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REVIEW ARTICLE

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A meta-analysis on gender differences in prevalence estimates of mental disorders following exposure to natural hazards

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ABSTRACT

Background: Women report higher rates of trauma-related disorders compared to men. With women being disproportionately impacted by the consequences of natural hazards, this gender disparity may increase in their aftermath.

Objective: This meta-analysis aimed at quantifying gender gaps in mental disorder prevalence following natural hazards, considering both the recent and long-term aftermath of natural hazards, the developmental status of affected countries, and type of hazard.

Method: A systematic search was conducted in MEDLINE, PsycINFO, and Web of Science in February 2024. Random effects models were used to calculate odds ratios (OR) based on point prevalences. OR adjusted for covariates were also descriptively reported.

Results: In total, 141 reports ($N = 3,726,153$ independent participants) were included. The prevalence for posttraumatic stress disorder (PTSD), major depression (MD), and generalized anxiety disorder (GAD) within the first year after the hazard were 24.95%, 8.11%, and 14.24%, respectively. More than one-year post-natural hazard the prevalence for PTSD and MD were 22.89% and 13.51%, respectively. Women had significantly higher odds for PTSD ($OR = 1.85$) and MD ($OR = 1.52$) within the first year after the hazard, as well as in later assessments ($OR = 1.83$ for PTSD, $OR = 1.41$ for MD). Only four studies reported on GAD gender differences in the recent aftermath of natural hazards, resulting in a non-significant OR of 1.85. Subgroup analyses indicated no differences between developmental status of affected countries and adjusted OR showed no systematic variations upon the inclusion of covariates. Gender differences were larger in the aftermath of earthquakes.

Conclusions: Significant gender differences for mental disorders following natural hazards exist, although these differences appear similar to other contexts. Gender-sensitive disaster response plans for mental health are essential.

HIGHLIGHTS
- We investigated gender differences in post-traumatic stress disorder, major depression, and generalized anxiety disorder prevalences post-natural hazard.
- Women were over 80% more likely to report post-traumatic stress and over 50% more likely to report major depression than men, with these differences remaining stable over time.
- Findings on non-binary and other genders are lacking in natural-hazard research.

Un metaanálisis sobre las diferencias de género en las estimaciones de la prevalencia de los trastornos mentales tras la exposición a desastres naturales

Antecedentes: Las mujeres informan tasas más altas de trastornos relacionados con traumas en comparación con los hombres. Dado que las mujeres se ven afectadas desproporcionadamente por las consecuencias de los desastres naturales, esta disparidad de género puede aumentar después de ellos.

Objetivo: Este metaanálisis tuvo como objetivo cuantificar las brechas de género en la prevalencia de los trastornos mentales después de desastres naturales, considerando tanto las consecuencias recientes como las de largo plazo de los desastres naturales, el estado de desarrollo de los países afectados, y el tipo de peligro.

Método: Se realizó una búsqueda sistemática en MEDLINE, PsycINFO, y Web of Science en febrero de 2024. Se utilizaron modelos de efectos aleatorios para calcular las razones de probabilidades (OR en su sigla en inglés) basados en prevalencias puntuales. Los OR ajustados por covariables también se informaron de manera descriptiva.

Resultados: En total, se incluyeron 141 informes ($N = 3.726.153$ participantes independientes). La prevalencia del trastorno de estrés postraumático (TEPT), la depresión mayor (DM), y el trastorno de ansiedad generalizada (TAG) durante el primer año después de un desastre fue del 24.95%, 8.11% y 14.24%, respectivamente. Más de un año después del desastre natural, la prevalencia del TEPT y la DM fueron del 22.89 y 13.51%, respectivamente. Las mujeres tuvieron probabilidades significativamente más altas de TEPT ($OR = 1.85$) y DM ($OR = 1.52$) durante el primer año después del desastre, así como en las evaluaciones posteriores ($OR = 1.83$ para TEPT, $OR = 1.41$ para DM). Solo cuatro estudios informaron sobre las diferencias de género en el TAG después de los recientes desastres naturales, lo que resultó en un OR no

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significativo de 1.85. Los análisis de subgrupos no indicaron diferencias entre el estado de desarrollo de los países afectados y el OR ajustado no mostró variaciones sistemáticas tras la inclusión de covariables. Las diferencias de género fueron mayores después de los terremotos. **Conclusiones:** Existen diferencias significativas de género en cuanto a los trastornos mentales después de desastres naturales, aunque estas diferencias parecen similares a las de otros contextos. Los planes de respuesta a desastres que tengan en cuenta las cuestiones de género en materia de salud mental son esenciales.

1. Introduction

Gender differences in mental health outcomes are notable, with women generally exhibiting higher prevalences of post-traumatic stress disorder (PTSD), major depression (MD), and anxiety disorders compared to men (Haering, Schulze, et al., 2024; Salk et al., 2017). Higher rates of PTSD among women still emerge when taking into account the varying nature of traumatic experiences by gender (Tolin & Foa, 2008). Possible explanations for gender disparities in mental health risk include increased rumination (Nolen-Hoeksema et al., 2008), increased societal expectations tied to caregiving roles (Nolen-Hoeksema, 2001), and higher rates of previous exposure to sexual assault and interpersonal violence, anxiety sensitivity, or peritraumatic distress (Haering, Seligowski, et al., 2024) in women compared to men.

Natural hazards may exacerbate pre-existing gender disparities, as they disproportionately affect women. Climate change has resulted in escalating frequencies of natural hazards like geophysical and extreme weather events (World Health Organization [WHO], 2006), posing significant threats to economies, environments, properties, and overall human health (Bokwa, 2013). In the aftermath, women face a heightened risk of interpersonal, including sexual, violence (Parkinson & Zara, 2013; Rao, 2020; UN Women, 2023), as temporary shelter may provide insufficient privacy and safety for women. Resource scarcity and impaired infrastructure can negatively affect maternal health, especially in low- and middle-income countries (Nashwan et al., 2023). Already existing disparities regarding food insecurity may exacerbate (FAO et al., 2024) and the wealth of families in which women are the primary earners is disproportionately affected (Llorente-Marrón et al., 2020). Furthermore, government recognition of economic and political rights of women can decline for up to two years post-natural hazard (Detraz & Peksen, 2017). Additionally, women of lower socio-economic status have higher mortality rates than men of the same status, both directly from natural hazard-related effects and indirectly from post-hazard events (Neumayer & Plümper, 2007).

An overall increase in prevalences of PTSD, MD, and anxiety disorders is observed in the aftermath of natural hazards (Cuijpers et al., 2023). Post-natural hazard reviews reported higher odds of PTSD (Gordon-Hollingsworth et al., 2018; Tang et al., 2017) and MD (Tang et al., 2014) in women, reflecting the broader gender disparities observed in the general population. Furthermore, these differences might diminish over time, as suggested by research with young survivors (Gordon-Hollingsworth et al., 2018). Though insightful, previous meta-analyses and systematic reviews contain some limitations. Tang et al. (2014, 2017) aggregated odds ratios with different sets of covariates controlled for, which makes them statistically incomparable. Gordon-Hollingsworth et al. (2018) focused on young survivors only and McKinzie and Clay-Warner (2021) applied a narrative approach only. We aimed to meta-analytically examine gender differences in mental disorder point prevalences post-natural hazard using raw data, while considering short- and long-term assessment timeframes, developmental statuses of affected countries and type of natural hazard.

2. Method

The meta-analysis was pre-registered on aspredicted (#176439) and followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Page et al., 2021).

Publications often lack clarity on whether gender and sex were assessed as, respectively, societal or biological factors, with reports mostly being restricted to man or woman (Hartung & Lefler, 2019). Acknowledging that this dichotomization is a simplification, we combined them under the umbrella term gender and categorized participants as woman/female or man/male due to ambiguity regarding the original studies' treatment of these concepts.

2.1. Literature search

The electronic database search considered all literature up to 13 February 2024, without restrictions regarding publication language, date, type, or geographical location of the studies. The databases MEDLINE (keywords and MeSH), PsycINFO, and Web of Science (keywords only) were used and results were uploaded into a web-tool for systematic reviews, Rayyan (Ouzzani et al., 2016). Our search strategy included terms

related to natural hazards (e.g. 'natural disaster' OR storm OR earthquake) and mental health (e.g. depress* OR anxiety OR 'mental health'), which were connected with the Boolean operator AND. These terms were searched for in titles, abstracts, and keywords (see Supplementary Table 1 for full search string and all search strategy details).

2.2. Selection of studies

Inclusion criteria were (1) assessment of a mental disorder with a validated (semi-)structured interview or self-report measure based on DSM or ICD criteria, (2) exposure to a natural hazard, (3) at least 100 participants, to ensure reliable effect size estimates (e.g. Hughes et al., 2017; O'Mahoney et al., 2023), with a mean age ≥ 18 years were included, (4) assessment was conducted at least one month post-natural hazard as the acute response was not the focus of the meta-analysis, (5) longitudinal or cross-sectional study designs with or without an unexposed control group were used, and (6) report of gender-specific prevalences, adjusted gender odds ratios (aOR; OR adjusted for covariates) or unadjusted OR (OR not adjusted for covariates). Since the comparative prevalence of mental disorders in men vs. women was the focus of this work, we included only studies with mixed gender samples and excluded studies with female-only or male-only samples. Exclusion criteria were (1) exposure to a technological disaster, agricultural pest, and/or a pandemic, samples consisting of subgroups (2a) with higher risk of exposure to aversive and traumatic events (e.g. first responders), (2b) recruited from support groups, or (2c) included based on the presence of specific symptoms (e.g. nightmares), (3) experimental or qualitative studies, (4) no reporting of diagnostic status or no clear cut-off values for single severity scores, or (5) a sample duplicate. If several reports presented gender-specific data for the same sample and mental health outcome, or a report examined more than one assessment time, we prioritized the later assessment within the categories of recent aftermath and long-term assessments, based on clinical relevance. We additionally considered the sample size of the included reports. Only independent samples were included in each analysis.

Given the high number of identified hits, four blinded reviewers independently screened a pilot sample of 440 studies with each reviewer screening all hits. The inter-rater reliability of this sample screening produced a Fleiss' Kappa of 0.76 (agreement rate of 84.7%), indicating good agreement between raters. The remaining studies were divided between the reviewers and unclear cases were discussed jointly. Full texts were screened by different sets of two independent reviewers. For this screening, the Fleiss' Kappa ranged between 0.82 (agreement rate of 91.0%) and 0.92 (agreement rate of 95.7%), indicating high strength of initial agreement.

2.3. Data extraction

The study settings were categorized into Global North (very high levels of development) and Global South (low to high levels of development) according to the Human Development Index (United Nations Development Programme [UNDP], 2024). The classification is based on the mean of three key dimensions: health, education, and standard of living. Sets of two reviewers independently extracted data and disagreements were discussed until consensus was reached. Extracted data contained details on the natural hazard, method of the study, mental disorder, and gender prevalence. The duration of study assessment was classified into recent aftermath (1–12 months post-natural hazard) and long-term aftermath (13 months and above). Articles written in English and Chinese were assessed by the authors, papers written in Spanish, Farsi, and Turkish by native-speaking research assistants.

2.4. Statistical analysis

Random-effects meta-analyses were performed in RStudio (version 2024.04.2 + 764) using the packages meta (Balduzzi et al., 2019), metafor (Viechtbauer, 2010), and dmetar (Harrer et al., 2019). Point prevalences for women and men were meta-analytically calculated. OR with 95% confidence intervals (CI) and 95% prediction intervals (PI) estimated gender differences using the Mantel-Haenszel pooling method and Paule-Mandel estimator for τ^2 (Higgins et al., 2019). Analyses required at least four reports per mental disorder and assessment time, in line with previous research (Hoppen et al., 2023; Morina et al., 2021). Sensitivity analyses were restricted to samples from the general population (i.e., not focusing on specific subgroups) for main analyses. aOR were descriptively contrasted due to varying covariate adjustments. Meta-analytic summaries focus on point prevalence, with OR for 12-month and lifetime prevalence reported in Supplementary Tables 2 and 3.

Between-study heterogeneity was estimated with Higgins I^2 (Higgins & Thompson, 2002) and Cochran's Q (Cochran, 1954). Outlier-adjusted analyses were run excluding all reports whose 95% CI fell outside of the 95% CI of the pooled OR. Study influence was examined with baujat plots (Baujat et al., 2002) and the leave-one-out method (Viechtbauer, 2010). Potential publication bias was investigated with funnel plots and Egger's tests (Egger et al., 1997) for models including at least ten studies (Sterne et al., 2011). Analyses with likely bias were recalculated using the trim-and-fill method (Duval &

Tweedie, 2000). Anticipating heterogeneity, subgroup analyses compared effect sizes by assessment time (recent vs. long-term aftermath), developmental status (Global North vs. Global South), and type of natural hazard.

3. Results

3.1. Study selection

After title and abstract screening of 24,979 hits, the full-text screening was conducted for 1385 records, and 20 records found through other sources (see Figure 1). Despite attempts to contact the authors, a total of 15 mainly older and non-English records could not be retrieved (see Supplementary Table 4). Authors were contacted for missing information and unpublished data was included for Yazawa et al. (2023). A total of 164 reports were excluded because they did not report on gender-specific prevalence estimates. Overall, 141 reports from 131 studies were included in the quantitative review (see Supplementary Table 5 for references of included studies and Supplementary Table 6 for details) and data from 95 reports were included in the meta-analysis.

3.2. Study characteristics

The 131 studies comprised $N = 3{,}726{,}153$ participants (49.89% female, $M_{age} = 48.64$). A total of 84 articles reported adjusted and/or unadjusted ORs and 108 reported raw data on gendered prevalences. Only three addressed genders beyond women and men (Cohen et al., 2023; Naeem et al., 2011; Vega et al., 2024).

Earthquakes were the most studied natural hazard (57.45%), followed by storms (15.60%), tsunamis (12.06%), floods (7.09%), wildfires (4.96%), volcanic eruptions (1.42%) and landslides (0.71%). One study (Reifels et al., 2019) investigated multiple hazards. Slightly more than half were conducted in Global South countries (53.20%), with the rest in Global North countries (46.80%). Most articles were in English (92.20%), with a few in Chinese (4.26%), Spanish (2.13%), Farsi (0.71%), and Turkish (0.71%). PTSD was most frequently investigated (84.40%), followed by MD (21.99%), and GAD (6.38%). Most articles reported point prevalence (92.91%), with fewer reporting 12-month prevalence (5.67%) and/or lifetime prevalence (4.26%). Assessments in recent natural hazard aftermath were reported more frequently (53.90%) than in long-term aftermath (46.81%). Two reports did not specify the time that had passed between natural hazard and assessment (see Supplementary Table 5).

3.3. Gender differences in mental disorders post-natural hazard

Random effects models were calculated for PTSD, MD, and GAD in recent hazard aftermath and for PTSD and MD in long-term aftermath (see Figures 2–6 for forest plots and Table 1 for details). GAD in long-term aftermath was assessed in only two studies
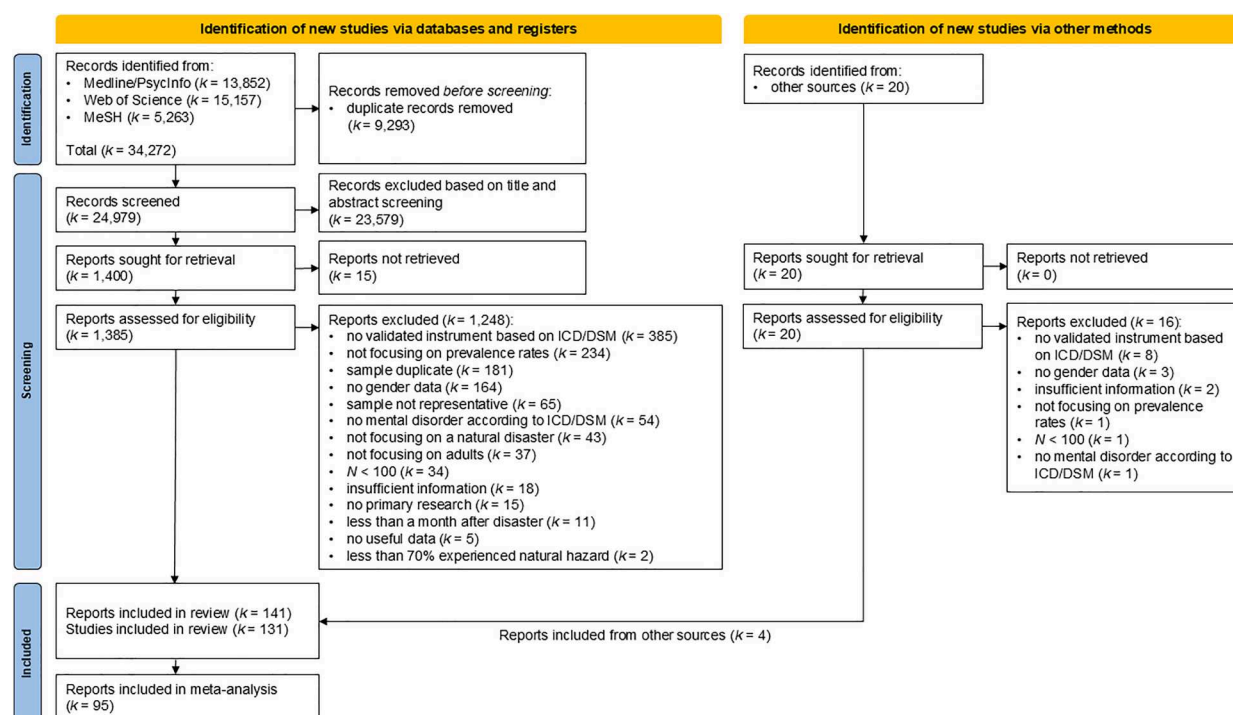

Figure 1. PRISMA flow diagram of study selection process.

Note: DSM = Diagnostic and Statistical Manual of Mental Disorders; ICD = International Classification of Diseases and Related Health Problems; MeSH = Medical Subject Headings.
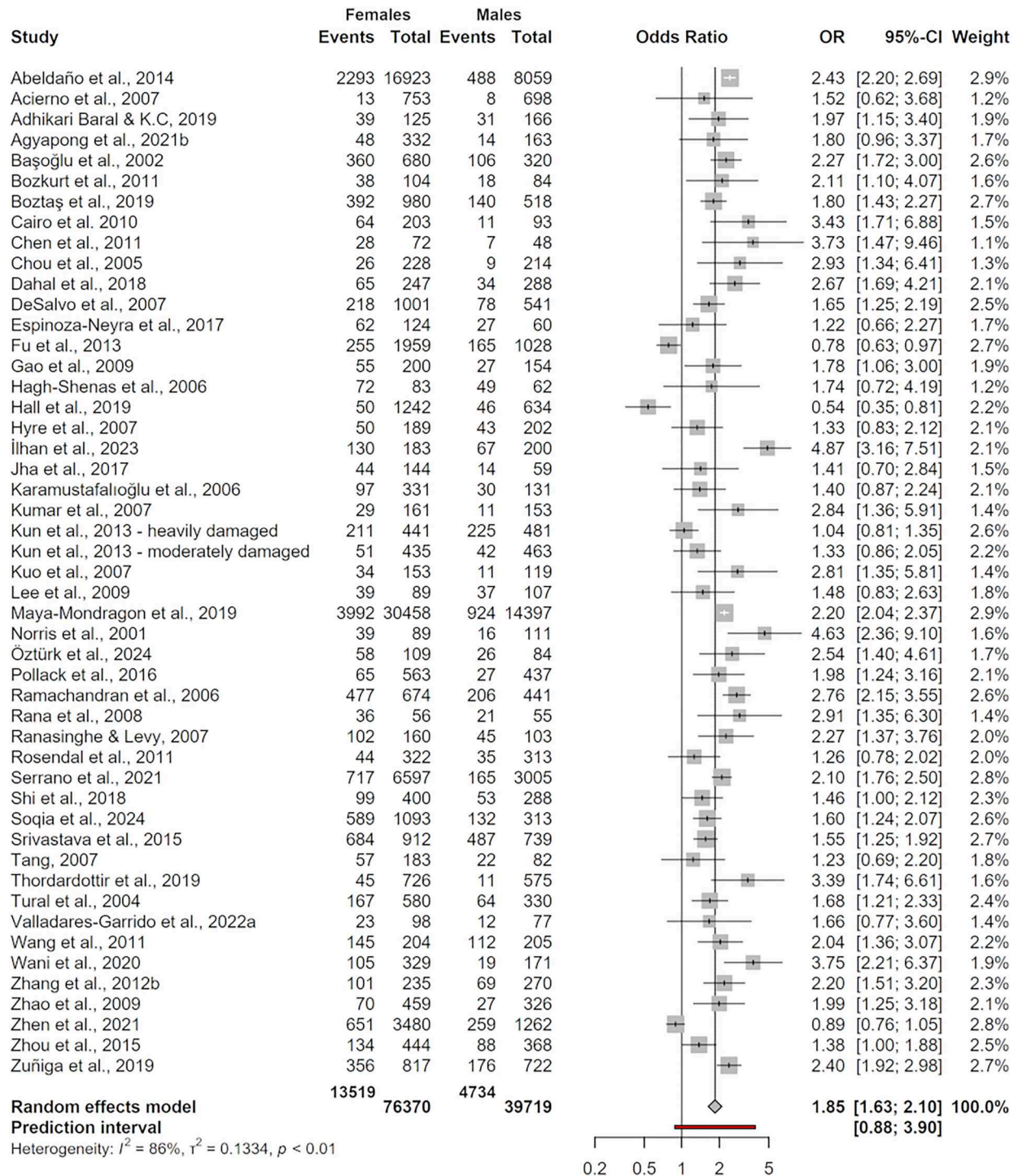
Figure 2. Forest plot for PTSD in recent aftermath of natural hazard.

and excluded from synthesis. Baujat plots and leave-one-out analyses are in Supplementary Figures 1–10.

For PTSD in recent aftermath (mean 5.58 months since onset), 49 samples from 48 reports were included. PTSD criteria were met by 18.15% of men and 29.75% of women, with women being 85% more likely to be diagnosed (OR = 1.85, 95% CI [1.63, 2.10], 95% PI [0.88, 3.90], $p < .001$). Between-study heterogeneity was substantial ($I^2 = 85.80\%$, $Q(48) = 337.75$, $p < .001$), and decreased to 38.20% after excluding nine outliers, with similar OR (OR = 1.88, 95% CI [1.74, 2.04]).

For PTSD in long-term assessments (mean 3.42 years after onset, range 13 months–17 years), 42 samples from 40 reports were included. Criteria were met by 17.18% of men and 27.58% of women, with women being 83% more likely to report PTSD (OR = 1.83, 95% CI [1.57, 2.15], 95% PI [0.77, 4.40], $p < .001$). Heterogeneity was considerable ($I^2 = 91.20\%$, $Q(41) = 463.57$, $p < .001$). The outlier-adjusted heterogeneity after excluding six outliers was lower yet still significant ($I^2 = 31.40\%$), with consistent OR (OR = 1.84, 95% CI [1.67, 2.03]). There were no significant gender differences between recent
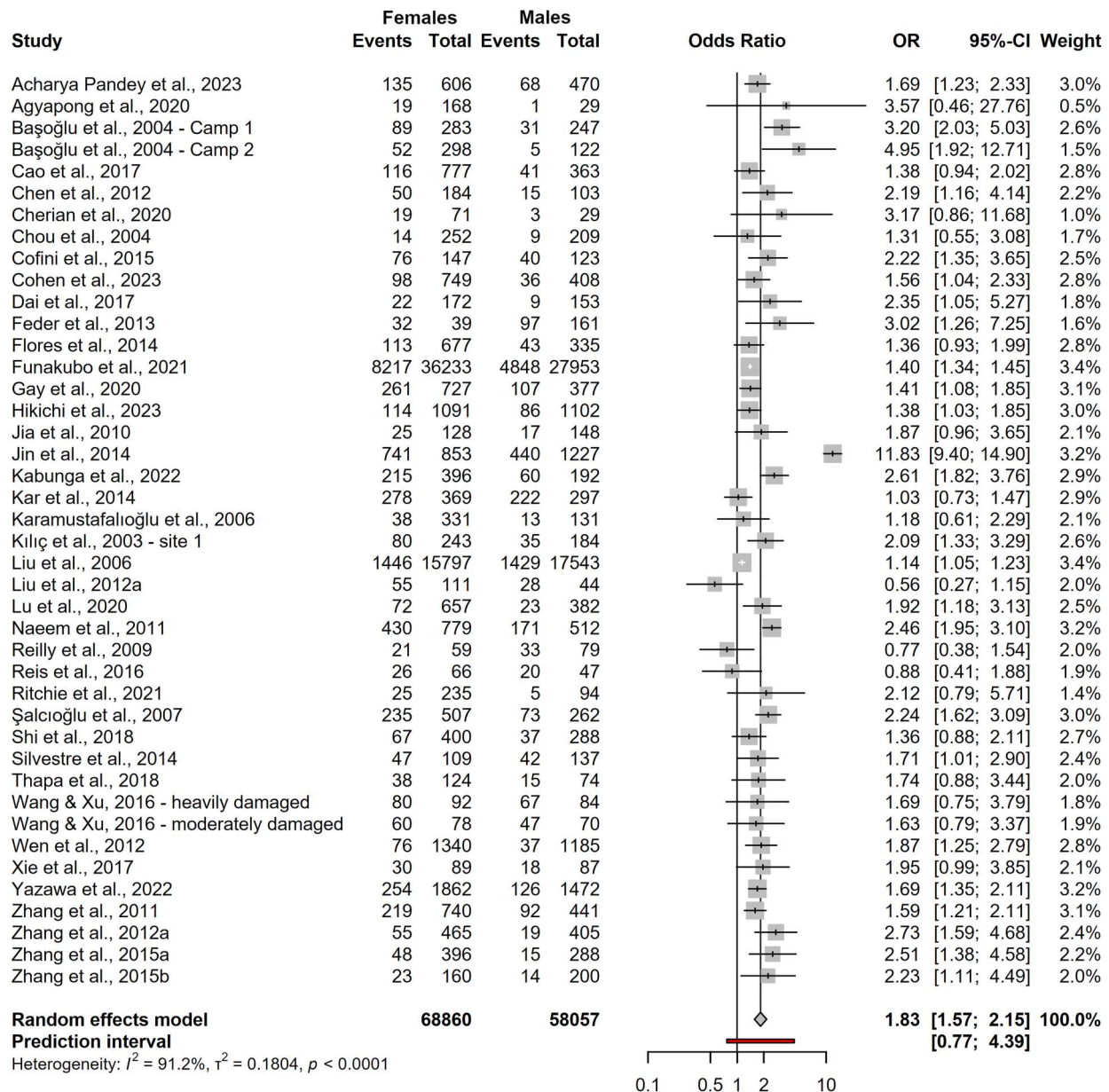
Study	Females Events	Females Total	Males Events	Males Total	OR	95%-CI	Weight
Acharya Pandey et al., 2023	135	606	68	470	1.69	[1.23; 2.33]	3.0%
Agyapong et al., 2020	19	168	1	29	3.57	[0.46; 27.76]	0.5%
Başoğlu et al., 2004 - Camp 1	89	283	31	247	3.20	[2.03; 5.03]	2.6%
Başoğlu et al., 2004 - Camp 2	52	298	5	122	4.95	[1.92; 12.71]	1.5%
Cao et al., 2017	116	777	41	363	1.38	[0.94; 2.02]	2.8%
Chen et al., 2012	50	184	15	103	2.19	[1.16; 4.14]	2.2%
Cherian et al., 2020	19	71	3	29	3.17	[0.86; 11.68]	1.0%
Chou et al., 2004	14	252	9	209	1.31	[0.55; 3.08]	1.7%
Cofini et al., 2015	76	147	40	123	2.22	[1.35; 3.65]	2.5%
Cohen et al., 2023	98	749	36	408	1.56	[1.04; 2.33]	2.8%
Dai et al., 2017	22	172	9	153	2.35	[1.05; 5.27]	1.8%
Feder et al., 2013	32	39	97	161	3.02	[1.26; 7.25]	1.6%
Flores et al., 2014	113	677	43	335	1.36	[0.93; 1.99]	2.8%
Funakubo et al., 2021	8217	36233	4848	27953	1.40	[1.34; 1.45]	3.4%
Gay et al., 2020	261	727	107	377	1.41	[1.08; 1.85]	3.1%
Hikichi et al., 2023	114	1091	86	1102	1.38	[1.03; 1.85]	3.0%
Jia et al., 2010	25	128	17	148	1.87	[0.96; 3.65]	2.1%
Jin et al., 2014	741	853	440	1227	11.83	[9.40; 14.90]	3.2%
Kabunga et al., 2022	215	396	60	192	2.61	[1.82; 3.76]	2.9%
Kar et al., 2014	278	369	222	297	1.03	[0.73; 1.47]	2.9%
Karamustafalıoğlu et al., 2006	38	331	13	131	1.18	[0.61; 2.29]	2.1%
Kılıç et al., 2003 - site 1	80	243	35	184	2.09	[1.33; 3.29]	2.6%
Liu et al., 2006	1446	15797	1429	17543	1.14	[1.05; 1.23]	3.4%
Liu et al., 2012a	55	111	28	44	0.56	[0.27; 1.15]	2.0%
Lu et al., 2020	72	657	23	382	1.92	[1.18; 3.13]	2.5%
Naeem et al., 2011	430	779	171	512	2.46	[1.95; 3.10]	3.2%
Reilly et al., 2009	21	59	33	79	0.77	[0.38; 1.54]	2.0%
Reis et al., 2016	26	66	20	47	0.88	[0.41; 1.88]	1.9%
Ritchie et al., 2021	25	235	5	94	2.12	[0.79; 5.71]	1.4%
Şalcıoğlu et al., 2007	235	507	73	262	2.24	[1.62; 3.09]	3.0%
Shi et al., 2018	67	400	37	288	1.36	[0.88; 2.11]	2.7%
Silvestre et al., 2014	47	109	42	137	1.71	[1.01; 2.90]	2.4%
Thapa et al., 2018	38	124	15	74	1.74	[0.88; 3.44]	2.0%
Wang & Xu, 2016 - heavily damaged	80	92	67	84	1.69	[0.75; 3.79]	1.8%
Wang & Xu, 2016 - moderately damaged	60	78	47	70	1.63	[0.79; 3.37]	1.9%
Wen et al., 2012	76	1340	37	1185	1.87	[1.25; 2.79]	2.8%
Xie et al., 2017	30	89	18	87	1.95	[0.99; 3.85]	2.1%
Yazawa et al., 2022	254	1862	126	1472	1.69	[1.35; 2.11]	3.2%
Zhang et al., 2011	219	740	92	441	1.59	[1.21; 2.11]	3.1%
Zhang et al., 2012a	55	465	19	405	2.73	[1.59; 4.68]	2.4%
Zhang et al., 2015a	48	396	15	288	2.51	[1.38; 4.58]	2.2%
Zhang et al., 2015b	23	160	14	200	2.23	[1.11; 4.49]	2.0%
Random effects model	**68860**		**58057**		**1.83**	**[1.57; 2.15]**	**100.0%**
Prediction interval						**[0.77; 4.39]**	

Heterogeneity: $I^2 = 91.2\%$, $\tau^2 = 0.1804$, $p < 0.0001$

0.1 0.5 1 2 10

Figure 3. Forest plot for posttraumatic stress disorder in long-term aftermath of natural hazard.

Study	Females Events	Females Total	Males Events	Males Total	OR	95%-CI	Weight
Acierno et al., 2007	55	753	34	698	1.54	[0.99; 2.39]	10.5%
Agyapong et al., 2019	55	322	17	162	1.76	[0.98; 3.14]	8.8%
Boscarino et al., 2014	7	130	5	70	0.74	[0.23; 2.42]	3.9%
Chen et al., 2015	3	174	12	145	0.19	[0.05; 0.70]	3.4%
Chou et al., 2005	29	228	13	214	2.25	[1.14; 4.46]	7.6%
Huang et al., 2010	114	7327	66	6880	1.63	[1.20; 2.21]	12.3%
Maya-Mondragon et al., 2019	3259	30458	864	14417	1.88	[1.74; 2.03]	14.3%
Pollack et al., 2016	12	563	5	437	1.88	[0.66; 5.38]	4.6%
Soqia et al., 2024	620	1093	150	313	1.42	[1.11; 1.83]	12.9%
Thordardottir et al., 2019	51	726	22	575	1.90	[1.14; 3.17]	9.6%
Tiyuri et al., 2023	317	1350	56	321	1.45	[1.06; 1.99]	12.1%
Random effects model	4522	43124	1244	24232	**1.52**	**[1.12; 2.08]**	**100.0%**
Prediction interval						**[0.63; 3.69]**	

Heterogeneity: $I^2 = 53\%$, $\tau^2 = 0.1337$, $p = 0.02$
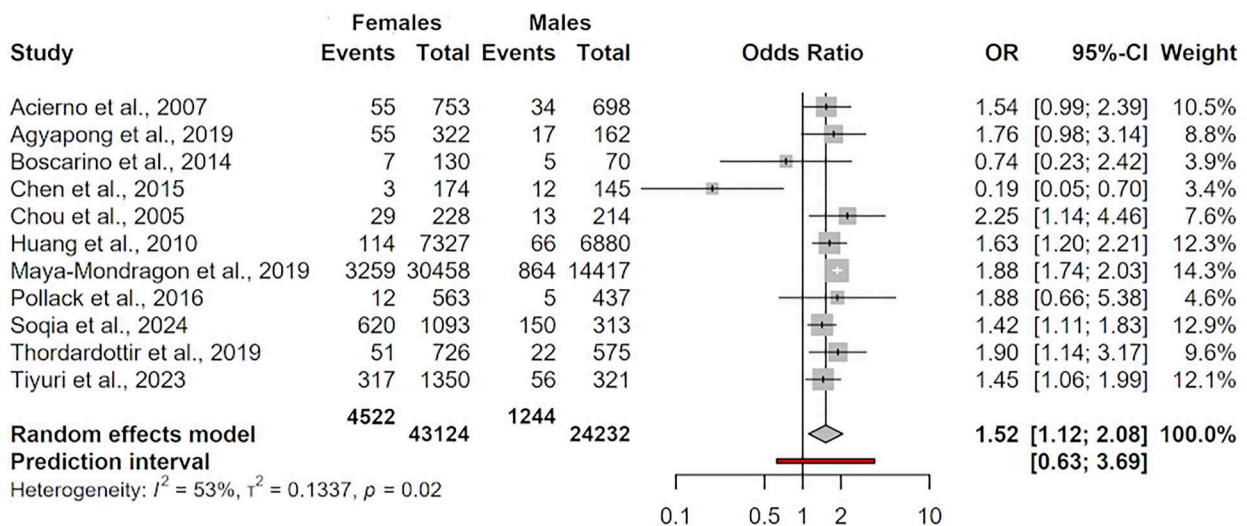
0.1 0.5 1 2 10

Figure 4. Forest plot for depression in recent aftermath of natural hazard.
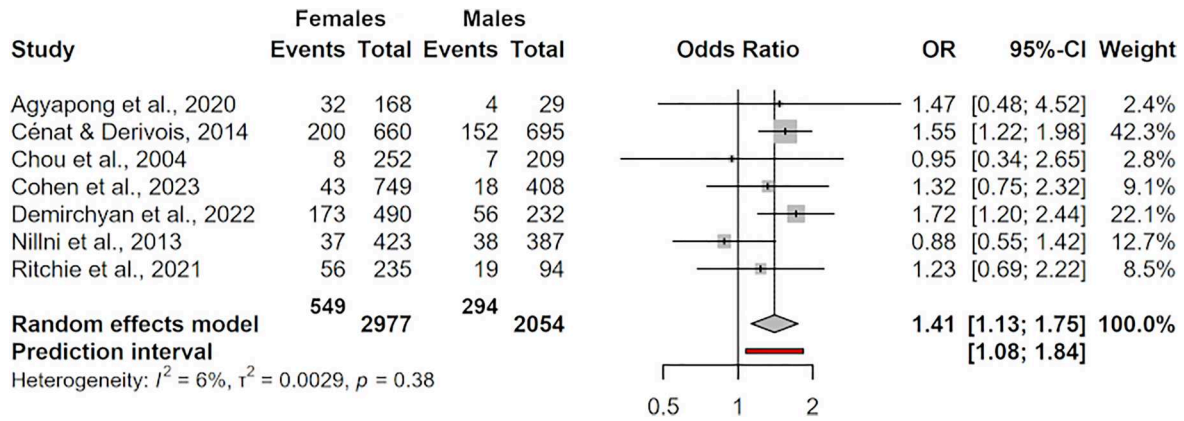
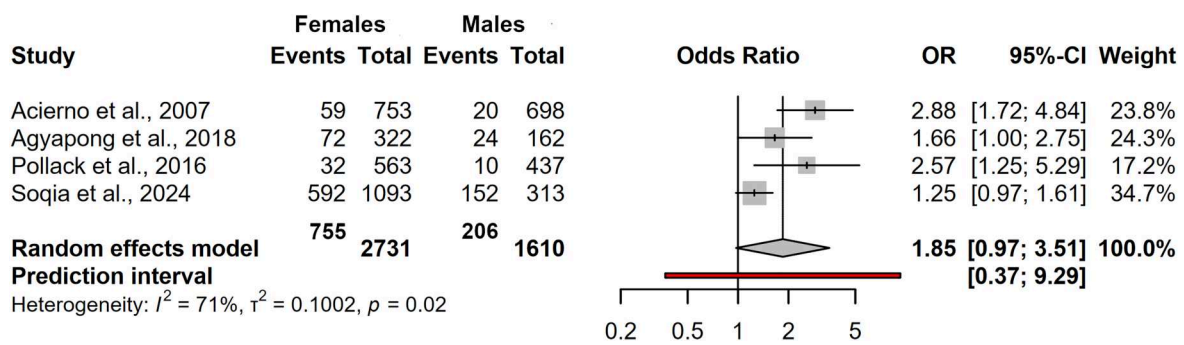**Figure 5.** Forest plot for depression in long-term aftermath of natural hazard.

Figure 6. Forest plot for generalized anxiety disorder in recent aftermath of natural hazard.

Table 1. Gender differences in PTSD, MD, and GAD.

	k	OR	95% CI	I^2	Q(df)	$p_{subgroup}$
Assessments Conducted in Recent and Long-Term Natural Hazard Aftermath						
PTSD					0.01 (1)	.936
Recent aftermath	49	1.85	[1.63, 2.10]	85.80%		
Long-term aftermath	42	1.83	[1.57, 2.15]	91.20%		
MDD					0.23 (1)	.629
Recent aftermath	11	1.52	[1.12, 2.08]	53.00%		
Long-term aftermath	7	1.41	[1.13, 1.75]	6.00%		
GAD						
Recent aftermath	4	1.85	[0.97, 3.51]	70.70%		
Global North vs. Global South by Assessments Conducted in Recent vs. Long-Term Natural Hazard Aftermath						
PTSD in recent aftermath					1.25 (1)	.263
Global North	20	2.01	[1.70, 2.38]	62.00%		
Global South	29	1.76	[1.47, 2.11]	89.40%		
PTSD in long-term aftermath					0.11 (1)	.741
Global North	14	1.77	[1.40, 2.23]	67.70%		
Global South	28	1.86	[1.50, 2.30]	93.50%		
MD in recent aftermath					0.68(1)	.408
Global North	5	1.70	[1.24, 2.33]	< 0.01%		
Global South	6	1.32	[0.63, 2.76]	72.50%		
Comparison of Natural Hazards by Assessments Conducted in Recent vs. Long-Term Natural Hazard Aftermath						
PTSD in recent aftermath					0.66(2)	.717
Earthquake	31	1.92	[1.67, 2.20]	82.40%		
Storm	9	1.60	[0.96, 2.65]	86.80%		
Tsunami	5	1.96	[1.18, 3.27]	68.80%		
PTSD in long-term aftermath					8.52(2)	.014
Earthquake	28	2.04	[1.66, 2.51]	89.40%		
Flood	4	1.40	[0.62, 3.19]	48.90%		
Tsunami	4	1.39	[1.06, 1.84]	45.60%		

Note: PTSD = posttraumatic stress disorder; GAD = generalized anxiety disorder; MD = major depression; k refers to the number of independent data-points. Only subgroups with $k \geq 4$ were included.

and long-term aftermath and the results appeared robust according to the leave-one-out analyses.

Eleven reports examined MD in recent hazard aftermath (mean 4.82 months after onset) and 6.32% of men and 8.30% of women met diagnostic criteria for MD, with women being 52% more likely to report MD (OR = 1.52, 95% CI [1.12, 2.08], 95% PI [0.63, 3.69], p = .013). Heterogeneity was moderate (I^2 = 53.00%, $Q(10)$ = 21.26, p = .019). Excluding an outlier (Chen et al., 2015) increased the OR to 1.77 (95% CI [1.62, 1.94]) and decreased heterogeneity to 8.20%.

For MD in long-term assessments (mean 5.08 years, range 1–23 years), assessed in seven reports, 11.51% of men and 14.34% of women met criteria, with women being 41% more likely to report MD (OR = 1.41, 95% CI [1.13, 1.75], 95% PI [1.08, 1.84], p = .009). Heterogeneity was low (I^2 = 6.00%, $Q(6)$ = 6.38, p = .381). The leave-one-out analysis (Supplementary Table 8) indicated that the pooled effect narrowly misses significance when omitting results from Cénat and Derivois (2014, OR = 1.31, 95% CI [0.97, 1.76]). There were no significant gender differences between recent and long-term aftermath.

Four reports assessed GAD in recent hazard aftermath (mean 5.75 months) and 9.32% of men and 16.99% of women reported GAD, with women being 85% more likely to meet GAD criteria. However, this difference in odds was non-significant (OR = 1.85, 95% CI [0.97, 3.51], 95% PI [0.37, 9.29], p = .055). Between-study heterogeneity was moderate (I^2 = 70.70%, $Q(3)$ = 10.24, p = .017). The non-significance of the pooled effect was driven by only one study, which limited the robustness of our findings (Soqia et al., 2024, Supplementary Figure 10).

3.4. Gender differences with consideration of covariates

A total of 59 articles reported aOR for women vs. men odds of PTSD, MD, or GAD (see Supplementary Table 8 for unadjusted OR and Supplementary Table 9 for aOR). Common covariates included age, education, socio-economic status, and disaster-related factors. For PTSD in the recent aftermath, 16 of 27 articles found significant aOR for women (1.45–4.66), one article identified a significant aOR for men (aOR = 0.56; Hall et al., 2019), and the rest reported non-significant aOR. In long-term assessments of PTSD, 17 of 19 articles found significant aOR for women (1.12–4.17), with the remaining finding no significant differences. For MD, six of 12 aOR were significant in favour of women in the recent aftermath (1.47–3.23), two studies had a lower confidence bound of 1.00 and the remaining were non-significant. For the long-term aftermath, two studies found a significant aOR (1.42 and 2.40) with the remaining four reporting non-significant differences. For GAD in the recent aftermath, two of four articles observed significant aOR for women (2.80 and 3.57) and two did not.

Few articles reported both adjusted and unadjusted OR. The inclusion of covariates did not considerably change the OR for GAD or MD compared to the reported unadjusted OR. Covariates affected the PTSD aOR differently. Compared to the reported unadjusted OR, the aOR were similar in seven reports (Acharya Pandey et al., 2023; Kabunga et al., 2022; Kumar et al., 2007; A. Liu et al., 2006; Soqia et al., 2024; Zhang et al., 2011; Zhang et al., 2012), decreased in two reports (Priebe et al., 2009; Ranasinghe et al., 2023), and increased in four reports (Dahal et al., 2017; Dai et al., 2017; Hashmi et al., 2011; Lommen et al., 2009).

3.5. Publication bias and sensitivity analysis

Potential influence of small study effect could be investigated for both PTSD assessment timeframes and MD in recent hazard aftermath. Funnel plots and the Egger's tests indicated significant small study effects for long-term assessment of PTSD and MD. Using the trim-and-fill method, PTSD OR decreased to 1.40 (95% CI [1.16, 1.68], k = 57) with high heterogeneity (I^2 = 94.00%). MD OR increased to 1.83 (95% CI [1.20, 2.81], k = 15) with moderate heterogeneity (I^2 = 67.70%).

Sensitivity analyses for samples representing the general population are presented in Supplementary Table 7. The ORs for PTSD increased to 1.99 for the recent aftermath and to 1.90 for the long-term aftermath. For MD in later assessments (k = 4), the OR decreased to 1.27 and was no longer significant.

3.6. Subgroup analyses to assess sources of heterogeneity

Subgroup analyses for varying gender inequalities by assessment time and developmental status of the study country indicated no significant differences (see Table 1). However, the heterogeneity in the results for MD in the recent aftermath reduced in the Global North group and remained high in the Global South group (I^2 = 72.5%). Type of natural hazard did not moderate gender differences for PTSD in the recent aftermath of natural hazards. In the long-term hazard-aftermath, however, gender differences were significantly larger with OR = 2.04 in the aftermath of earthquakes compared to other types of hazards ($Q(2)$ = 8.52, p = .014).

3.7. Findings on gender differences in other mental disorders

Findings on gender differences in other mental disorders were limited (Supplementary Table 10). Three

studies investigated prolonged grief disorder, with one study reporting significantly more cases in women in recent hazard aftermath and the other two reporting no significant differences. Two studies on insomnia in long-term assessments found significantly higher odds for women (Hagiwara et al., 2017; Ide-Okochi et al., 2022). One report found higher odds of women reporting suicidality in the recent hazard aftermath (Chou et al., 2005), while another found no gender differences for suicidal thoughts (Mamun et al., 2021). Finally, Chou et al. (2005) found higher odds for men reporting alcohol and substance use disorders. The results for dysthymia and panic disorder were non-significant.

4. Discussion

We systematically reviewed and synthesized gender differences in mental disorder prevalence post-natural hazard. Results indicate that women are over 80% and 40% more likely to meet PTSD and MD diagnostic criteria, respectively, than men. These gender differences were stable over time and across developmental status of affected countries. For GAD, the gender difference was non-significant.

The point prevalence of mental disorders post-natural hazard was similar to prevalences in survivors of motor vehicle accidents (Lin et al., 2018), lower than in survivors of armed conflicts (Morina et al., 2018), and higher than in the general population (Institute for Health Metrics and Evaluation, 2024; H. Liu et al., 2017). Higher PTSD prevalences in women vs. men were reported in both abovementioned meta-analyses on other trauma populations. With regards to depression, Morina et al. (2018) found no significant differences in prevalence for depression in war-surviving women vs. men.

Natural hazards disproportionately affect women. Yet, our results for gender differences in mental disorders are similar to those reported in other contexts (Haering, Schulze, et al., 2024; OR = 1.72). Notably, 31.09% of studies assessed PTSD symptoms specifically related to the natural hazard, while the remaining studies assessed PTSD symptoms post-natural hazard but encompassing all experienced traumatic events. The gender distribution in our analysis was balanced (49.89% female), contrasting with studies on other traumas, which often include less women (Haering, Schulze, et al., 2024). Heterogeneity was large but decreased after omitting outliers. Publication bias was detected in some analyses but had minimal impact on results. MD gender differences were smaller post-natural hazard than in other contexts (Salk et al., 2017; OR = 1.95) and those found for PTSD in our meta-analysis. This may reflect age-related trends, as gender differences peak in adolescence and stabilize in adulthood (Salk et al., 2017). Further research on

long-term MD differences is needed as results shifted after accounting for potential publication bias, restricting analyses to representative samples, or considering covariates.

The observed gender difference was not influenced by the time since hazard, contrasting with previous research (Diamond et al., 2022; Gordon-Hollingsworth et al., 2018). Subgroup analyses also revealed gender differences were consistent regardless of the developmental status of affected countries. There are several possible explanations for this non-significant finding. The results may reflect true similarities in gender disparities regarding mental health disorders, consistent with the most recent Global Gender Gap Report, which highlights minimal global variation in the health index (World Economic Forum, 2023). Prevalences may further be higher for both women and men in the Global South as both are more likely to have experienced other traumatic events such as armed conflicts (Kip, Valencia, et al., 2024). Conversely, the results may have been influenced by varying degrees of gender stereotypes and stigmatization, the limited number of studies examining MD, or the overall substantial between-study heterogeneity in findings. When investigating gender differences specific to natural hazard, significant differences were observed only in PTSD in long-term aftermath (with larger differences in earthquake samples), aligning with previous research (Gordon-Hollingsworth et al., 2018).

Regarding GAD, the OR suggested an 85% higher likelihood in women, though it narrowly missed statistical significance ($p = .055$), likely due to the limited number of included studies which heightened sensitivity to individual study influence. The leave-one-out analysis revealed notable fluctuations in both the OR and between-study heterogeneity when individual studies were omitted and more studies on GAD are needed to obtain robust pooled estimates. Other contexts have found significant higher prevalence of GAD and worrying for women vs. men (Robichaud et al., 2003).

Most studies focused on internalizing disorders, whereas men may be more prone to substance use and externalizing disorders (Seedat et al., 2009). One study found this direction post-natural hazard, yet, more research on externalizing disorders and violent behaviour is needed, especially given increased post-hazard interpersonal violence against women (Parkinson & Zara, 2013; Rao, 2020).

4.1. Limitations and recommendations for future research

Future research should consider the following limitations of our meta-analysis, which partially reside in the included studies. First, ambiguous reporting in

the included articles made it difficult to distinguish between gender and sex and insufficient reporting of non-binary genders precluded investigating these groups specifically. Insufficient reporting of applied gender definitions has been addressed in a recent overview of trauma research of the past years (Langeland & Olff, 2024). Future studies should adhere to recommendations by Lindqvist et al. (2021) to specify the facet of the gender construct under investigation. Second, although our review is based on extensive data from 131 studies, several reports did not include raw data on gender-specific prevalence estimates and could not be included in the meta-analyses, restricting our ability to conduct subgroup analyses concerning important methodological or sample characteristics. Future research should consider the Sex and Gender Equity in Research (SAGER) guidelines (Heidari et al., 2016) in their reporting, and journals are encouraged to require gender-sensitive reporting. Nonetheless, missing gender-specific data can be assumed to be random and unlikely to have significantly altered the findings. Third, the reliance on self-reports for diagnosing mental disorders arguably introduces bias; Sigmon et al. (2005) found that men may underreport depressive symptoms in certain contexts. More studies using clinician-administered interviews are needed to enhance diagnostic reliability and validity of the measurements. Fourth, gender differences in comorbidity could not be investigated, as most publications lacked gender-specific comorbidity estimates. Yet, past research has shown significant gender differences in comorbidity (McLean et al., 2011). Finally, it was not possible to examine the confounding role of subsequent adverse life events in prevalences in the long-term hazard-aftermath. Therefore, longitudinal studies are required to examine pre-existing gender inequalities as well as the interaction of pre-, peri-, and post-natural hazard factors and psychopathology.

4.2. Clinical implications

Although gender disparities in mental disorders following natural hazards do not appear significantly higher than those observed in other contexts, adopting a gender-sensitive approach to screening and psychological interventions remains essential. Women may face unique post-hazard hardships, including increased caregiving responsibilities, economic insecurity, loss of social networks due to displacement, and exposure to gender-based violence, all of which can exacerbate their vulnerability to mental health challenges. Stigma surrounding mental health and restrictive norms may limit women's access to support systems or formal help-seeking pathways.

Incorporating gender-dependent risk and maintenance factors into post-hazard intervention designs could improve our understanding of mental disorders in this population. Community-based programmes that address stigma and integrate gender norms into outreach strategies can help reduce barriers to care. Additionally, tailoring prevention and intervention programmes to meet gender-specific needs may enhance their effectiveness. Meta-analyses suggest that psychotherapy effectively addresses PTSD following natural hazards (Kip, Brouër, et al., 2024) and that both men and women significantly benefit from psychotherapy (Cuijpers et al., 2014; Wade et al., 2016). However, access to and uptake of psychotherapy as well as intervention efficacy can be improved by incorporating gender-relevant strategies. For example, offering gender-sensitive psychoeducation could help challenge misconceptions about therapy and normalize participation. Moreover, including discussions about gender-specific experiences during treatment, such as caregiving burdens or experiences of violence, can be beneficial.

5. Conclusion

This meta-analysis suggests that female natural hazard survivors report higher prevalence of PTSD and MD compared to males. Overall, the gender differences do not appear larger relative to non-hazard contexts. Nonetheless, the findings highlight the need for gender-awareness in response plans and gender-sensitive mental health interventions. Future research on non-binary identities and the influence of pre-hazard disparities would deepen the understanding of gendered differences of natural hazards.

Disclosure statement

Data availability statement

Data and R script can be found under https://osf.io/wu367/.

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