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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.

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\textsuperscript{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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neuropsychological effects of the Ebola outbreak on survivors and
For example, Lee et al. found that the prevalence rate of PTSS decreased
time course of the PHE and population group. The number of follow-up
Maunder et al., 2006 ).
diagnosis (Chan, Huak, 2004 ). Haryruluck et al. (2004) examined the
effect due to quarantine(Haryruluck et al., 2004), and other
Lötsch et al., 2017). To our knowledge, there is still a lack of the overall esti-
found that PTSD was one of the five most common sequelaes (Lötsch
2. Method

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

2.1. Search strategy

We conducted a systematic review using Pubmed, PsycholINFO, 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 Tech-
nology Journal Database. No restrictions on publication type that con-
servation 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 (Ebola virus) 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 (coro-
navirus disease-19) OR (2019-nCoV) OR (2019 novel coronavirus dis-
ease); 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 preva-
ence 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 esti-
mating 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

Bastenbroek, Osterhaus, & Fouquier, 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, Ram-
baut, & 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 re-
ported globally (WHO, 2019). The Ebola epidemic in Democratic Re-
public 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 chal-
lenged 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;
Shulz, Baingana, & Neria, 2015; Yang et al., 2020). PHEs exposed in-
dividuals to multiple stressors including physical health consequences
associated with disease (Zhou et al., 2020), anxiety over getting infected
(Axmundson & Taylor, 2020), social isolation (Brooks et al., 2020),

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%, and 0%, 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 thematic.

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 PTSS
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

With 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, 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 (PSS-SS), Davidson Trauma Scale-Chinese version (DTS-C), the postrauumatic diagnostic scale for DSM-5 (PDS-SS), 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 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, I² = 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 α = 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 31.93 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%:
4.6%–33.1%); Crimean-Congo hemorrhagic fever, 18.5% (95CI%: 10.3%–31.1%); Ebola, 12.1% (95CI%: 6.7%–20.0%); 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 months, 4–6 months, 7–12 months, 13–24 months, >24 months were respectively 23.7% (95CI%: 17.1%–32.0%), 23.4% (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 medical staff | 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 | HCWs | IES-R | 2(mean) | 195 | 11 | 0.06 | 8 |
| Cai et al., 2004 | China | SARS | 3 | patients | NR | NR | 277 | 26 | 0.06 | 7 |
| Liu et al., 2005 | China | SARS | 3 | 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 | Canada | SARS | 19 | HCWs | IES | 26 | 769 | 96 | 0.12 | 7 |
| Lin et al., 2007 | China | SARS | 12 | ≥12 | PTSD-SS + CCMDIII criteria | 48 | 67 | 31 | 0.46 | 8 |
| Su et al., 2007 | China | SARS | 1.5 | HCWs | DTS-C | 40 | 83 | 16 | 0.19 | 7 |
| Yang et al., 2007 | China | SARS | 12 | nurses | CCMDIII criteria | 23 | 102 | 29 | 0.28 | 7 |
| Lancee et al., 2008 | Canada | SARS | 19 | HCWs | CAPS | – | 139 | 2 | 0.01 | 7 |
| Reynolds et al., 2008 | Canada | SARS | 1 | patients in quarantine | IES-R | 20 | 1057 | 148 | 0.14 | 8 |
| Hong et al., 2009 | China | SARS | 2.5 | patients | IES-R | 2(mean) | 70 | 28 | 0.40 | 8 |
| Lin 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 |
| 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 aid workers | NR | NR | 33 | 3 | 0.09 | 5 |
| Colorado, 2018 | Sierra Leone | Ebola | 0 | patients | 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 | PCL-5 | 26 | 359 | 183 | 0.51 | 7 |
| Sipos et al., 2018 | Liberia | Ebola | 0 | survivors | IES-R | PCL-5 | 26 | 359 | 183 | 0.51 | 7 |
| Lee et al., 2019 | Korea | MERS | 12 | patients | IES-R | 25 | 52 | 22 | 0.42 | 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 |
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 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-5 | 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.

Table 2

| National Epidemiologic Survey* | 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.

Fig. 2. Estimated prevalence of PTSS during or after PHE.

Note. Estimated prevalence = 0.170 (95% CI: 0.135–0.212).
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 3
Estimated PTSS prevalence on different variables.

| Country               | k | n       | Estimated rate | Lower limit (95% CI) | upper limit (95% CI) | Q-value | p for heterogeneity test |
|-----------------------|---|---------|----------------|----------------------|----------------------|---------|-------------------------|
| Canada                | 4 | 1955    | 0.124          | 0.070                | 0.212                | 27.574  | <0.001                  |
| China                 | 21 | 6210   | 0.162          | 0.107                | 0.238                | 790.040 | <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                   |
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 women 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 PTSD, a more comprehensive evaluation of psychopathological symptoms, confirmed by interview tended to be discreet in diagnostic process, 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% (Rigby 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., 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 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. 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.

### 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 | $\Delta \tau^2$ | $\Delta R^2$ | Test of a single covariate within model |
|----------------------------------|---|----------------|-------------|----------------------------------------|
| 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                       |
| The entire model                 | 0.3336 | 0.64        | 50.93 17 <0.001                      |

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

### 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), $t = 0.22519$, $df = 38$, $p = .41152$.  

The entire model 0.3336 0.64 50.93 17 <0.001
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 examinations and the study quality may lead to bias in the estimated PTSS prevalence related to PHEs.

The main results showed 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; Gu, 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, & Goldblom, 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, Xu, & Zhang, 2005; Mak, Chu, Pan, Yiu, & Chan, 2009; Maunder et al., 2006; Reynolds et al., 2008; Shi et al., 2005; Sim, Chan, Chong, & Soon, 2010; Sim, Phui, Yiong, & Soon, 2004; Sipos, Kim, Thomas, & Adler, 2018; Su et al., 2007; Sun et al., 2020a; Sun et al., 2020b; Than 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
Supplementary data to this article can be found online at https://doi.org/10.1016/j.cpr.2020.101938.

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