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Review

The prevalence of PTSS under the influence of public health emergencies in last two decades: A systematic review and meta-analysis

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ABSTRACT

Background: Since the beginning of 21st century, several major public health emergencies (PHEs) have threatened the health of people globally. Posttraumatic stress symptoms (PTSS) was one of the most concerned mental health problems. The objective of this study is to systematically estimate the prevalence of PTSS under the influence of PHEs.

Method: We searched both English and Chinese databases. This meta-analysis used a random-effects model to estimate the prevalence of PTSS. Subgroup analyses were conducted to analyze the source of heterogeneity. Meta-regression model was used to calculate the proportion of the variance explained by subgroup moderators.

Results: Forty eligible studies (n = 15,538) were identified. The results revealed a pooled prevalence of PTSS of 17.0% (95%CI: 13.5%–21.2%), higher than that of previous epidemiological survey, with high between-studies heterogeneity (Q = 1199, I^2 = 96.75%, $p < .001$). There was variance of prevalence in different countries (4.0%–36.5%) and epidemics (12.1%–36.5%). The prevalence of PTSS showed the feature of fluctuation in the change of time (Q = 6.173, p = .290). Patients had higher prevalence (26.2%) compared to healthcare workers (HCWs) (18.5%) and community samples (12.4%) and frontline HCWs had marginally significantly higher estimated rate than general HCWs (22.2%, 95%CI:16.0%–30.1% vs. 10.4%, 95%CI: 6.4%–16.6%). The variance of prevalence screened by interview and self-reported was significant (Q = 3.393, p = .05) and studies with higher quality possessed lower prevalence (high:12.4%; moderate: 17.3%; low: 18.0%). The total variance explained by subgroup moderators was estimated 64% by meta regression model.

Limitations: Limitations include high level of heterogeneity between studies and within subgroups as well as the lack of studies with high quality and using probability sampling.

Conclusions: This study suggested that the PTSS was common under the influence of PHEs. It was crucial to further explore the psychological mechanism and effective strategies for prevention and intervention in future research with more high-quality studies.

1. Introduction

Public health emergency (PHE) refers to the sudden occurrence of major infectious diseases such as congregative disease of unknown reasons, serious food and occupational poisoning, and other events that severely threaten public health (State Council of the people's Republic of China, 2011). Since the beginning of the 21st century, several major PHEs related to infectious disease have challenged public health globally (Holshue et al., 2020; Lai, Shih, Ko, Tang, & Hsueh, 2020; Remuzzi & Remuzzi, 2020). The ongoing PHE is coronavirus disease-2019 (COVID-19) with the first confirmed case reported in December 2019. The COVID-19 was declared a global pandemic on March 11(Director-General, 2020). Up to April 15, the confirmed COVID-19 global cases were 1,914,916 with 123,010 deaths (WHO, 2020a). Several pandemics emerged over the past two decades including SARS, Middle East respiratory syndrome (MERS), (Drosten et al., 2003; Zaki, van Boheemen,

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Bestebroer, Osterhaus, & Fouchier, 2012) and Ebola virus disease (EVD), formerly known as Ebola hemorrhagic fever, which started in Guinea 2014, then spread to Sierra Leone and Liberia (Holmes, Dudas, Rambaut, & Andersen, 2016). SARS has caused 8422 global cumulative cases and 916 deaths by August 7 in 2003 (WHO, 2003). At the end of September 2019, a total of 2468 laboratory-confirmed cases of MERS, including 851 associated deaths (case–fatality rate: 34.4%) were reported globally (WHO, 2019). The Ebola epidemic in Democratic Republic of the Congo has been around since 2018 (Ebola Outbreak Epidemiology Team, 2018), with 3456 confirmed cases and 2266 deaths reported up to April 12 (WHO, 2020). These major PHEs have challenged the development of human society in the new era.

Mental health consequences associated with PHEs need to be addressed as much as physical health consequences(Chen et al., 2020; Shultz, Baingana, & Neria, 2015; Yang et al., 2020). PHEs exposed individuals to multiple stressors including physical health consequences associated with disease (Zhou et al., 2020), anxiety over getting infected (Asmundson & Taylor, 2020), social isolation(Brooks et al., 2020), depression due to quarantine(Hawryluck et al., 2004), and other stressful events arising during epidemic (e.g., unemployment and loss of loved ones)(Chaves, Castellanos, Abrams, & Vazquez, 2018). One common psychological distress resulted from PHEs is posttraumatic stress disorder (PTSD), a psychological disorder that occurs after traumatic events (Lötsch, Schnyder, Goorhuis, & Grobusch, 2017; Rogers et al., 2020). Chan and Huak reported that two months after SARS outbreak, around 20% of 661 healthcare workers (HCWs) of a medium–size regional general hospital in Singapore, had a probable PTSD diagnosis (Chan & Huak, 2004). Hawryluck et al. (2004) examined the psychological effects of quarantine during SARS epidemic among individuals in Toronto, Canada, and found that 28.9% of 129 participants showed symptoms of PTSD.

Diagnosis of PTSD could be conducted by psychiatrists using uniform diagnostic criteria for symptoms (e.g. Chinese Classification and Diagnostic Criteria of Mental Disorders 3rd edition (CCMDIII), DSM-IV). Having individuals complete a self-rated psychometric scale and seeing if they met the cut-off score of PTSD could lead to a probable PTSD diagnosis (Hawryluck et al., 2004; Su et al., 2007). Individuals being diagnosed with PTSD or met cut-off score were considered to have significant posttraumatic stress symptoms (PTSS). Due to more cautious considerations on clinical diagnosis, the heterogeneity of PTSS prevalence rate caused by screening method is high (Lancee et al., 2008; Maunder et al., 2006).

In addition, the prevalence rate of PTSS under PHEs varied across time course of the PHE and population group. The number of follow-up studies on PTSS prevalence was limited and shows inconsistent results. For example, Lee et al. found that the prevalence rate of PTSS decreased over time after MERS (12–18 months: 42%–27%)(Lee et al., 2019), but another study tracked the prevalence of PTSS in SARS convalescent patients and found the rate to be stable at different time points: 40% (2.5 months), 41% (7 months), 39% (10 months), 40% (24 months), and 39% (46 months)(Hong et al., 2009). The prevalence rate of PTSS tends to be high among patients (Zhang et al., 2005). Shi et al. (2005) found that the prevalence rate in patients, first-line HCWs, second-line HCWs, general HCWs, and colleges students after SARS epidemic were 50%, 5%, 5%, 0%, and 7%, respectively. Liu et al. (2020) investigated the prevalence of PTSS in residents during COVID-19 epidemic in Wuhan, China, and found the rate was 7%. Moreover, it was still unexplored whether the prevalence under PHEs were affected by different country and epidemic.

A systematic review evaluated the psychological impact of deploying in support of the U.S. Response to Ebola by analyzing articles related to infectious disease and HCWs. It was estimated that effect size for PTSD was relatively small and non-significant (SMD = 0.12, 95%CI = −0.23 to 0.47, HCWs vs. low-risk control group)(Vyas, Delaney, Webb-Murphy, & Johnston, 2016). Another study systematically reviewed the long-term neuropsychological effects of the Ebola outbreak on survivors and found that PTSD was one of the five most common sequelaes (Lötsch et al., 2017). To our knowledge, there is still a lack of the overall estimation of the prevalence rate of PTSS under the influence of major PHEs. To fill this gap, we conducted a meta-analytic review to improve our understanding of trauma-related mental health related to PHEs and further explored variation in prevalence by country, epidemic, time period, population group, screening method, and study quality.

2. Method

We followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher, Liberati, Tetzlaff, Altman, & Prisma Group, 2009) and Meta-analysis Of Observational Studies in Epidemiology (MOOSE) guidelines (Stroup et al., 2000).

2.1. Search strategy

We conducted a systematic review using Pubmed, PsychoINFO, EMBASE, and SCOPUS for publications in English. Publications in Chinese were searched through China National Knowledge Infrastructure Database (CNKI), the Wanfang database, and China Science and Technology Journal Database. No restrictions on publication type that conference proceedings and dissertations were also included. The searches were concluded by March 21, 2020. Two unpublished manuscripts were included with the approval of their authors (Sun et al., 2020a,2020b). The search terms for PHE were: (Severe Acute Respiratory Syndrome virus) OR (SARS) OR (SARS Coronavirus) OR (Hemorrhagic Fever) OR (Ebola) OR (Ebolavirus) OR (Avian Influenza) OR (Influenza in Bird) OR (Avian Flu) OR (Fowl Plague) OR (Bird flu) OR (MERS) OR(Middle East respiratory syndrome) OR (2019 novel coronavirus infection) OR (COVID) OR (COVID-2019) OR (coronavirus disease 2019) OR (coronavirus disease-19) OR (2019-nCoV) OR (2019 novel coronavirus disease); search terms for PTSS were: (PTSD) OR (Posttraumatic stress disorder) OR (Post-traumatic stress disorder) OR (Posttraumatic). See Supplementary Materials for details of search terms used for each database.

2.2. Inclusion/exclusion criteria

The following inclusion criteria were applied:1) participants under the influence of PHE; 2) prevalence of PTSS in study samples being surveyed and reported; 3) use of measures that have good psychometrics to assess PTSS or retrieve from reliable records.

The following studies were excluded from this meta-analysis:1) commentary, editorial, case report, or review; 2) not reporting prevalence data; 3) studies explicitly referring to different disorders, such as depressive symptoms. 4) articles that could not be retrieved in full-text form through online databases, library requests or email correspondence with the authors of the studies.

2.3. Data extraction and coding

Two authors screened the title and/or abstracts independently, and then the full text of the studies was retrieved and independently assessed based on the inclusion and exclusion criteria. The two independent authors also applied a uniform data extraction form to record data such as authors, publication year, countries, epidemic, time after epidemic, study participants, screen tools, sample size, the prevalence of PTSS and other subgroup data, etc. For studies (k = 3) with multiple assessment points, a mean value of combined results was calculated when estimating the overall prevalence rate; all time points were used as a separate study when estimating the prevalence rate across different time points. The ‘time after epidemic’ was estimated based on information provided by articles and records on the World Health Organization website (e.g. summary table of SARS cases by country)(WHO, 2003). When the same samples were assessed using multiple assessments, a

mean value of combined prevalence rate was calculated. When multiple studies were based on the same dataset, the study with a larger sample size was included. Interrater reliability was calculated for continuous variables (e.g. event rate, sample size) using intraclass correlation coefficients (ICC) and for categorical moderators (e.g. study quality, country, epidemic). Interrater agreement was high (ICC = 0.99 and Kappa = 0.77 for continuous and categorical variables, respectively) across studies, and discrepancies were resolved through discussion.

We divided the participants in the studies into three categories: patients, healthcare workers (HCWs), and community samples. Patients referred to individuals with diseases related to PHEs. HCWs referred to individuals who provided medical services. Frontline HCWs referred to medical workers who had direct contact with patients. Community samples included individuals who were in quarantine, college students, residents, persons visiting the community primary health care, and patients in psychiatric department (mixed sample).

2.4. Quality assessment

The quality of each study was assessed by a Risk of Bias Tool for prevalence studies developed by Hoy et al. (2012). The tool consists of 10 items, divided into external validity and internal validity subscales. The external validity subscale has four items, including representation of the national population, sampling frame, random sampling, and nonresponse bias. The internal validity subscale has six items: data collected directly from the subjects or a proxy, case definition, quality of instruments, consistency of data collection mode, the length of the prevalence period, and the calculation of prevalence. Each item was assigned a score of 1 (yes, high quality) or 0 (no, low quality), thus the total score ranged from 1 to 10. Consistent with previous studies (Tang, Tang, Ren, & Wong, 2019), the quality of each study was classified as high (> 8), moderate (6–8), or low (≤5). Two investigators (Yaoguang Zhou and Luna Sun) independently assigned the scores, and inconsistencies were resolved by discussion. The detail of quality assessment is shown in Supplementary Materials.

2.5. Meta-analytic procedures

Due to the between-studies heterogeneity, a random effects model was applied to estimate the mean value of prevalence rate, and it gave an overall estimate across studies weighted by sampling error and true variance (Borenstein, Hedges, & Rothstein, 2007). The Q-value was chosen as an indicator of heterogeneity, with p less than 0.05 suggesting a significant heterogeneity across studies. In addition, we made a raw comparison between the estimated mean prevalence rate with the PTSD prevalence rate in National Epidemiologic Survey(NES)(Pietrzak, Goldstein, Southwick, & Grant, 2011). NES refers to an up-to-date assessment of the lifetime prevalence and Axis I comorbidity of DSM-IV PTSD and partial PTSD, with a representative sample of the civilian, noninstitutionalized U.S. population (n = 34,653).

We performed subgroup analysis stratified by countries, epidemic, time periods, population groups, screening method, and study quality. Since there were more homogeneous groups in included studies (i.e. studies from China, studies in SARS, studies within 6 months after epidemic, studies in sample of community samples, HCWs, and patients), sensitivity analyses were conducted with subgroup moderators mentioned above in those groups. Sensitivity analyses were also performed by leave one out analysis. Meta-regression model was built by using maximum likelihood calculation to find moderators that explained the majority of the variance across studies. Publication bias was assessed using funnel plots and Egger's tests. Comprehensive Meta-Analysis (V3, Biostat, Englewood, NJ, USA) was used for the meta-analyses.

3. Results

3.1. Study selection and study characteristics

The screening process is shown in Fig. 1. Based on the search terms, we found a total of 158 non-duplicate articles. Of these, 33 were excluded by screening titles and abstracts, leaving a total of 125 full texts to be assessed for eligibility. After the full text screening, 40 articles met the inclusion criteria. Of the 85 articles that were excluded, 46 were commentary, editorial, case report, or review, 13 did not report prevalence data, 3 were not PTSS study conducted under the influence of public health emergency, 20 had duplicate samples and 3 were not accessible in full-text-form.

Table 1 shows 40 included studies with a total of 15,538 participants. Sample sizes ranged from 29 to 3564. These studies were from 8 countries and 5 PHEs (SARS, Ebola, Crimean-Congo hemorrhagic fever, MERS, COVID-19), with three major population groups participating in these studies: patients, HCWs, and community samples. Fourteen studies obtained their samples from patients, 17 from HCWs and 13 from community samples. The investigation was conducted on 0–46 months from the time of epidemic. Dates of publication ranged from 2004 to 2020. Ten self-report scales were used to identify PTSS: The Impact of Event Scale—Revised (IES-R), the Impact of Event Scale (IES), the PTSD checklist (PCL), the PTSD self-rating scale (PTSD-SS), Davidson Trauma Scale-Chinese version(DTS-C), the posttraumatic diagnostic scale for DSM-5 (PDS-5), the Impact of Event Scale-6 (IES-6, a shortened version of the full IES-R), the PTSD Checklist-Specific (PCL-S), PTSD checklist Cuvukuab version (PCL—C), and PTSD checklist for DSM-5(PCL-5). Three interview scales were used to identify PTSD diagnose: Composite International Diagnostic Interview-PTSD, Version 2.1 (CIDI 2.1), Clinician-Administered PTSD Scale (CAPS), and PTSD symptom scale–Interview (PSS-I). Regarding study quality, 3 out of 40 studies are of high quality, 34 are of moderate quality, and 3 are of low quality.

3.2. Prevalence of PTSS under the influence of PHEs

The overall pooled estimates of PTSS reported by 40 studies yielded a crude summary of prevalence of 17.0% (95% CI: 13.5%–21.2%) with significant heterogeneity present ($Q = 1199$, $I^2 = 96.75\%$, $p < .001$). See Fig. 2.

Under a raw comparison (17.0% vs 6.6% and 6.4%), the 95%CI lower limit (13.5%) of estimated prevalence in current study is higher than the upper limit of prevalence of PTSD (9.9%) and partial PTSD (10.1%) in a National Epidemiologic Survey(NES), suggesting a significant difference on the level of $\alpha = 0.05$. See Table 2.

3.3. Subgroup analysis

To further determine the source of heterogeneity, meta-analyses stratified by multiple moderators were conducted (See Table 3). When stratified by countries, there was significant heterogeneity in the estimates of PTSS prevalence ($p < .001$). Specifically, the prevalence of each country were as follows: Canada, 12.4% (95CI%: 7.0%–21.2%); China, 16.2% (95CI%: 10.7%–23.8%); Guinea, 6.3% (95CI%: 2.9%–13.4%); Korea, 36.5% (95CI%: 20.6%–56.0%); Liberia, 4.0% (95CI%: 1.9%–8.2%); Sierra Leone, 20.3% (95CI%: 10.0%–33.6%); Singapore, 20.8% (95CI%: 14.1%–29.5%); Turkey, 18.5% (95CI%: 10.3%–31.1%). When stratified by China vs other countries (16.2%, k = 21 vs 17.8%, k = 19), there was no significant heterogeneity between two groups ($p = .700$). Between-group Q value was reduced to 0.418 (Q value was 31.931 when grouping by different countries). Subsequent analysis of prevalence of PTSS on different variables among studies from China was presented at Table S1.

When stratified by different PHEs, there was no significant heterogeneity in the estimates of PTSS prevalence ($p = .095$). Specifically, prevalence in each epidemic were as follows: COVID-19, 13.5% (95CI%:

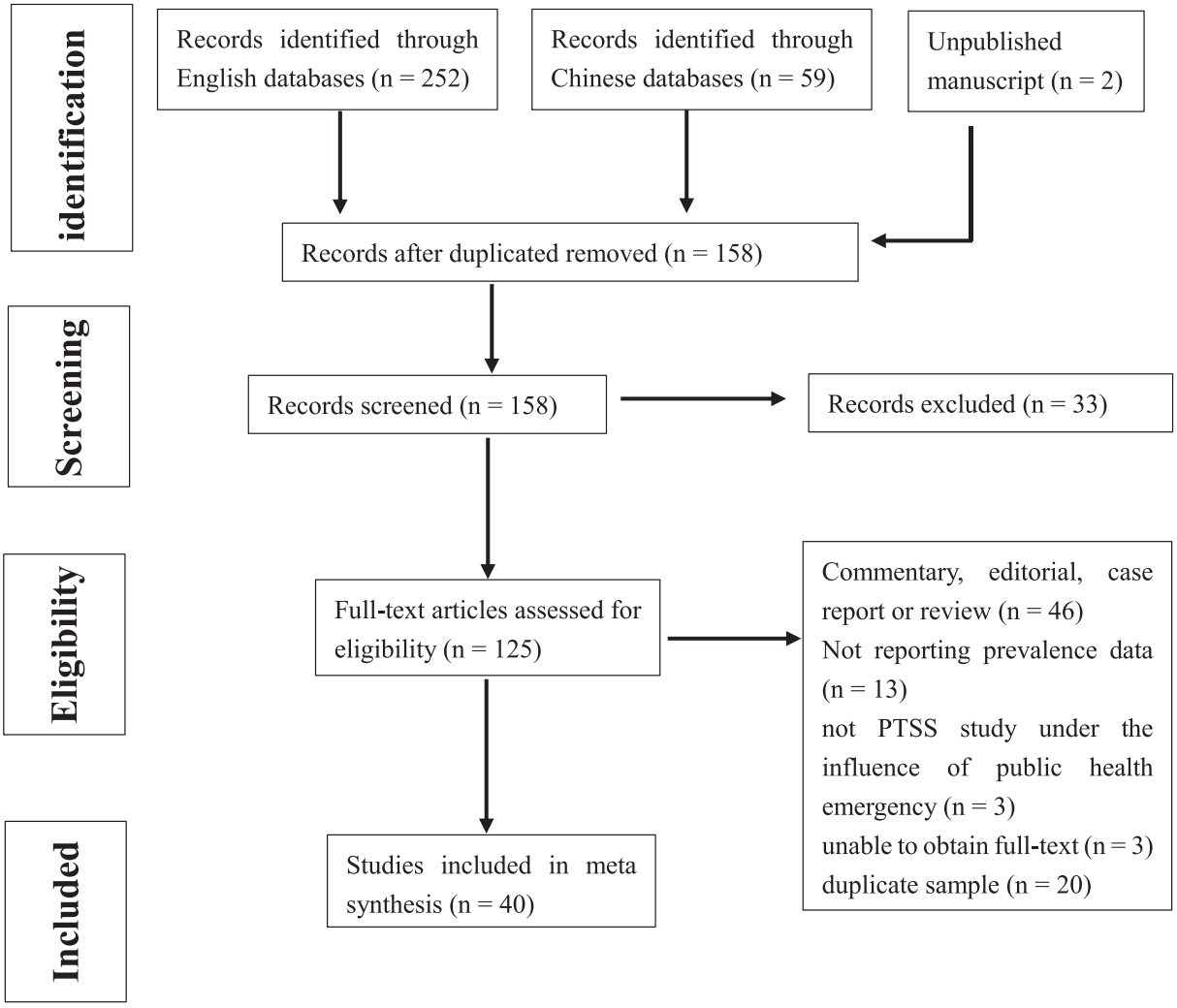

Fig. 1. PRISMA Flowchart of Study Selection.

4.6%–33.1%); Crimean-Congo hemorrhagic fever, 18.5% (95CI%: 10.3%–31.1%); Ebola, 12.1% (95CI%: 6.7%–21.0%); MERS, 36.5% (95CI%: 20.6%–56.0%); SARS, 17.4% (13.4%–22.3%). When stratified by SARS vs other PHEs (17.4%, k = 24 vs 16.5%, k = 16), heterogeneity was not significant (p = .826). Between-group Q value was reduced to 0.049 (Q value was 7.21 when grouping by different PHEs). Subsequent analysis of prevalence of PTSS on different variables among SARS-related studies was presented in Table S2.

The prevalence of PTSS fluctuated along with the time course. And there was no significant heterogeneity on different time period (p = .290). During the epidemic, the estimated PTSS prevalence rate was 16.1% (95CI%: 10.3%–24.2%). The estimated rate after 1–3 moths, 4–6 months, 7–12 months, 13–24 months, >24 months were respectively 23.7% (95CI%: 17.1%–32.0%), 12.4% (95CI%: 7.1%–20.7%), 25.6% (95CI%: 14.1%–41.9%), 19.2% (95CI%: 7.9%–39.7%), 23.0% (95CI %:8.6%–48.4%). Subsequent analysis of prevalence of PTSS on different variables among studies within 6 months was presented in Table S3.

The prevalence of PTSS among patients (26.2%, 95%CI: 13.1%–37.9%) was significantly higher than community samples (12.4%, 95% CI: 9.1%–16.6%), and HCWs had a moderate prevalence rate (18.5%, 95%CI: 12.7%–26.2%), with significant heterogeneity among these three groups (p = .014). In group of HCWs, frontline HCWS had marginally significantly higher PTSS prevalence rate than general HCWs (22.2%, 95%CI:16.0%–30.1% vs. 10.4%, 95%CI: 6.4%–16.6%). The heterogeneity was significant (p = .009). Subsequent analysis of prevalence of PTSS on different variables among different population groups was presented in Table S4-S6.

When stratified by screening method, the estimated pooled prevalence rate screened by interview was lower than that screened by self-report scale (10.8%, 95%CI: 6.3%–18.1% vs. 19.1%, 95%CI: 14.8%–24.3%), with marginally significant heterogeneity between these two groups (p = .051). In terms of study quality, there was no significant heterogeneity (p = .238) among studies with high (12.4%, 95%CI: 0.09%–16.8%), moderate (17.3%, 95%CI: 12.9%–22.8%) and low (18.0%, 95%CI: 10.7%–28.7%) quality, with higher quality possessing lower estimated prevalence rate.

3.4. Meta regression model

Subgroup moderators were all included as covariates of a meta regression model, except epidemic which caused high collinearity with other variables. Thirty-five studies were available from regression analysis based on datasets. The test of the model showed that Q = 50.93, df = 17, p < .001, suggesting the model was significantly efficient on explaining the variance across studies. The proportion of total between-study variance explained by the model was 64% (R^2 = 0.64, See Table 4).

Table 1
Study characteristics of the included studies.

Author(s) year	Country	epidemic	Time after epidemic (month)	participants	Screening tool	Cutoffs	Valid sample size	Cases above cutoffs	prevalence	Quality rating
Chan & Huak, 2004	Singapore	SARS	2	HCWs	IES	30	661	127	0.19	7
Hawryluck et al., 2004	Canada	SARS	0	persons in quarantine	IES-R	20	129	35	0.27	5
Sim et al., 2004	Singapore	SARS	0	medical stuff	IES-R	DMS-IV criteria	277	26	0.09	7
Tham et al., 2004	Singapore	SARS	6	HCWs	IES	26	96	17	0.18	7
Cai et al., 2004	China	SARS	10	patients	NR	NR	29	1	0.03	6
Lau et al., 2005	China	SARS	6	residents	IES	NR	818	128	0.16	5
Wu et al., 2005	China	SARS	1	patients	IES-R	2(mean)	195	11	0.06	8
Liu et al., 2005	China	SARS	3	patients	IES-R	20	117	65	0.56	7
Shi et al., 2005	China	SARS	6	patients, HCWs, college students	PCL	NR	162	9	0.06	7
Yan et al., 2005	China	SARS	3	patients	CIDI2.1	NR	286	28	0.10	7
Zhang et al., 2005	China	SARS	3	patients, HCWs, community sample	IES-R	20	296	115	0.39	7
Kwek et al., 2006	Singapore	SARS	3	patients	IES	26	63	26	0.41	7
Lee et al., 2006	China	SARS	2	residents	IES-R	26	146	13	0.09	7
Maunder et al. 2006[a]	Canada	SARS	19	HCWs	IES	26	769	96	0.12	7
Gao et al., 2006	China	SARS	3 12 ≥12	patients	PTSD-SS + CCMDIII criteria	48	67 67 67	31 26 37	0.46 0.39 0.55	8
Lin et al., 2007	China	SARS	1.5	HCWs	DTS-C	40	83	16	0.19	7
Su et al., 2007	China	SARS	0	nurses	DTS-C	23	102	29	0.28	7
Yang et al., 2007	China	SARS	12	HCWs	CCMDIII criteria	–	112	5	0.04	7
Lancee et al. 2008[a]	Canada	SARS	19	HCWs	CAPS	–	139	2	0.01	7
Reynolds et al., 2008	Canada	SARS	1	persons in quarantine	IES-R	20	1057	148	0.14	8
Hong et al., 2009	China	SARS	2.5 7 10 24 46	patients	IES + CCMDIII criteria	NR	70 61 57 58 57	28 25 22 23 24	0.40 0.41 0.39 0.40 0.39	8
Mak et al., 2009	China	SARS	30	patients	IES-R	2(mean)	90	23	0.26	8
Wu et al., 2009	China	SARS	36	hospital employees	IES-R	20	549	55	0.10	9
Sim et al., 2010	Singapore	SARS	2	persons visiting the community primary health care	IES-R	DMS-IV criteria	415	107	0.26	7
Gul et al., 2012	Turkey	Crimean-Congo hemorrhagic fever	12	patients	DSM-IV-TR criteria	–	54	10	0.19	7
Betancourt et al., 2016	Sierra Leone	Ebola	0	general public	PSS-I	NR	1008	114	0.11	10
Keita, Taverne, et al., 2017	Guinea	Ebola	0	patients in psychiatric department	NR	NR	68	4	0.04	7
Keita et al.(2) 2017	Guinea	Ebola	24	patients with depressed symptom	NR	NR	33	3	0.09	5
Colorado, 2018	Sierra Leone	Ebola	0	aid workers	PDS-5	30	403	163	0.40	7
Jalloh et al., 2018	Sierra Leone	Ebola	0	general public	IES-6	9	3564	570	0.16	9
Lee et al., 2018	Korea	MERS	0	hospital workers	IES-R	26	359	183	0.51	7
Sipos et al., 2018	Liberia	Ebola	0	active duty soldiers, medical mission	PCL-S	50 and DSM-IV criteria	173	7	0.04	8
Lee et al., 2019	Korea	MERS	12 18	survivors	IES-R	25	52 52	22 14	0.42 0.27	6
Huang et al., 2020	China	COVID-19	0	HCWs	PTSD-SS	50	230	63	0.27	8
Jung et al., 2020	Korea	MERS	2	nurses	IER-R	25	147	37	0.25	7
Liu et al., 2020	China	COVID-19	0	residents(hardest-hit)	PCL-5	DSM-5 criteria	285	20	0.07	8

(*continued on next page*)

Table 1 (*continued*)

Author(s) year	Country	epidemic	Time after epidemic (month)	participants	Screening tool	Cutoffs	Valid sample size	Cases above cutoffs	prevalence	Quality rating
Sun, Yi, et al., 2020b	China	COVID-19	0	residents	PCL-5	33	2091	96	0.05	8
Li et al., 2020	China	COVID-19	0	nurses	PCL-C	38	205	104	0.51	8
Tian et al., 2020	China	COVID-19	0	villager	PTSD-SS	50	87	2	0.02	7
Sun, Sun, et al., 2020a	China	COVID-19	0	patients	PCL-5	DSM-5 criteria	190	43	0.23	8

a. These two studies used different screening tools for the same participants. The mean value of the results was obtained when analyzing overall estimated pooled prevalence.

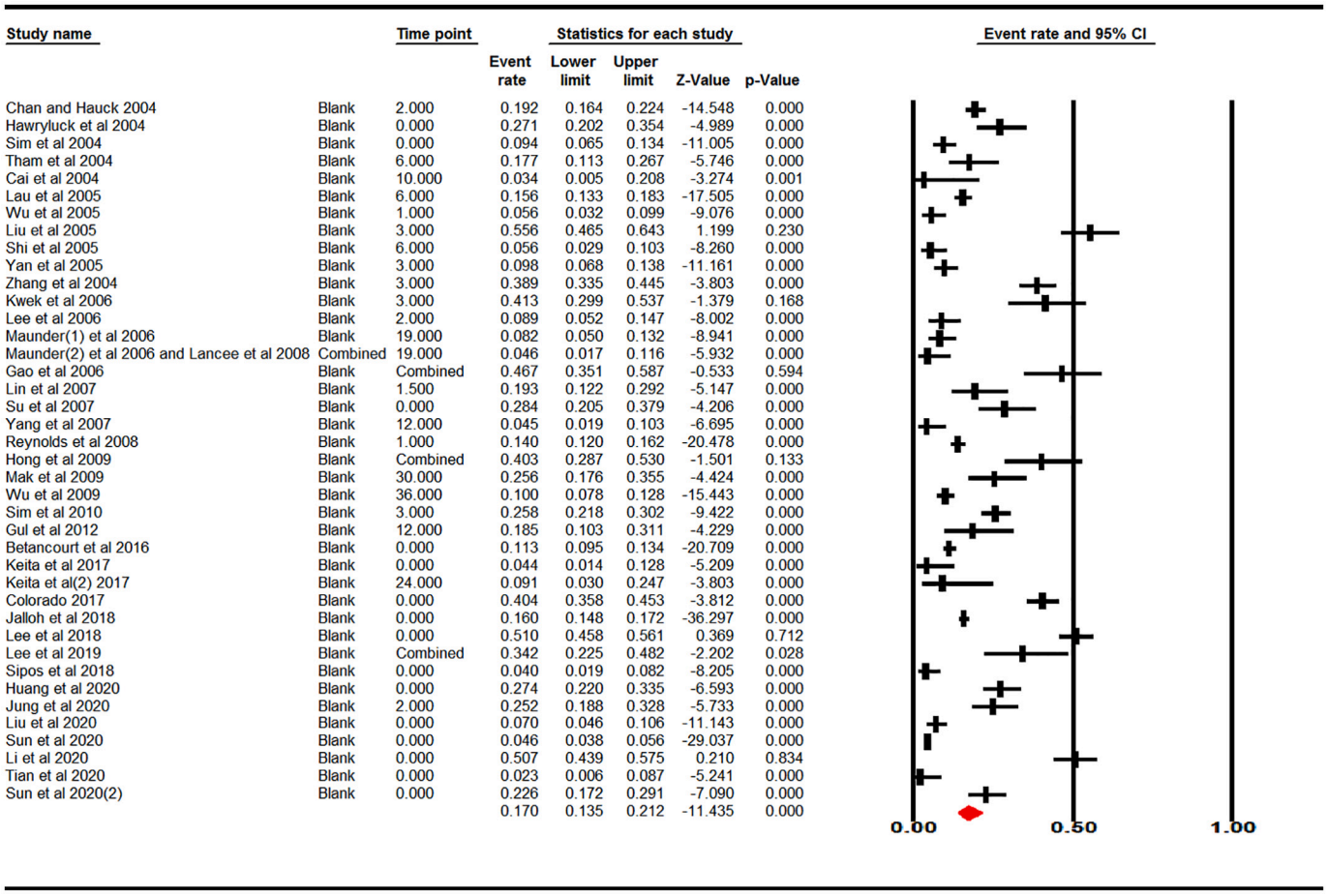

Fig. 2. Estimated prevalence of PTSS during or after PHE.
Note. Estimated prevalence = 0.170 (95% CI: 0.135–0.212).

Table 2
Raw comparison between NES of prevalence of PTSD and the PTSS prevalence in the current study.

	National Epidemiologic Survey[a]		Current study
	Partial PTSD	Full PTSD	PTSS
n	34,653		15,538
Prevalence rate	0.066	0.064	0.170
Lower limit(95%CI)	0.031	0.029	0.135
Upper limit(95%CI)	0.101	0.099	0.212

a· NES refers to an up-to-date assessment of the lifetime prevalence and Axis I comorbidity of DSM-IV PTSD and partial PTSD, with a representative sample of the civilian, noninstitutionalized U.S. population.

3.5. Sensitivity analysis

Sensitivity analysis, carried out leave one out analysis by omitting each study, demonstrated that no individual study affected the prevalence estimate of PTSS under the influence of PHE more than 4.7%. Details were presented in Fig. S1.

3.6. Publication bias

Visual inspection of the funnel plot of studies revealed significant asymmetry (see Fig. 3). Evidence of substantial publication bias was not identified using Egger's test ($p = .41$).

Table 3
Estimated PTSS prevalence on different variables.

	k	n	Estimated rate	Lower limit (95% CI)	upper limit (95% CI)	Q-value	p for heterogeneity test
Country							
Canada	4	1955	0.124	0.070	0.212	27.574	<0.001
China	21	6210	0.162	0.107	0.238	700.040	<0.001
Guinea	2	101	0.063	0.029	0.134	0.836	0.361
Korea	3	558	0.365	0.206	0.560	28.333	<0.001
Liberia	1	173	0.040	0.019	0.082	0.000	1.000
Sierra Leone	3	4975	0.203	0.100	0.336	163.101	<0.001
Singapore	5	1512	0.208	0.141	0.295	42.938	<0.001
Turkey	1	54	0.185	0.103	0.311	0.000	1.000
Between group						31.931	<0.001
China vs other countries							
China	21	6210	0.162	0.107	0.232	496.261	<0.001
Other countries	19	9328	0.178	0.134	0.238	700.040	<0.001
Between group						0.148	0.070
Epidemic							
COVID-19	6	3088	0.135	0.046	0.331	370.286	<0.001
Crimean-Congo hemorrhagic fever	1	54	0.185	0.103	0.311	0.000	1.000
Ebola	6	5294	0.121	0.067	0.210	188.901	<0.001
MERS	3	558	0.365	0.206	0.560	28.833	<0.001
SARS	24	6589	0.174	0.134	0.223	403.181	<0.001
Between group						7.921	0.095
SARS vs other PHEs							
SARS	24	6589	0.174	0.134	0.223	795.223	<0.001
Other PHEs	16	8949	0.165	0.106	0.246	403.181	<0.001
Between group						0.049	0.826
Time period (month)							
0	15	9171	0.161	0.103	0.242	809.485	<0.001
1–3	13	3603	0.237	0.171	0.320	262.458	<0.001
4–6	3	1076	0.124	0.071	0.207	11.068	0.004
7–12	6	432	0.256	0.141	0.419	38.503	<0.001
13–24	6	1118	0.192	0.079	0.397	76.584	<0.001
>24	3	696	0.230	0.086	0.484	45.095	<0.001
Between group						6.173	0.290
Population group							
Community sample	13	9791	0.124	0.091	0.166	266.269	<0.001
Healthcare workers	16	4383	0.185	0.127	0.262	468.199	<0.001
frontline HCWs	*13*	*1695*	*0.222*	*0.160*	*0.301*	*134.500*	<0.001
general HCWs	*9*	*1193*	*0.104*	*0.064*	*0.166*	*33.132*	<0.001
Between group						*6.788*	*0.009*
patients	14	1364	0.262	0.171	0.379	189.347	<0.001
Between group						8.529	0.014
Screening method							
Based on interview	10	1886	0.108	0.063	0.181	92.905	<0.001
Based on self-report scale	30	13,791	0.191	0.148	0.243	1085.232	<0.001
Between group						3.693	0.051
Study quality							
High	3	5121	0.124	0.090	0.168	23.336	<0.001
Moderate	34	9437	0.173	0.129	0.228	1045.855	<0.001
Low	3	980	0.180	0.107	0.287	11.522	0.003
Between group						2.875	0.238

4. Discussion

This systematic meta-analysis of 40 studies involving 15,538 participants under the influence of PHEs yielded an estimated prevalence of PTSS of 17.0%.

As reported in results, the Wave 2 NES on Alcohol and Related Conditions reported the lifetime full PTSD and partial PTSD were 6.4% and 6.6% in the United States, respectively (Pietrzak et al., 2011). Although the true deviation was obscure due to the bias confounded in meta-analytic result (e.g., mixed samples, time period), the prevalence of PTSS following PHEs was higher than the lifetime prevalence of general population. Furthermore, another study investigated the 12 month PTSD prevalence in the worldwide scale found that the prevalence rate was 1.1% in the total sample (Karam et al., 2014). Those evidences preliminarily demonstrated that more attention should be paid to the trauma-related psychological impacts caused by PHEs.

Subgroup analysis showed that the prevalence rate varied across countries and epidemics, but this variance became minimal when stratified by China and other countries (from 4.0%–36.5% to 16.2%–17.8%), and SARS and other PHEs (from 13.5–36.5% to 16.5%–17.4%). With increased studies included in each subgroup, the pooled prevalence was closer to the overall estimate of 17.0%, suggesting the representativeness of our results. However, the results should still be taken with caution due to the heterogeneity in each subgroup. Among the included studies, there were relatively high correlations between country and epidemic. For instance, the prevalence of PTSS under COVID-19 and SARS was mainly reported in China, while EVD was mainly reported in African countries. After controlling one variable (country or epidemic, Table S1-S2) or setting a multivariate regression model, our results preliminarily showed country or epidemic might not have a significant

Table 4
Summary of meta-regression model using country, time, population group, screening method and study quality to explain variance across studies.

Covariates included sequentially [a]	k	ΔTau^2	ΔR^2	Test of a single covariate within model		
				Q value	*df*	*p*
Country	35	−0.2317	0.25	10.51	7	0.1614
Time		−0.0781	0.09	4.93	5	0.4246
Population group		−0.1715	0.18	11.59	2	0.0035
Screening method		−0.0740	0.08	6.90	1	0.0086
Study quality		−0.0338	0.04	3.43	2	0.1802
		Tau^2	R^2	Test of the model		
The entire model		0.3336	0.64	50.93	17	<0.001

a. The covariates were all included as dummy variables in the meta-regression model. Each had a reference group.

effect on prevalence rate; However, there was a considerable amount of within-group heterogeneity. Nevertheless, the cross-cultural variations in PTSS prevalence have been previously reported in multiple large-scale investigations. In 2005, Kessler and colleagues have reported lifetime PTSD prevalence in the USA of 7.8% and 12-month prevalence of 3.9%(Kessler et al., 2005). Creamer, Burgess, and McFarlane (2001) have reported a much lower 12-month PTSD prevalence (1.3%) in Australia, despite comparable levels of exposure to trauma. Relative to the USA, the prevalence of PTSD is lower in Canada (2.7% for woman and 1.2% for men) (Stein, Walker, Hazen, & Forde, 1997), China (0.2%) (Karam et al., 2014), and 12 European countries (1.1%) (Darves-Bornoz et al., 2008). Therefore, there was complexity in the cross-cultural differences on the morbidity of PTSD and it could be still implicated that trauma-related mental health emergency strategies towards PHEs ought to be rigorously planned on the reference to those differences. In addition, to truly understand the impact of different PHEs on PTSS, a comparative study of more homogenous population groups in different epidemics was needed but relevant research is rare.

The PTSS prevalence fluctuated over time, which was mainly related to mixed characteristics in general population samples, healthcare workers, and patients. The PTSS prevalence in the general population was relatively low, with the highest prevalence emerging on 1–3 months after epidemic, and only available for three time windows (0, 1–3, 4–6). There was a trend of declining in prevalence of HCWs and constant high level in patients. But the studies for each time window in each population group were highly heterogeneous or limited in numbers (Table S3-S6). Notably, there is a lack of obvious decline in prevalence rate, with peak observed among 7–12 months after epidemic. The presence of PTSS could be delayed relative to the occurrence of traumatic event(Carty, O'Donnell, & Creamer, 2006), along with the possibility of suffering from subsequent traumatic event (Pietrzak et al., 2011). Meanwhile, PTSS could exist in a long time after index trauma. For instance, according to an investigation in the US army, approximately 9000 veterans endured PTSS 40 years after the Vietnam War (Marmar et al., 2015). To more accurately describe the longitudinal trajectory of PTSS under the PHEs, future studies should conduct longer follow-up studies among different populations, as well as examine the protective and risk factor towards PTSS. In conclusion, these results preliminarily suggested that the prevalence was relatively high in a long time period. The wide range time effect of PTSS implicated the crucial need for consistent intervention and care towards posttraumatic psychiatry after PHEs.

Patients who had a higher risk of confronted with stressful experiences (e.g. fear of deterioration) and physical lesion, had the highest prevalence among participant groups. The estimated prevalence of patients in the current study was comparable to another systematic review that reported the prevalence of PTSD symptoms in adult critical care survivors was 19.8% (Righy et al., 2019). HCWs also had a relatively high prevalence of PTSS, with frontline HCWs yielding a higher estimated rate than general HCWs. As a systematic review concluded, work-related critical incidents are positively related to PTSS(de Boer et al., 2011).The front-line personnel are in direct contact with patients, facing greater challenges in work intensity and complexity, as well as safety protection. The PTSS of the community samples is relatively low, while the estimated rate was still higher than the majority of the other trauma-related conditions reported in a international survey(Kessler et al., 2017). Some effective control measures towards the epidemic, such as quarantine, may also be positively correlated with PTSS(Brooks et al., 2020). Hence it is necessary to develop targeted psychological protection in PHE based on the posttraumatic characteristics of different populations.

The prevalence screened by interview which was constantly regarded as a more objective way to evaluate the PTSS was estimated lower than by self-reported assessment. It could be inferred that positive PTSD confirmed by interview tended to be discreet in diagnostic process, for more comprehensive evaluation of psychopathological symptoms, traumatic events, and considerations of following consequences of a

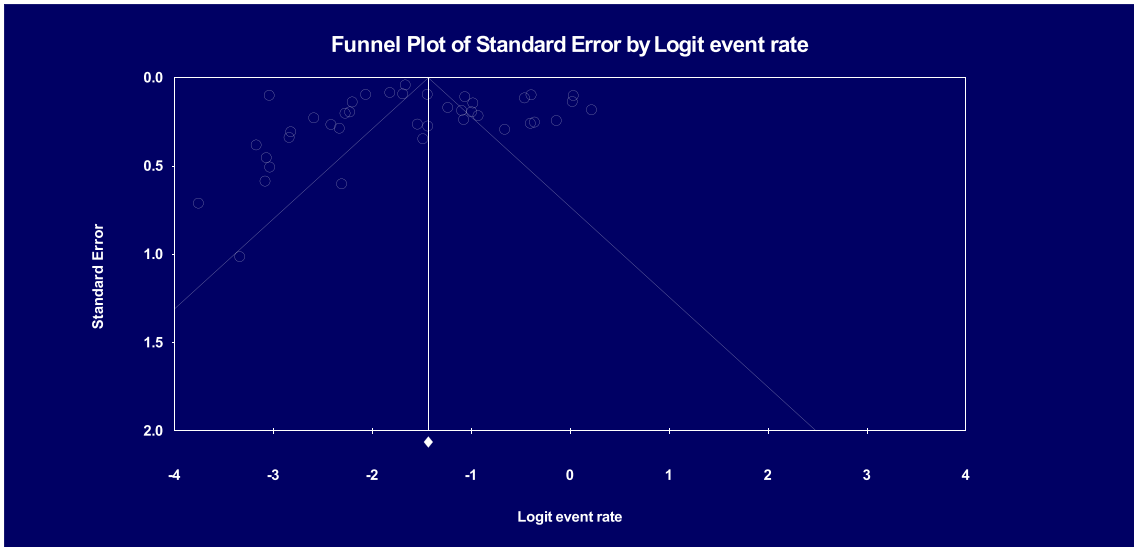

Fig. 3. Funnel plot.
Note. Egger's Test of the Intercept shows intercept (B0) as-0.35502, with 95% confidence interval (−3.54659, 2.83655), $t = 0.22519$, $df = 38$. $p = .41152$.

psychiatric verdict being needed (Bonfils et al., 2018), while the PTSS points rated by self-reported scales were constantly seen as a reference to the symptom severity. It was also demonstrated that studies with higher quality were estimated at a higher rate than lower ones, which is similar to another systematic review studying the prevalence of the depress symptoms in Chinese young adolescents (Tang et al., 2019). The above results suggested that the difference in psychometric measurements and the study quality may lead to bias in the estimated PTSS prevalence related to PHEs.

The strength of this study is thoroughly reviewed studies that examined PTSS under the influence of PHEs and applied a multivariate meta-regression model to investigate variances explained by subgroup moderators. Nevertheless, several limitations should be noted. First, there was a relatively high risk of bias in included studies, with only a few studies used probability sampling and had a high study quality. Second, there is a high heterogeneity (36%) among studies remaining largely unexplained by the variables investigated. Third, the main results remained to be updated for the COVID-19 epidemic since there are ongoing surveys concerning the trauma-related mental health. Fourth, the study was not pre-registered and might lead to potential bias by post hoc decisions in review methods (Liberati et al., 2009). Lastly, samples included in this study could not represent the general population, leading to an imbalance of sample composition and biased estimation of prevalence.

5. Conclusion

In summary, our study suggests that PTSS are frequently experienced by various populations under PHEs and the impact can be long-lasting. Several strategies can be taken to improve the accuracy of the estimated prevalence rate. For example, future studies may include larger-scale samples by probability sampling, use statistical methods to eliminate the variance between screening by interview and self-report, utilize measurements with good psychometric properties and valid cutoffs for the targeted population, and conduct a longer follow-up. Moreover, since the correlated factors of PTSS under the PHEs had been studied in previous articles, more high-quality investigations and systematic reviews are needed to explore the characteristics and mechanisms of PTSS under PHEs. Finally, more randomized controlled trials are needed to identify effective prevention, intervention, or treatment pointing at PTSS under the PHEs.

(Betancourt et al., 2016; Cai, Liu, Zhou, Liu, & Qin, 2004; Chan & Huak, 2004; Colorado, 2018; Gao et al., 2006; Gul et al., 2012; Hawryluck et al., 2004; Hong et al., 2009; Huang, Han, Luo, Ren, & Zhou, 2020; Jalloh et al., 2018; Jung, Jung, Lee, & Kim, 2020; Keita et al., 2017; Keita et al., 2017; Kwek et al., 2006; Lancee, Maunder, & Goldbloom, 2008; Lau et al., 2005; Lee et al., 2019; Lee, Kang, Cho, Kim, & Park, 2018; Lee, Chi, Chung, & Chou, 2006; Li et al., 2020; Lin et al., 2007; Liu et al., 2020; Liu, Lu, Xu, & Zhang, 2005; Mak, Chu, Pan, Yiu, & Chan, 2009; Maunder et al., 2006; Reynolds et al., 2008; Shi et al., 2005; Sim, Chan, Chong, Chua, & Soon, 2010; Sim, Phui, Yiong, & Soon, 2004; Sipos, Kim, Thomas, & Adler, 2018; Su et al., 2007; Sun et al., 2020a; Sun et al., 2020b; Tham et al., 2004; Tian, Zhang, & Qian, 2020; Wu, Chan, & Ma, 2005; Wu et al., 2009; Yan, Guo, Li, Yan, & Liu, 2005; Yang et al., 2007; Zhang et al., 2005)

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Authors' contributions

YZ, ZS, YW, CX contributed to the writing, and the meta analysis of this article, who are co-first authors, WL leaded the whole study, including putting forward this study, carrying out the study, and was the corresponding author. LS, ZS contributed to search process, study inclusion, and data extraction/coding and quality assessment.

Declaration of Competing Interest

The authors declare that they have no conflicts of interest.

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Appendix A. Supplementary data

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