asia & Pacific; Europe & Central Asia; Latin America & Caribbean; Middle East & North Africa; South Asia; Sub-Saharan Africa; rural; prevalence; epidemiology. Other databases will be modified as needed. The overall selection process of included and excluded studies will be presented in a PRISMA 2020 Flow Diagram available in [Appendix E](#).

All searched articles will be transferred into EndNote for screening and Rayyan for screening. The search will be done throughout May to June 2024. All databases will be searched on the same day for consistency. It will be tested and revised by the main author (EC) and the second reviewer Ava-Clare Steed (ACS), and approved by the supervisors (HAR, ME) on all identified databases before being finalised.

2.4 Study records

2.4.1 Data management

Two reference management software will be used: Rayyan and EndNote. Studies obtained through the search strategy will be transferred Rayyan to first identify and eliminate duplicates, then proceed to screening. Once the included studies have been finalised, they will be inputted into EndNote which will be used as a reference citation tool. References obtained from hand-searching methods through Google, Google Scholar, and reference lists of included studies will be inputted into a Microsoft Excel spreadsheet for screening. Extracted data from all included studies will also be inputted and stored on a spreadsheet.

A data management plan (DMP) has also been created through the University of Cape Town's DMP template. The online tool helps outline a plan to develop data management practices before the study which includes plans for data collection, storage, ethics, retention and sharing, and implementation. The DMP for this review is available in [Appendix F](#) and the link is available here:

http://dmp.lib.uct.ac.za/users/invitation/accept?invitation_token=wy_Gs9r88dwaTtCPCRWJ

2.4.2 Selection process

The primary author (EC) will conduct the searches outlined in the search strategy in all identified databases. Retrieved studies will be imported into Rayyan where duplicates will first be removed by the primary author. The selection process for inclusion/exclusion of studies will follow two steps: first through title and abstract screening, then second, through full-text screening. Each screening step will be done through Rayyan between two reviewers (EC, ACS) independently and blinded to determine eligibility for inclusion according to the criteria. During full-text screening, the same two reviewers will independently record reasons for exclusion. Any conflict will be resolved through discussion between the two reviewers and if necessary, a third reviewer (HAR or ME) will intervene to resolve through consensus.

2.4.3 Data collection process

Data extraction will be done by two reviewers (EC, ACS) independently on a purpose-designed data extraction form developed for this study. Any disagreements will be resolved through discussion to reach consensus with a third reviewer (HAR or ME) intervening if needed. The initial extraction form will be pilot tested and refined to the key characteristics of included studies deemed relevant to this review.

2.5 Data items

Data will be extracted under five main headings: 1) Study characteristics, 2) Population characteristics, 3) EWE exposure, 4) Mental health impacts & results, and 5) Risk of Bias assessment. Any critical data that is missing to calculate the prevalence of mental health outcomes will be attempted to be resolved through contacting corresponding authors.

The list of data to be extracted is as outlined below in Table 2. The data extraction excel sheet is available in [Appendix G](#).

Table 2. Data Items for extraction

1) Study characteristics
Title, authors, year of publication, study design, country, regional classification (WHO guidelines)
2) Population characteristics
Country income status (by World Bank guidelines), sample size (n =), age range (definition of children and adolescents), country of population (if different from geographical location from study) EWE (by IRDR guidelines)
3) EWE exposure
EWE experienced, EWE category (defined by IRDR), duration time between experienced EWE and outcome assessment for study (time point measured)
4) Mental health impacts & results
Mental health outcome(s), measurement of mental health outcomes/definition of mental health outcomes (diagnostic instrument), prevalence of mental health disorder(s), prevalence period (if applicable), key limitations
5) ROB assessment
Hoy et al. questions: i) was the study's target population representative to national population? ii) was the sampling frame representative of target population? iii) was some form of random selection used to select the sample or was census undertaken? iv) was the likelihood of non-response bias minimal? v) were data collected directly from the subjects? vi) was an acceptable case definition used in the study? vii) was the study instrument measuring interest shown to have reliability and validity? viii) was the same mode of data collection used for all subjects? ix) was the length of the shortest prevalence period for the parameter of interest appropriate? x) were the numerators and denominators for the parameter of interest appropriate?

2.6 Risk of bias in individual studies

Risk of bias (ROB) will be assessed using the developed guideline tool by Hoy et al. (2012) for prevalence studies ([Appendix H](#)) [114]. Because data needed to conduct the ROB assessment will be extracted at the same time as data extraction, the same two reviewers (EC, ACS) will independently evaluate and assess the methodological quality of the included studies. Any disagreements will be resolved through discussion with the intervention of a third reviewer (HAR or ME) if necessary.

External Validity

The ROB tool developed by Hoy et al. (2012) [114], will assess external validity through the following examinations: 1) if the study population is a close representation of the national population; 2) if the sampling frame is a true or close representation of the study's target population; 3) if random selection was present; and 4) if non-response bias was minimal.

Internal Validity

In addition to the four external validity questions, Hoy et al. also assess internal validity through the following six examinations: 5) if the data was collected directly from the subjects or via proxy; 6) if appropriate definitions were clearly stated; 7) if the instrument of measurement was reliable and valid; 8) if the same measurement was applied to all subjects; 9) if the prevalence period was appropriately short; and 10) if the numerator(s) and denominator(s) are appropriate to the parameter of interest.

2.7 Data synthesis

Characteristics of selected studies for inclusion will be summarised in tables and further classified in meaningful groups such as type of mental health disorder, specific age groups, and type of EWEs where appropriate and applicable. Where data are amiable to conduct a meta-analysis, a pooled prevalence with 95% confidence intervals will be computed using the statistical software Stata. We will use the *metaprop_one* routine with the Freeman-Tukey arcsine transformation to describe the combined prevalence estimates of all included studies with the standard error across the unadjusted estimates [115]. Data will be presented in a forest plot. Sub-grouped meta-analysis will be conducted based on the potential meaningful groups mentioned above. Heterogeneity between studies will be identified by Higgins test for I^2 statistic. An I^2 of over 50% will be considered a significant indicative of moderate to high heterogeneity, where 25% is low and 75% is high. Moderate to high heterogeneity is anticipated due to the various measurements of assessing the outcome, which is why a random-effects model will be used to pool prevalence estimates. Where heterogeneity is present, sensitivity analyses will be conducted to assess the impact of outlier study results on the overall effect.

In the case where this is not possible with not enough relevant data available, a descriptive analysis will be done to comprehensively report and present data in accordance with the guideline SWiM (Synthesis Without Meta-analysis), developed by the ICONS-Quant (Improving the Conduct of reporting of Narrative Synthesis of Quantitative data) project by Cochrane ([Appendix I](#)) [116]. SWiM requires for the reporting of description and certainty of findings in line with the research question [116]. The prevalence rates of key subgroups identified in the included studies (type of EWE, type of mental health disorder, etc.) with their confidence levels will be synthesised in the analysis. Reporting of SWiM guidelines will be done by the main author (EC) with discussions with both supervisors (HAR, ME). Implications on policy, planning, decision-making, and directions for future research will follow the data analysis.

2.8 Meta-bias(es)

Publication bias will be addressed by not only doing academic database searches, but also through the acknowledgement of identifying predatory journals capture in systematic reviews as recommended by Rice and colleagues [117]. This will be done in discussion with the main supervisor (HAR) and if necessary, a third author (ME) to come to a consensus.

In addition, bias raised from the elevated chances of being published if favoring certain results will be eliminated by including non-peer reviewed articles. This will not include opinionated writings like letters and comments as mentioned in the exclusion criteria, but grey literature, governmental and internationally recognised reports (i.e. reports by the UN, WHO, etc.).

Bias raised from potential selective reporting within studies may be present which will bridge from publication bias. Any bias in selective reporting will be resolved in the data extraction phase where two reviewers will be independently extracting the results, and therefore blinding will take place.

3. Ethics

This review does not require an ethics approval since it utilises secondary data from available published and unpublished studies. As required for the degree, the protocol will be submitted to the School of Public Health's Departmental Research Committee (DRC) at the University of Cape Town for approval. Submission to the International Prospective Register of Systematic Reviews (PROSPERO) is done with the registration number obtained: CRD42024535106. The final manuscript will be made available online in agreement to the university's open access library policy.

4. Conclusion

4.1 Limitations

Several limitations from biases that are anticipated in this review are selection bias, reporting bias, language bias, and publication bias. Selection bias may rise during the selection process of screening for inclusion and exclusion. To reduce selection bias, there will be two reviewers (EC, ACS) independently screening articles with a thoroughly developed inclusion and exclusion criteria. A third reviewer (HAR or ME) will also be ready to intervene when conflict arises, making sure to remove biases that would rise if only one reviewer selected all the studies for inclusion. Language bias may also rise in this stage since only studies published in English will be included. However, numerous studies today are translated into English, and to broaden it further, studies with abstracts in English will also be considered for inclusion. Anticipated reporting bias will be reduced by registering the protocol on PROSPERO to increase transparency, in addition to following the PRISMA-P guidelines for the protocol and PRISMA for the actual reporting of the study. Lastly, to reduce publication bias, the inclusion criteria of type of publication has been opened to not only original studies, but also to grey literature, including conference data and thesis publications. The search strategy will also be expanded to find both published and unpublished studies through preprint databases like BioRxiv, MedRxiv, and Google Scholar. With the extracted data, funnel plots will also be used to investigate further publication bias in the included studies for the meta-analysis, as well as a statistical Egger's test to check for asymmetry in the funnel plots.

The restricted resources may also act as a limitation to the study since the review will only be able to access published literature that is either open or accessible through the University of Cape Town's permission.

4.2 Timeline

The review will follow the timeline outlined below to complete and submit the thesis for examination.

Table 3. Proposed timeline to meet appropriate milestones for the graduation date of September 2024.

Month	Milestones
May 2023	<ul style="list-style-type: none"> • Concept paper
October 2023	<ul style="list-style-type: none"> • First draft of proposal submitted to supervisors
November – December 2023	<ul style="list-style-type: none"> • Proposal editing
January 2024	<ul style="list-style-type: none"> • Second draft of proposal submitted to supervisors
February - April 2024	<ul style="list-style-type: none"> • Third draft of proposal to supervisor • Fourth draft of proposal to supervisors • Register on PROSPERO
May 2024	<ul style="list-style-type: none"> • Submit final proposal draft to DRC for approval by beginning May • Databases and literature searches completed • First screening of identified records – titles and abstract • Second screening of identified records – full text documents • Data extraction
June 2024	<ul style="list-style-type: none"> • Risk of Bias conducted for included studies • Meta-analysis for included studies • GRADE conducted
July 2024	<ul style="list-style-type: none"> • First draft of journal article submitted to supervisors • Edit manuscript with comments from supervisors
August 2024	<ul style="list-style-type: none"> • Final draft of journal article submitted to supervisors beginning June • Submit first full draft of thesis for supervisors' review • Final submission of full thesis draft • Intention to Submit finalised 6 weeks before submission
September 2024	<ul style="list-style-type: none"> • Final Turnitin submission to supervisor • Submission of thesis to Post Graduate office

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6. Appendices

6.1. Appendix A: PRISMA 2020 checklist

PRISMA 2020 Main Checklist

(computed with sample answers)

Topic	No.	Item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Section 1, Page 2
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Section 4, Line 7
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Line XX-ZZ
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Line XX-ZZ
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Line XX-ZZ
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Line XX-ZZ
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Line XX-ZZ

Topic	No.	Item	Location where item is reported
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Line XX-ZZ
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Line XX-ZZ
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Line XX-ZZ
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Line XX-ZZ
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Line XX-ZZ
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item 5)).	Line XX-ZZ
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Line XX-ZZ
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Line XX-ZZ
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Line XX-ZZ
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Line XX-ZZ

Topic	No.	Item	Location where item is reported
Reporting bias assessment	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Line XX-ZZ
	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Line XX-ZZ
	Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Line XX-ZZ
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Line XX-ZZ
Study characteristics	17	Cite each included study and present its characteristics.	Line XX-ZZ
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Line XX-ZZ
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Line XX-ZZ
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Line XX-ZZ
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Line XX-ZZ
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Line XX-ZZ
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	Line XX-ZZ
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	Line XX-ZZ

Topic	No.	Item	Location where item is reported
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Line XX-ZZ
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Line XX-ZZ
	23b	Discuss any limitations of the evidence included in the review.	Line XX-ZZ
	23c	Discuss any limitations of the review processes used.	Line XX-ZZ
	23d	Discuss implications of the results for practice, policy, and future research.	Line XX-ZZ
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Line XX-ZZ
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Line XX-ZZ
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Line XX-ZZ
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Line XX-ZZ
Competing interests	26	Declare any competing interests of review authors.	Line XX-ZZ
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Line XX-ZZ

PRIMSA Abstract Checklist

Topic	No.	Item	Reported?
TITLE			
Title	1	Identify the report as a systematic review.	No
BACKGROUND			
Objectives	2	Provide an explicit statement of the main objective(s) or question(s) the review addresses.	No
METHODS			
Eligibility criteria	3	Specify the inclusion and exclusion criteria for the review.	Yes
Information sources	4	Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched.	No
Risk of bias	5	Specify the methods used to assess risk of bias in the included studies.	Yes
Synthesis of results	6	Specify the methods used to present and synthesize results.	Yes
RESULTS			
Included studies	7	Give the total number of included studies and participants and summarise relevant characteristics of studies.	Yes
Synthesis of results	8	Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favoured).	Yes
DISCUSSION			
Limitations of evidence	9	Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision).	Yes
Interpretation	10	Provide a general interpretation of the results and important implications.	Yes
OTHER			
Funding	11	Specify the primary source of funding for the review.	Yes
Registration	12	Provide the register name and registration number.	Yes

6.2. Appendix B: PRISMA-P 2015 checklist

PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist: recommended items to address in a systematic review protocol*

Section and topic	Item No	Checklist item
ADMINISTRATIVE INFORMATION		
Title:		
Identification	1a	Identify the report as a protocol of a systematic review
Update	1b	If the protocol is for an update of a previous systematic review, identify as such
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number
Authors:		
Contact	3a	Provide name, institutional affiliation, e-mail address of all protocol authors; provide physical mailing address of corresponding author
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments
Support:		
Sources	5a	Indicate sources of financial or other support for the review
Sponsor	5b	Provide name for the review funder and/or sponsor
Role of sponsor or funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol
INTRODUCTION		
Rationale	6	Describe the rationale for the review in the context of what is already known
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)
METHODS		
Eligibility criteria	8	Specify the study characteristics (such as PICO, study design, setting, time frame) and report characteristics (such as years considered, language, publication status) to be used as criteria for eligibility for the review
Information sources	9	Describe all intended information sources (such as electronic databases, contact with study authors, trial registers or other grey literature sources) with planned dates of coverage
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated
Study records:		
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review
Selection process	11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis)
Data collection process	11c	Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and

		confirming data from investigators
Data items	12	List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis
Data synthesis	15a	Describe criteria under which study data will be quantitatively synthesised
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I^2 , Kendall's τ)
	15c	Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (such as GRADE)

*** It is strongly recommended that this checklist be read in conjunction with the PRISMA-P Explanation and Elaboration (cite when available) for important clarification on the items. Amendments to a review protocol should be tracked and dated. The copyright for PRISMA-P (including checklist) is held by the PRISMA-P Group and is distributed under a Creative Commons Attribution Licence 4.0.**

From: Shamseer L, Moher D, Clarke M, Ghersi D, Liberati A, Petticrew M, Shekelle P, Stewart L, PRISMA-P Group. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ. 2015 Jan 2;349(jan02 1):g7647.

6.3. Appendix C: Integrated research on disaster risk: Peril classification and hazard glossary

Family	Main Event	Peril
Geophysical	Earthquake Mass Movement Volcanic Activity	Ash Fall Fire following EQ Ground Movement Landslide following EQ Lahar Lava Flow Liquefaction Pyroclastic Flow Tsunami
Hydrological	Flood Landslide Wave Action	Avalanche: Snow, Debris Coastal Flood Coastal Erosion Debris/Mud Flow/Rockfall Expansive Soil Flash Flood Ice Jam Flood Riverine Flood Rogue Wave Seiche Sinkhole
Meteorological	Convective Storm Extratropical Storm Extreme Temperature Fog Tropical Cyclone	Cold Wave Derecho Frost/Freeze Hail Heat Wave Lightning Rain Sandstorm/Dust storm Snow/Ice Storm Surge Tornado Wind Winter Storm/Blizzard
Climatological	Drought Glacial Lake Outburst Wildfire	Forest Fire Land fire: Brush, Bush, Pasture Subsidence
Biological	Animal Incident Disease Insect Infestation	Bacterial Disease Fungal Disease Parasitic Disease Prion Disease Viral Disease
Extraterrestrial	Impact Space Weather	Airburst Collision Energetic Particles Geomagnetic Storm Radio Disturbance Shockwave

Figure 4: Peril classification at the Family, Main Event and Peril levels. The association of perils with main events is solely a suggestion. Some perils may change their main event association based on the actual event and loss trigger.

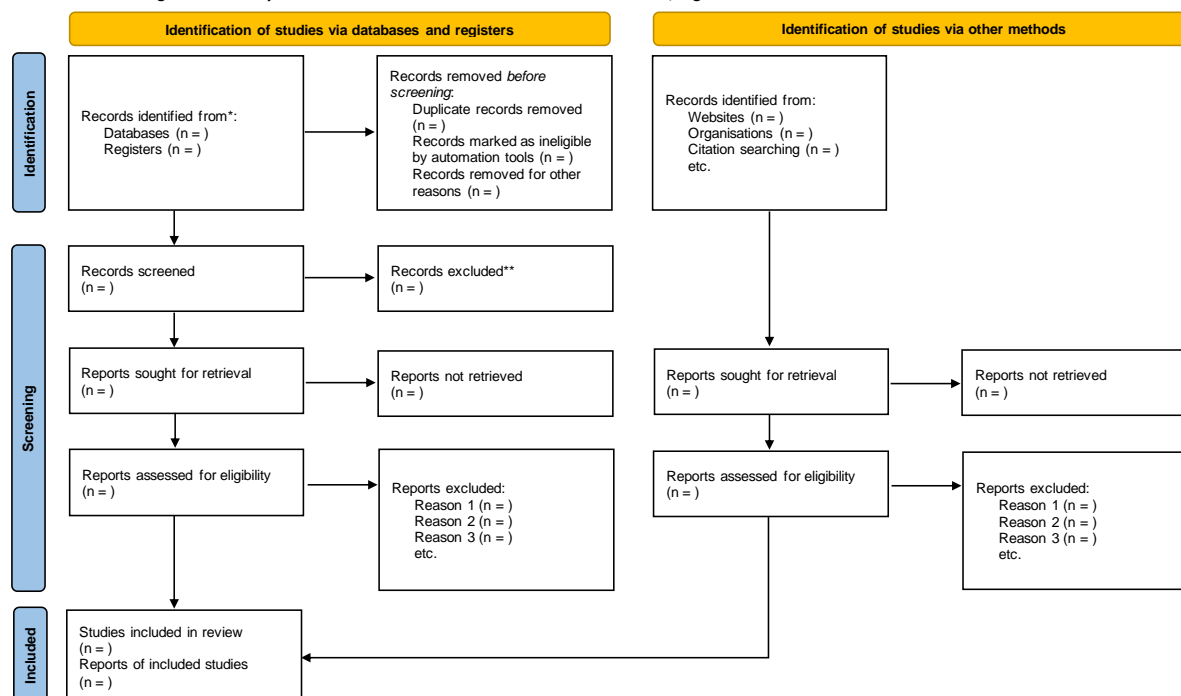
6.4. Appendix D: Search strategy for PubMed and Scopus

Population: Children and adolescents		
#1	MeSH terms:	Child; adolescent; infant; young adult;
#2	Text Word:	adolescent OR adolescents OR adolescence OR babies OR baby OR boy OR boys OR child OR children OR girl OR girls OR infant OR infants OR pediatric OR paediatric OR teen OR teenager OR teenagers OR teens OR toddler OR toddlers OR young adult or youth OR youths
#3		#1 OR #2
Exposure: Extreme weather events		
#4	MeSH terms:	Extreme weather events; weather; climatic processes; disasters
#5	Text Word:	avalanche OR avalanches OR climate change OR cyclone OR cyclones OR cyclonic OR drought OR droughts OR El Nina OR La Nina OR El Nino OR La Nino OR El Nino-southern oscillation OR extreme cold OR extreme heat OR extreme precipitation OR extreme temperature OR flood OR floods OR flooding OR global warming OR heat wave OR heatwave OR heavy precipitation OR heavy rain OR heavy rainfall OR global warming OR hurricane OR hurricanes OR landslide OR landslides OR mudslide OR mudslides OR natural disasters OR storm OR storms OR tidal wave OR tidal waves OR tornado OR tornadoes OR tsunami OR tsunamis OR wildfires OR weather OR weather-driven
#6		#4 OR #5
Condition: Mental health outcomes		
#7	MeSH terms:	Mental health, mental disorders
#8	Text Word:	alcohol use OR alcohol abuse OR anger OR anxiety OR attachment disorders OR cognition OR cognitive OR coping OR depression OR depressive OR drug use OR drug abuse OR emotion OR emotions OR emotional OR mental OR mood OR phobias OR post-traumatic OR posttraumatic OR PTSD OR psychological OR psychology OR psychosocial OR sleep disorders OR stress OR substance abuse OR substance use OR temperament OR trauma OR traumatic OR
#9		#7 OR #8
Context: Low- and middle-income countries		
#10	MeSH terms:	Developing countries, low-income countries, middle-income countries, low-middle income countries
#11	Text Word:	Deprived Countries OR Deprived Population OR Deprived Populations OR Developing Countries OR Developing Country OR Developing Economies OR Developing Economy OR Developing Nation OR Developing Nations OR Developing Population OR Developing Populations OR Developing World OR LAMI Countries OR LAMI Country OR Less Developed Countries OR Less Developed Country OR Less Developed Economies OR Less Developed Nation OR Less Developed Nations OR Less Developed World OR Lesser Developed Countries OR Lesser Developed Nations OR LMIC OR LMICS OR Low GDP OR Low GNP OR Low Gross Domestic OR Low Gross National OR Low Income Countries OR Low Income Country OR Low Income Economies OR Low Income Economy OR Low Income Nations OR Low Income Population OR Low Income Populations OR Lower GDP OR lower gross domestic OR Lower Income Countries OR Lower Income Country OR Lower Income Nations OR Lower Income Population OR Lower Income Populations OR Middle Income Countries OR Middle Income Country OR Middle Income Economies OR Middle Income Nation OR Middle Income Nations OR Middle Income Population OR Middle Income Populations OR Poor Countries OR Poor Country OR Poor Economies OR Poor Economy OR Poor Nation OR Poor Nations OR Poor Population OR Poor Populations OR poor world OR Poorer Countries OR Poorer Economies OR Poorer Economy OR Poorer Nations OR Poorer Population OR Poorer Populations OR Third World OR Transitional Countries OR Transitional Country OR Transitional Economies OR Transitional Economy OR Under Developed Countries OR Under Developed Country OR under developed nations OR Under Developed World OR Under Served Population OR Under Served Populations OR Underdeveloped Countries OR Underdeveloped Country OR underdeveloped economies OR underdeveloped nations OR underdeveloped population OR Underdeveloped World OR Underserved Countries OR Underserved Nations OR Underserved Population OR Underserved Populations
#12	Text Word:	East Asia OR East Asia and Pacific OR Cambodia OR Indonesia OR Kiribati OR Democratic People's Republic of Korea OR Laos OR Micronesia OR Mongolia OR Myanmar OR Papua New Guinea OR Philippines OR Samoa OR Solomon Islands OR Timor-Leste OR Vanuatu OR Vietnam
#13	Text Word:	Europe OR Central Asia OR Kyrgyzstan OR Tajikistan OR Ukraine OR Uzbekistan

#14	Text Word:	Bolivia OR Caribbean OR El Salvador OR Haiti OR Honduras OR Latin America OR Nicaragua OR Venezuela
#15	Text Word:	Algeria OR Djibouti OR Egypt OR Iran OR Lebanon OR Middle East OR Morocco OR North Africa OR Syria OR Tunisia OR Palestine OR Gaza OR Yemen
#16	Text Word:	Afghanistan OR Bangladesh OR Bhutan OR India OR Nepal OR Pakistan OR South Asia OR Sri Lanka
#17	Text Word:	Angola OR Benin OR Burkina Faso OR Burundi OR Cabo Verde OR Cameroon OR Central Africa OR Chad OR Comoros OR Congo OR Republic of Congo OR Democratic Republic of Congo OR Cote d'Ivoire OR Eritrea OR Eswatini OR Ethiopia OR Gambia OR Ghana OR Guinea OR Guinea-Bissau OR Kenya OR Lesotho OR Liberia OR Madagascar OR Malawi OR Mali OR Mauritania OR Mozambique OR Niger OR Nigeria OR Rwanda OR Sao Tome and Principe OR Senegal OR Sierra Leone OR Somalia OR South Sudan OR Sub-Saharan Africa OR Sudan OR Tanzania OR Togo OR Uganda OR Zambia OR Zimbabwe
#18		#10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17
#19		#3 AND #6 AND #9 AND #18

6.5. Appendix E: Prisma 2020 flow diagram

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).

**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: <http://www.prisma-statement.org/>

6.6. Appendix F: Data management plan

Prevalence of mental health disorders among LMIC children and adolescents exposed to climate change-related extreme weather events: A systematic review protocol

A Data Management Plan created using UCT DMP

Creator: Elizabeth Choi

Affiliation: University of Cape Town

Template: UCT Student Generic DMP

Project abstract:

The emerging threats to climate change are no longer an unknowing silent threat, but rather a harsh reality of destructive consequences of which the increasing numbers of extreme weather events (EWEs) have become major indicators of. However, despite this assertion, there is still much unexplored research concerning the disproportionately detrimental consequences climate change has on vulnerable populations, notably low- and middle-income countries (LMICs) and younger populations. When put together, children and adolescents living in LMICs are characterized as one of the most vulnerable populations in the world due to the combined and therefore, intensified fragility. Out of the numerous consequences that climate change induces, mental health has been the most neglected human health outcome, despite evident findings on associations between climate change EWEs and mental health disorders. Negligence, inaction, and failure to prioritise the mental health issue is especially pertinent among the vulnerable population: LMIC youth. The aim of this review is to therefore compute a prevalence estimate and answer the question of measuring the burden of disease of mental health impacts among LMIC children and adolescents after having experienced EWE(s). Measuring prevalence and understanding the burden of disease allows for an overall assessment of the burden at the current point in time which acts as critical evidence to not only advocate for its prioritization to decision-making governing bodies but also to know where to place the issue in a global public health agenda. The question raised for this review answers how prominent, and therefore, how weak and vulnerable LMIC children are, through a rigorous and standardized method to uncover how attributable climate change and EWEs are to the vulnerable population.

ID: 4817

Start date: 01-06-2023

End date: 12-02-2024

Last modified: 25-10-2023

Prevalence of mental health disorders among LMIC children and adolescents exposed to climate change-related extreme weather events: A systematic review protocol - Student Outline DMP

1. General guidelines

PURPOSE OF THIS TEMPLATE - The purpose of the Outline DMP is to indicate your initial plans for how your data will be collected, shared and stored, and to give you a chance to think about these data-focused aspects of the research process. As you begin doing your research, your data process may change, and it is perfectly acceptable to change your data management plan to accommodate the changes in your research process. Indicate below that you understand the purpose of completing this Outline DMP template.

- I understand the Outline DMP template is a projection of my anticipated data management planning requirements and should be updated as my project develops.

2. Authors and supervisors

PROJECT NAME - Replicate the title of your project, dissertation or thesis exactly as it appears in your proposal document.

Prevalence of mental health disorders among LMIC children and adolescents exposed to climate change-related extreme weather events: A systematic review protocol

PERSONAL DETAILS - Indicate the name(s) and student number(s) of the student(s) who will be involved in this project, dissertation or thesis.

Elizabeth Choi - CHXELI002

SUPERVISOR(S) DETAILS - Indicate who will supervise this project, dissertation or thesis. If you do not yet have a

supervisor, leave this section blank.

Prof. Hanna-Andrea Rother & Prof. Mark Engel

3. Data Collection/Generation

COLLECTION OF ORIGINAL DATA - Indicate whether or not you intend to gather/produce original data for your study, and provide a brief description of the kind of data you think you will collect. If you are unsure at this time, indicate what you think you are most likely to collect. If you are not intending to gather or collect your own data, declare that here.

- I do not intend to collect original data.

USE OF EXISTING DATA - Indicate if you intend to re-use existing data, either from online searches or from datasets provided by your supervisor, lab, or funder. If you are not intending to re-use existing data, declare that here.

- I intend to reuse existing data in my study (described below).

I intend to use secondary data from original pre-existing studies made available in various academic databases and online searches. Data will be taken from already published and/or online available studies and will not need other permission for usage.

DATA SHARING - Indicate whether or not you are intending to publish your research data. If you are, indicate where you are intending to publish your data and under what licensing conditions, such as Creative Commons. If you are not intending to publish your data, provide reasons and reference the appropriate ethical considerations, commercial applications/patenting ambition, or data re-use agreements that prevent you from publishing your data.

- I intend to share my data (details below).

If possible, I intend to publish the data from my research. However, no ethical clearance is needed since the data is already from published sources and are all secondary data. Nonetheless, the protocol for a systematic review will go through the University of Cape Town's Department of Research Council (DRC) and Human Research Ethics Committee (HREC).

4. Data Storage

ANTICIPATED DATASET SIZE - Indicate the estimated size of your completed dataset, and indicate whether or not you will need to access additional data storage facilities. If such storage is not provided by your unit or department, you may need to factor in the cost of purchasing additional storage space.

- 20GB or less

No access is needed for additional data storage.

DATA BACKUPS - Indicate how you plan to ensure your data is secure and retrievable in case of errors or hardware failure. Describe what procedures you will put in place to back-up copies of your data and where they will be stored.

- I intend to backup my data using a service provided by UCT (UCT GoogleDrive, UCT OneDrive, Netstorage, ZivaHub etc.).

During my data collection and analysis phase, data will be secured in both GoogleDrive and personal storage.

5. Data Centre(s)/Repositories

DATA CENTRES/REPOSITORIES - Once your project, dissertation or thesis is complete, it is advisable to curate and archive your completed dataset with an established data centre or repository. Note that you should archive your data even if you are not intending to publish it. Check with your supervisor or funder if you are required to deposit your data in a specific repository, or declare that you will deposit the data in ZivaHub (see the Guidance section).

- At the end of my study, I will deposit my data on ZivaHub.

METADATA - Metadata is descriptive information that others will need to make sense of your dataset. Metadata includes things like study descriptions or abstracts, study instruments (sample collection schedules, codebooks for variables, survey instruments, etc.), subject codes, and keywords. Indicate what metadata will accompany your curated dataset.

The completed dataset will be accompanied by keywords, MeSH terms, Text Word search terms, short descriptions taken from the dissertation abstract and relevant paragraphs on the data process taken from my methods section.

6. Budget

BUDGET - Indicate any costs specifically relating to the management and curation of your data, such as purchasing additional storage space, digitisation of physical media, data storage or curation charges, and data audits. Most student research will be able to make use of free options provided by UCT and will not have to budget for data costs.

I do not anticipate any data costs as my data is less than 10GB, and I will be using a storage system provided by UCT (UCT GoogleDrive, UCT OneDrive, Netstorage, ZivaHub, etc.) to curate my data

6.7. Appendix G: Data extraction sheet

Data Extraction Table

	Study 1	Study 2, etc.
Title		
Author/Year		
Country		
Regional Classification (by WHO guidelines)		
Country Income Status (by World Bank)		
Study Design		
Sample size (n =)		
Age Range		
EWE type (by IRDR)		
Time Point Measured		
Outcome(s) (mental health disorders)		
Measurement Tool		
Prevalence of Outcomes		
ROB questions:		
Item 1		
Item 2		
Item 3, etc.		

6.8. Appendix H: Hoy et al. risk of bias tool

Appendix 1: Risk of Bias Tool

Name of author(s): _____ Year of publication: _____ Name of paper/study: _____

This tool is designed to assess the risk of bias in population-based prevalence studies. Please read the additional notes for each item when initially using the tool. Note: If there is insufficient information in the article to permit a judgement for a particular item, please answer **No (HIGH RISK)** for that particular item.

Risk of bias item	Criteria for answers (please circle one option)	Additional notes and examples
<i>External Validity</i>		
1. Was the study's target population a <u>close representation</u> of the national population in relation to relevant variables, e.g. age, sex, occupation?	<ul style="list-style-type: none"> • Yes (LOW RISK): The study's target population was a <u>close</u> representation of the national population. • No (HIGH RISK): The study's target population was clearly <u>NOT</u> representative of the national population. 	<p>The target population refers to the group of people or entities to which the results of the study will be generalised. Examples:</p> <ul style="list-style-type: none"> • The study was a national health survey of people 15 years and over and the sample was drawn from a list that included all individuals in the population aged 15 years and over. The answer is: Yes (LOW RISK). • The study was conducted in one province only, and it is not clear if this was representative of the national population. The answer is: No (HIGH RISK). • The study was undertaken in one village only and it is clear this was not representative of the national population. The answer is: No (HIGH RISK).
2. Was the sampling frame a <u>true or close representation</u> of the target population?	<ul style="list-style-type: none"> • Yes (LOW RISK): The sampling frame was a <u>true or close</u> representation of the target population. • No (HIGH RISK): The sampling frame was NOT a <u>true or close</u> representation of the target population. 	<p>The sampling frame is a list of the sampling units in the target population and the study sample is drawn from this list. Examples:</p> <ul style="list-style-type: none"> • The sampling frame was a list of almost every individual within the target population. The answer is: Yes (LOW RISK). • The cluster sampling method was used and the sample of clusters/villages was drawn from a list of all villages in the target population. The answer is: Yes (LOW RISK). • The sampling frame was a list of just one particular ethnic group within the overall target population, which comprised many groups. The answer is: No (HIGH RISK).
3. Was some form of <u>random selection</u> used to select the sample, OR, was a census undertaken?	<ul style="list-style-type: none"> • Yes (LOW RISK): A census was undertaken, OR, some form of random selection was used to select the sample (e.g. simple random sampling, stratified random sampling, cluster sampling, systematic sampling). • No (HIGH RISK): A census was NOT undertaken, AND some form of random selection was NOT used to select the sample. 	<p>A census collects information from every unit in the sampling frame. In a survey, only part of the sampling frame is sampled. In these instances, random selection of the sample helps minimise study bias. Examples:</p> <ul style="list-style-type: none"> • The sample was selected using simple random sampling. The answer is: Yes (LOW RISK). • The target population was the village and every person in the village was sampled. The answer is: Yes (LOW RISK). • The nearest villages to the capital city were selected in order to save on the cost of fuel. The answer is: No (HIGH RISK).
4. Was the likelihood of <u>non-response bias minimal?</u>	<ul style="list-style-type: none"> • Yes (LOW RISK): The response rate for the study was $\geq 75\%$, OR, an analysis was performed that showed no significant difference in relevant demographic characteristics between responders and non-responders • No (HIGH RISK): The response rate was $< 75\%$, and if any analysis comparing responders and non-responders was done, it showed a significant difference in relevant demographic characteristics between responders and non-responders. 	<p>Examples:</p> <ul style="list-style-type: none"> • The response rate was 68%; however, the researchers did an analysis and found no significant difference between responders and non-responders in terms of age, sex, occupation and socio-economic status. The answer is: Yes (LOW RISK). • The response rate was 65% and the researchers did NOT carry out an analysis to compare relevant demographic characteristics between responders and non-responders. The answer is: No (HIGH RISK). • The response rate was 69% and the researchers did an analysis and found a significant difference in age, sex and socio-economic status between responders and non-responders. The answer is: No (HIGH RISK).

Internal Validity		
5. Were data collected <u>directly from the subjects</u> (as opposed to a proxy)?	<ul style="list-style-type: none"> • Yes (LOW RISK): All data were collected directly from the subjects. • No (HIGH RISK): In some instances, data were collected from a proxy. 	<p>A proxy is a representative of the subject. Examples:</p> <ul style="list-style-type: none"> • All eligible subjects in the household were interviewed separately. The answer is: Yes (LOW RISK). • A representative of the household was interviewed and questioned about the presence of low back pain in each household member. The answer is: No (HIGH RISK).
6. Was an acceptable case definition used in the study?	<ul style="list-style-type: none"> • Yes (LOW RISK): An acceptable case definition was used. • No (HIGH RISK): An acceptable case definition was <u>NOT</u> used. 	<ul style="list-style-type: none"> • For a study on low back pain, the following case definition was used: "Low back pain is defined as activity-limiting pain lasting more than one day in the area on the posterior aspect of the body from the bottom of the 12th rib to the lower gluteal folds." The answer is: Yes (LOW RISK). • For a study on back pain, there was no description of the specific anatomical location „back“ referred to. The answer is: No (HIGH RISK). • For a study on osteoarthritis, the following case definition was used: "Symptomatic osteoarthritis of the hip or knee, radiologically confirmed as Kellgren-Lawrence grade 2-4". The answer is: LOW RISK.
7. Was the study instrument that measured the parameter of interest (e.g. prevalence of low back pain) shown to have <u>reliability and validity (if necessary)</u> ?	<ul style="list-style-type: none"> • Yes (LOW RISK): The study instrument had been shown to have reliability and validity (if this was necessary), e.g. test-re-test, piloting, validation in a previous study, etc. • No (HIGH RISK): The study instrument had <u>NOT</u> been shown to have reliability or validity (if this was necessary). 	<ul style="list-style-type: none"> • The authors used the COPCORD questionnaire, which had previously been validated. They also tested the inter-rater reliability of the questionnaire. The answer is: Yes (LOW RISK). • The authors developed their own questionnaire and did not test this for validity or reliability. The answer is: No (HIGH RISK).
8. Was the <u>same mode of data collection</u> used for all subjects?	<ul style="list-style-type: none"> • Yes (LOW RISK): The same mode of data collection was used for all subjects. • No (HIGH RISK): The same mode of data collection was <u>NOT</u> used for all subjects. 	<p>The mode of data collection is the method used for collecting information from the subjects. The most common modes are face-to-face interviews, telephone interviews and self-administered questionnaires. Examples:</p> <ul style="list-style-type: none"> • All eligible subjects had a face-to-face interview. The answer is: Yes (LOW RISK). • Some subjects were interviewed over the telephone and some filled in postal questionnaires. The answer is: No (HIGH RISK).
9. Was the <u>length of the shortest prevalence period</u> for the parameter of interest appropriate?	<ul style="list-style-type: none"> • Yes (LOW RISK): The shortest prevalence period for the parameter of interest was appropriate (e.g. point prevalence, one-week prevalence, one-year prevalence). • No (HIGH RISK): The shortest prevalence period for the parameter of interest was not appropriate (e.g. lifetime prevalence) 	<p>The prevalence period is the period that the subject is asked about e.g. "Have you experienced low back pain over the previous year?" In this example, the prevalence period is one year. The longer the prevalence period, the greater the likelihood of the subject forgetting if they experienced the symptom of interest (e.g. low back pain). Examples:</p> <ul style="list-style-type: none"> • Subjects were asked about pain over the past week. The answer is: Yes (LOW RISK). • Subjects were only asked about pain over the past three years. The answer is: No (HIGH RISK).
10. Were the <u>numerator(s) and denominator(s)</u> for the parameter of interest appropriate?	<ul style="list-style-type: none"> • Yes (LOW RISK): The paper presented appropriate numerator(s) AND denominator(s) for the parameter of interest (e.g. the prevalence of low back pain). • No (HIGH RISK): The paper did not present numerator(s) AND denominator(s) for the parameter of interest but one or more of these were inappropriate. 	<p>There may be errors in the calculation and/or reporting of the numerator and/or denominator. Examples:</p> <ul style="list-style-type: none"> • There were no errors in the reporting of the numerator(s) AND denominator(s) for the prevalence of low back pain. The answer is: Yes (LOW RISK). • In reporting the overall prevalence of low back pain (in both men and women), the authors accidentally used the population of women as the denominator rather than the combined population. The answer is: No (HIGH RISK).
11. Summary item on the overall risk of study bias		
<ul style="list-style-type: none"> • LOW RISK OF BIAS: Further research is <u>very unlikely</u> to change our confidence in the estimate. • MODERATE RISK OF BIAS: Further research is likely to have an important impact on our confidence in the estimate and may change the estimate. 		

- **HIGH RISK OF BIAS:** Further research is very likely to have an important impact on our confidence in the estimate and is likely to change the estimate.

6.9. Appendix I: Synthesis Without Meta-analysis (SWiM) reporting guideline

Synthesis Without Meta-analysis (SWiM) reporting items

The citation for the Synthesis Without Meta-analysis explanation and elaboration article is: Campbell M, McKenzie JE, Sowden A, Katikireddi SV, Brennan SE, Ellis S, Hartmann-Boyce J, Ryan R, Shepperd S, Thomas J, Welch V, Thomson H. Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline BMJ 2020;368:l6890 <http://dx.doi.org/10.1136/bmj.l6890>

SWiM is intended to complement and be used as an extension to PRISMA			
SWiM reporting item	Item description	Page in manuscript where item is reported	Other*
<i>Methods</i>			
1 Grouping studies for synthesis	1a) Provide a description of, and rationale for, the groups used in the synthesis (e.g., groupings of populations, interventions, outcomes, study design)		
	1b) Detail and provide rationale for any changes made subsequent to the protocol in the groups used in the synthesis		
2 Describe the standardised metric and transformation methods used	Describe the standardised metric for each outcome. Explain why the metric(s) was chosen, and describe any methods used to transform the intervention effects, as reported in the study, to the standardised metric, citing any methodological guidance consulted		
3 Describe the synthesis methods	Describe and justify the methods used to synthesise the effects for each outcome when it was not possible to undertake a meta-analysis of effect estimates		
4 Criteria used to prioritise results for summary and synthesis	Where applicable, provide the criteria used, with supporting justification, to select the particular studies, or a particular study, for the main synthesis or to draw conclusions from the synthesis (e.g., based on study design, risk of bias assessments, directness in relation to the review question)		

Synthesis Without Meta-analysis (SWiM) reporting items

SWiM reporting item	Item description	Page in manuscript where item is reported	Other*
5 Investigation of heterogeneity in reported effects	State the method(s) used to examine heterogeneity in reported effects when it was not possible to undertake a meta-analysis of effect estimates and its extensions to investigate heterogeneity		
6 Certainty of evidence	Describe the methods used to assess certainty of the synthesis findings		
7 Data presentation methods	Describe the graphical and tabular methods used to present the effects (e.g., tables, forest plots, harvest plots).		
	Specify key study characteristics (e.g., study design, risk of bias) used to order the studies, in the text and any tables or graphs, clearly referencing the studies included		
<i>Results</i>			
8 Reporting results	For each comparison and outcome, provide a description of the synthesised findings, and the certainty of the findings. Describe the result in language that is consistent with the question the synthesis addresses, and indicate which studies contribute to the synthesis		
<i>Discussion</i>			
9 Limitations of the synthesis	Report the limitations of the synthesis methods used and/or the groupings used in the synthesis, and how these affect the conclusions that can be drawn in relation to the original review question		

PRISMA=Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

*If the information is not provided in the systematic review, give details of where this information is available (e.g., protocol, other published papers (provide citation details), or website (provide the URL)).