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Work-related critical incidents in hospital-based health care providers and the risk of post-traumatic stress symptoms, anxiety, and depression: A meta-analysis

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ABSTRACT

This meta-analysis reviewed existing data on the impact of work-related critical incidents in hospital-based health care professionals. Work-related critical incidents may induce post-traumatic stress symptoms or even post-traumatic stress disorder (PTSD), anxiety, and depression and may negatively affect health care practitioners' behaviors toward patients. Nurses and doctors often cope by working part time or switching jobs. Hospital administrators and health care practitioners themselves may underestimate the effects of work-related critical incidents. Relevant online databases were searched for original research published from inception to 2009 and manual searches of the Journal of Traumatic Stress, reference lists, and the European Traumatic Stress Research Database were conducted. Two researchers independently decided on inclusion and study quality. Effect sizes were estimated using standardized mean differences with 95% confidence intervals. Consistency was evaluated, using the I^2-statistic. Meta-analysis was performed using the random effects model. Eleven studies, which included 3866 participants, evaluated the relationship between work-related critical incidents and post-traumatic stress symptoms. Six of these studies, which included 1695 participants, also reported on the relationship between work-related critical incidents and symptoms of anxiety and depression. Heterogeneity among studies was high and could not be accounted for by study quality, character of the incident, or timing of data collection. Pooled effect sizes for the impact of work-related critical incidents on post-traumatic stress symptoms, anxiety, and depression were small to medium. Remarkably, the effect was more pronounced in the longer than in the shorter term. In conclusion, this meta-analysis supports the hypothesis that work-related critical incidents are positively related to post-traumatic stress symptoms, anxiety, and depression in hospital-based health care professionals. Health care workers and their supervisors should be aware of the harmful effects of critical incidents and take preventive measures.

Introduction

Post-traumatic stress symptoms and even full criteria for the diagnosis of post-traumatic stress disorder PTSD (APA, 1994) have been recognized in rescue and ambulance workers (Alexander & Klein, 2001; Jonsson, Segesten, & Mattsson, 2003; Marmar, Weiss, Metzler, Ronfeldt, & Foreman, 1996). Hospital-based physicians and nurses (hereafter called health professionals) in critical care also regularly deal with dying patients, severe injury and threat. After a critical incident, the immediate stress reactions enable health professionals to adequately deal with these situations, but a prolonged stress response could eventually cause health problems (Selye, 1976).

For the present study, a critical incident is defined as: 'a sudden unexpected event that has an emotional impact sufficient to overwhelm the usually effective coping skills of an individual and cause significant psychological stress' (see Caine & Ter-Bagdasarian, 2003, p. 59); this is not necessarily an extreme event (Kleber & Van der Velden, 2003). The subjective nature of critical incidents has been demonstrated before in intensive care nurses; among their most critical incidents were not primarily the extreme events but incidents like the dying of a patient they identified with, or miscommunication

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with serious consequences for patients (De Boer, Van Rikxoort, Bakker, & Smit, submitted for publication).

Normal recovery from critical incidents may take weeks or even months, and in frequent exposure, post-traumatic stress symptoms (intrusions, avoidance, hyper arousal) may accumulate and add to the development of PTSD and its most common co-morbid disorders, anxiety and depression (Michael & Jenkins, 2001; van der Ploeg & Kleber, 2003). Strictly speaking, in the first month after a critical incident, post-traumatic stress symptoms do not allow a PTSD diagnosis. From two days to four weeks after a critical incident, severe post-traumatic stress symptoms refer to acute stress disorder (ASD), that requires at least 3 dissociative symptoms, together with marked avoidance and arousal, whereas the PTSD diagnosis is more strict with regard to the number of avoidance/numbing symptoms (at least 3) and arousal symptoms (at least 2), but requires no dissociative symptoms (APA, 1994, 2011; Bryant, Friedman, Spiegel, Ursano, & Strain, 2010).

Social support and active problem focused coping generally help individuals to handle the traumatic stressor, control the situation, and avoid long-term emotional dysregulation (Alexander & Wells, 1991; Brewin & Holmes, 2003; Olff, Langeland, & Gersons, 2005; Taylor & Frazer, 1982). However, the threatening aspect of the stimulus is maintained in defensive coping, which is often reported after critical incidents, such as withdrawal, or denial (Acker, 1993; Birmes, Hazane, Calahan, Sztulman, & Schmitt, 1999). Though in the short-term defensive coping can be protective against overwhelming emotions, it ultimately has been proven to be ineffective and may prevent normal recovery (Ehlers & Clark, 2000; Gersons & Olff, 2005). In turn, enduring post-traumatic stress responses cause many health professionals to reduce their work hours or even to switch jobs (Laposa & Alden, 2003; Laposa, Alden, & Fullerton, 2003). Additionally, poor and non-empathic behavior toward patients may also originate in traumatic experiences (Jonsson et al., 2003).

Prevalence of post-traumatic stress symptoms among hospital-based health professionals who deal with critical incidents as part of their jobs, has been established in several studies. Among emergency room personnel (predominantly nurses) for example, 12% met full criteria of PTSD, and more than 30% reported post-traumatic stress symptoms, while in 37% the critical incidents caused clinically significant distress or impairment in social, occupational, or other important areas of functioning (Laposa et al., 2003). In a study among emergency room, intensive care, and general floor nurses, however, none of them was in the clinically significant range for PTSD (Kerasiotis & Motta, 2004). In a third study among emergency medicine residents in four different stages of their training, 11.7% met PTSD criteria and 30% had one or more symptoms in all three symptom clusters; in all clusters, the number of symptoms significantly increased with years of experience (Mills & Mills, 2004).

The use of different questionnaires and different control groups may explain part of the varying effects demonstrated. In addition, several situational and personal factors may have contributed to the mental health effects found in previous studies. In an extensive review, three factors consistently contributed to development of PTSD: a psychiatric history, childhood abuse, and a family psychiatric history. Factors like gender, age, and race are related to PTSD in some populations but not in others, while socio-economic status, education, intelligence, previous trauma, childhood adversity, trauma severity, social support, and life stress predict PTSD more consistently across different populations, but to a varying extent. Overall, factors operating during or after the incident, like trauma severity, lack of social support and additional life stress have somewhat stronger effects than pre-trauma factors (Brewin, Andrews, & Valentine, 2000). None of the studies in the latter review, however, comprised mental health effects of potentially traumatizing incidents that are part of health professionals' jobs.

Although many health professionals feel impaired in one or more important areas of functioning, relatively few seek help (Laposa et al., 2003). Hospital administrators as well as health professionals themselves often seem to underestimate the impact of critical incidents on their personal and occupational life. The same phenomenon was observed among medical students with a near 15% rate of moderate to severe depression; possibly partly resulting from work-related critical incidents. Despite seemingly good access to health care, the depressive students hesitated to seek counseling because they feared this would indicate inadequate coping skills. Besides, they thought that if they would seek help others might question their ability to handle responsibilities, disrespect their opinions, and regard them as dangerous to their patients (Schwenk, Davis, & Wimsatt, 2010). These stigmatizing perceptions may be common with respect to post-traumatic stress symptoms in other health professionals as well, and underlie their denial, that seems even stronger than among firefighters and police officers.

Therefore, the objectives of the present meta-analysis are: a) to identify the consistency of the relationship between critical incidents and mental health consequences in hospital-based health professionals by demonstrating the pooled effect on the primary outcome *post-traumatic stress symptoms* and on the secondary outcomes *anxiety* and *depression*, b) to explore varying effects among different groups of health professionals, and c) to explore the relative impact of different kinds of incidents.

Research methods

To identify relevant articles for this review, we began by introducing the following search terms: (1) *health personnel*, *health care provider*, *physician*, *doctor* or *nurse* and (2) *acute stress response, traumatic stress*, *traumatic stress disorder, post-traumatic stress disorder* or *acute stress disorder* in PubMed and PsychINFO. We also manually searched the reference lists from relevant publications, and the Journal of Traumatic Stress (special issues included). Finally, we screened the European Traumatic Stress Research Database for relevant ongoing studies. Inclusion criteria for eligibility were as follows: peer reviewed articles; published from inception to 2009; written in English, French or German; based on original research; and included a clearly defined control group. If more than one study reported on the same data, the paper with the most complete and relevant information was selected. Excluded were studies with military or mental health providers representing the high-risk group and articles that primarily reported on secondary traumatic stress, vicarious trauma, or compassion fatigue.

The review was performed taking guidelines for meta-analyses into account (Berman & Parker, 2002; Stroup, Berlin, Morton, Olkin, Williamson, Rennie et al., 2000). To diminish reporting bias and error in data collection, two independent reviewers used a standardized form (Berman & Parker, 2002) to abstract the data; disagreements were resolved through discussion and consensus. In cases where the available information in the articles was insufficient, additional data were obtained from the principal investigator.

The reported means and standard deviations (SD) were used to express the association between critical incidents and the pre-specified primary outcome (i.e. post-traumatic stress symptoms) and the secondary outcomes (i.e. anxiety and depression).

Because the quality of the studies retrieved can distort results in a meta-analysis, each study chosen for review was assessed by two independent researchers using a standardized form (Berman & Parker, 2002). Studies were rated regarding: quality of information (5 items, e.g. Was the paper published in a peer reviewed

journal?, or Was the purpose of the trial indicated?); information about funding (3 items, e.g. Were the investigators independent of the funding agency?); study design (3 items + 1 adapted item; e.g. Was the design appropriate to the study questions?, or the adapted item Was exposure/non-exposure to the stressor clearly defined?); study outcomes (2 items, e.g. Were the outcomes clearly defined, including the methods of measurement?); study subjects (2 items, e.g. Did the subjects meet the inclusion/exclusion criteria?); control subjects (1 item, i.e. Were the control subjects comparable to the participants?); implementation (2 items, e.g. Were inclusion and exclusion criteria strictly adhered to?); method (1 item, i.e. Were social and psychological scales validated?); statistics (2 items, e.g. Were the analytic methods clearly described and appropriate?); and response (1 item, i.e. Was there a high rate of non-response?). Items from the original form that did not apply to this meta-analysis were eliminated a priori. The topics were evaluated as a percentage of the items that scored positive. Finally, an overall consensus score was calculated for every study.

Heterogeneity among studies was examined, using the I^2-statistic. I^2 is based on Cochran's Q and describes the percentage of total variation across studies that is due to between-study variation rather than chance. Observed heterogeneity initiated further analyses in an attempt to explain the findings. Ideally, there is no heterogeneity at all ($I^2 = 0$). When heterogeneity is high, the analytical approach requires applying a random effects model, which involves the assumption that the effects being estimated in the different studies are not identical. I^2 values of 25%, 50%, and 75% represent low, moderate and high levels of heterogeneity, respectively (Higgins, Thompson, Deeks, & Altman, 2003).

Publication bias was examined with a funnel plot. A funnel plot, in which effect sizes are plotted against participants per study, is used as a visual aid to detect publication bias. A symmetric funnel arises from a well-balanced dataset; an asymmetric plot suggests publication bias (Egger, Davey Smith, Schneider, & Minder, 1997; Light & Pillemer, 1984; Normand, 1999).

Standardized Mean Differences (*SMDs*) (Normand, 1999) with 95% confidence intervals (CI) were calculated for the impact of critical incidents on the outcomes (i.e. post-traumatic stress symptoms, anxiety, and depression) in exposed versus non-exposed health professionals. In addition, sensitivity analysis was performed to gain insight into studies that reported deviating results. Similar to Cohen's *d* (Cohen, 1988), *SMD* values equal to .20 were considered to indicate a small effect, *SMD* values equal to .50 a medium effect, and *SMD* values equal to .80 a large effect.

Results

Search results

In the initial search 1121 titles were identified. Duplicates, book chapters, theses, and results that were clearly irrelevant were eliminated. The remaining 815 titles/abstracts were then examined closely for potential inclusion according to pre-set criteria, which left 88 papers deemed eligible to be subjected to systematic evaluation (Berman & Parker, 2002). Of these, 16 papers were reviews, 19 were letters or editorials, 24 were studies without appropriate control group, two were case reports, seven were opinion based papers, two papers were focused on characteristics of critical events, four were about interventions, one was a theoretical paper, and one article could not be obtained, even after several attempts. Another paper was excluded because additional data could not be obtained from the author. Two studies reported on the same data, so the paper with the most complete and relevant information was selected. Consequently, 10 articles remained from the initial search for meta-analysis. None of the topics of the 16 reviews identified was similar to that of the intended meta-analysis: eight were evaluations of interventions, four were reviews about workplace violence, two were book (chapter) reviews, and two were about patients and not about health professionals.

Fifty-seven titles were identified from the reference lists. Further examination revealed that: 23 of these were duplicates, and 33 did not meet inclusion criteria; consequently, one additional article remained. Finally, 11 studies reporting on the relationship between critical incidents and post-traumatic stress symptoms (Ntotal = 3866; range of N = 92–934; Fig. 1) were considered eligible for inclusion (Chan & Huak, 2004; Chen, Wu, Yang, & Yen, 2005; Kerasiotis & Motta, 2004; Lin et al., 2007; Luce, Firth-Cozens, Midgley, & Burges, 2002; Maunder, Lancee, Balderson, Bennett, Borgundvaag, Evans et al., 2006; McAlonan, Lee, Cheung, Cheung, Tsang, Sham et al., 2007; Mealer, Shelton, Berg, Rothbaum, & Moss, 2007; Styra et al., 2008; Su, Lien, Yang, Su, Wang, Tsai et al., 2007; Weiniger et al., 2006); 6 of these studies (Ntotal = 1695) also reported on the secondary outcomes, anxiety and depression (Chan & Huak, 2004; Chen et al., 2005; Kerasiotis & Motta, 2004; McAlonan et al., 2007; Mealer et al., 2007; Su et al., 2007).

Characteristics of included studies

Two independent researchers assessed all included papers (Berman & Parker, 2002) and together assigned a consensus score on study quality. Overall, the 11 studies scored 98% positive on quality of information, 33% positive on information about funding, 100% positive on study design, 100% positive on study outcomes, 95% positive on study subjects, 100% positive on control subjects, 59% positive on study implementation, 100% positive on method, and 100% positive on statistics. Response rate of subjects in the studies ranged from 26% to 95%. The selected studies were all questionnaire-based. The key elements of the separate studies can be found in Table 1.

In one study (Lin et al., 2007), *SE* was converted by the authors into *SD* (SD = SE × √N). In six other studies (Chan & Huak, 2004; Chen et al., 2005; Kerasiotis & Motta, 2004; Luce et al., 2002; Styra et al., 2008; Su et al., 2007), $M(SD)$ of high-risk participants or low-risk controls that represented equivalent groups with respect to exposure to critical incidents were pooled according to the following formulas (where M_p denotes pooled mean and SD_p denotes pooled standard deviation):

$$M_p = \frac{(N_1 \times M_1) + (N_2 \times M_2)}{(N_1 + N_2)}$$

$$SD_{\mathrm{p}} = \sqrt{\frac{\left(\left(Sd_a^2\right) \times (N_a - 1)\right) + \left(\left(Sd_b^2\right) \times (N_b - 1)\right)}{(N_a + N_b - 2)}}$$

In one study (Su et al., 2007) mean age was significantly lower in the neurology subgroup than in the other three subgroups (SARS unit, SARS ICU and CCU; $p < .05$; 2-tailed). In another study (Chen et al., 2005) the mean age in the high-risk group was higher than in the control group ($p < .05$; 2-tailed); in a third paper (McAlonan et al., 2007) more participants than controls were in a lower age group ($p < .001$; 2-tailed). In two studies (Chan & Huak, 2004; Kerasiotis & Motta, 2004) the mean age marginally differed between the participants and the control group; however, this difference was not tested for significance. Age was evenly distributed among groups in the remaining six studies (Kerasiotis & Motta, 2004; Lin et al., 2007; Maunder et al., 2006; Mealer et al., 2007; Styra et al., 2008; Weiniger et al., 2006).

With respect to gender, no significant differences between high-risk groups and control groups were reported, although gender was

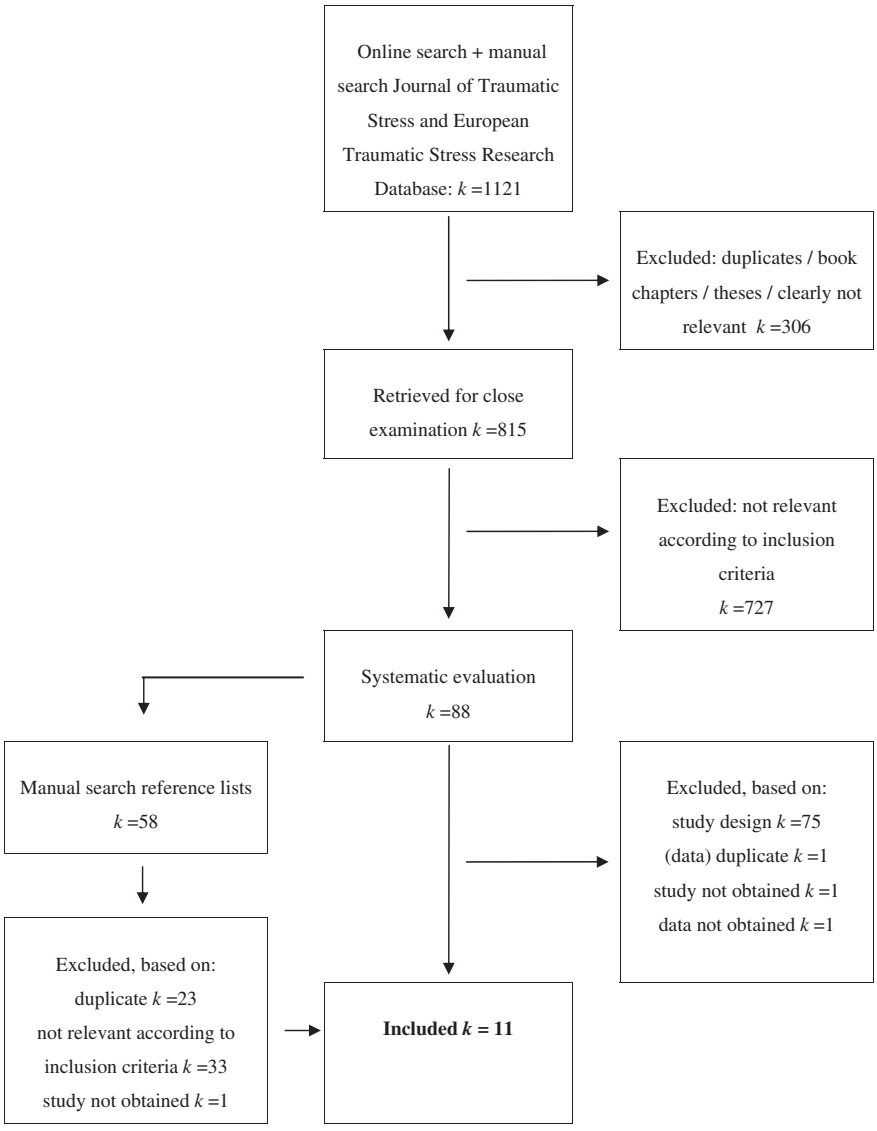

Fig. 1. Flow diagram of search strategy and study selection.

only given for participants and controls together in one study (Kerasiotis & Motta, 2004) and was not reported in another (Chan & Huak, 2004).

In seven papers (Chan & Huak, 2004; Chen et al., 2005; Lin et al., 2007; Maunder et al., 2006; McAlonan et al., 2007; Styra et al., 2008; Su et al., 2007) the critical incident comprised 'treating SARS patients'. The control groups in six of these studies consisted of health professionals who did not have direct contact with SARS patients (e.g. from units such as neurology, oncology, critical care, general medicine). In one study (Lin et al., 2007) the control group consisted of psychiatric ward nurses and physicians. Two papers (Luce et al., 2002; Weiniger et al., 2006) concerned treating victims of terror; the control groups in both of these studies consisted of health professionals from other units without involvement with the victims. The remaining two studies (Kerasiotis & Motta, 2004; Mealer et al., 2007) were about the influence of treating patients in critical care units; in both, the control groups were composed of general floor nurses.

The time since the incident varied considerably between studies. Some researchers gathered data when the stressor was still ongoing (Chan & Huak, 2004; Chen et al., 2005; Kerasiotis & Motta, 2004; Mealer et al., 2007; Styra et al., 2008; Su et al., 2007; Weiniger et al., 2006), while others collected data up to 26 months after exposure (Lin et al., 2007; Luce et al., 2002; Maunder et al., 2006; McAlonan et al., 2007).

Six different validated questionnaires were used to measure post-traumatic stress symptoms; four were based on three PTSD symptom clusters, one on two PTSD symptom clusters (APA, 1994), and one was a shortened 10-question inventory.

Usually, questionnaires evaluating post-traumatic stress symptoms aim at a specific event or a set of events. In some studies this was explicitly stated: e.g. the Omagh bombing (Luce et al., 2002), changes since SARS (Maunder et al., 2006), and exposure to victims of terror at work (Weiniger et al., 2006). In another study, nurses were told that 'the purpose of the study was to gain knowledge about the impact of the critical care environment on the nursing population' (Mealer et al., 2007, p. 696). None of these four studies mentioned that the incident (one should refer to when completing the questionnaire) was another event for the control group than for the intervention group. In the rest of the studies it was not explicitly stated that the questionnaire should be completed with a specific incident in mind (Chan & Huak, 2004; Chen et al., 2005; Kerasiotis & Motta, 2004; Lin et al., 2007; McAlonan, Lee, Cheung, Cheung,

Table 1
Characteristics of the studies included in the Meta-Analysis of work-related critical incidents and post-traumatic stress symptoms, anxiety, and depression.

Study	Year	Study quality	Incident	Location	Participants		Controls		Time since incident	Outcomes	Sample size	
					Age	Gender	Age	Gender			HR[a]	LR[b]
Luce	2002	79%	Treating victims of a bomb attack	Omagh	HPs[c] purely professional + professional/personal involvement Overall: association between age and PTSD = NS Overall: association between gender and PTSD = NS		HPs without involvement		4 months after incident	Post-traumatic stress symptoms (p-tss)[i]	406	528
Chan	2004	81%	Treating SARS[d] patients	Singapore	Nurses and doctors with direct contact with SARS[d] patients <25 = 16(15%) 25–30 = 37(35%) 31–40 = 28(26%) 41–50 = 12(11%) >50 = 13(12%)	Gender: NR[e]	Nurses and doctors without contact with SARS patients <25 = 97(17%) 25–30 = 184(33%) 31–40 = 151(27%) 41–50 = 82(15%) >50 = 38(7%)	Gender: NR	2 months after the first case	p-tss[j] anxiety[o] depression[u]	106	555
Kerasiotis	2004	73%	Treating patients in critical care units	New York	ICU[f] + ED[g] nurses *M* = 38.1 *SD* = 7.3 Overall: 89% female		General floor nurses *M* = 37.8 *SD* = 10.8		Cross-sectional	p-tss[k] anxiety[p] depression[v]	30	96
Chen	2005	85%	Treating SARS patients	Taiwan	Nurses in SARS units (partly involuntary conscribed to) *M* = 26.9 *SD* = 3.5	100% Female	Nurses in 'low-risk for SARS' units *M* = 25.7 *SD* = 2.2	100% Female	Peak SARS	p-tss[j] anxiety[q] depression[w]	86	42
Maunder	2006	87%	Treating SARS patients	Toronto/Hamilton	HPs from SARS units (ICU + isolation + ED) *M* = 42.2 *SD* = 10.2	86% Female	HPs from non-SARS hospital *M* = 41.9 *SD* = 9.6	90% Female	13–26 months after the outbreak	p-tss[j]	538	168
Weiniger	2006	93%	Treating victims of terror	Jerusalem	Physicians treating victims (mainly surgeons) *M* = 42.2 *SD* = 10.0	16% Female	Physicians not treating victims (general medicine) *M* = 39.4 *SD* = 10.1	25% Female	After a 5 month period of exposure	p-tss[i]	94	99
Lin	2007	70%	Treating SARS patients	Taiwan	ED nurses and physicians *M* = 33.5 *SD* = 6.9	92% Female	Psychiatric ward nurses and physicians *M* = 34.5 *SD* = 5.4	89% Female	1 month after the end of the outbreak	p-tss[l]	66	26
McAlonan	2007	88%	Treating SARS patients	Hong Kong	HPs (mainly physicians and nurses) from SARS respiratory medicine units <30 *y* = NR 30–40 *y* = 41% 41–50 *y* = 18% >50 *y*= NR	66% Female	HPs (mainly physicians and nurses) from other units <30 *y* = NR 30–40 *y* = 31% 41–50 *y* = 37% >50 *y*= NR	63% Female	1 year after the outbreak	p-tss[j] anxiety[r] depression[x]	71	113
Mealer	2007	90%	Treating patients in critical care units	Atlanta	Critical Care Nurses *M* = 40.0 *SD* = 9.7	88% Female	General medicine + surgical nurses *M* = 37.7 *SD* = 10.4	92% Female	Cross-sectional	p-tss[m] anxiety[s] depression[y]	371	121

Su	2007	91%	Treating SARS patients	Taiwan	Nurses in SARS unit + SARS ICU $M = 30.4$ $SD = 7.1$	100% Female	Nurses in non-SARS units (Neurology + CCU[h]) $M = 28.9$ $SD = 3.6$	100% Female	0–3 + 4–7 weeks after the second peak	p-tss[l] anxiety[t] depression[v]	70	32
Styra	2008	79%	Treating SARS patients	Toronto	HPs (mainly nurses) in SARS unit + SARS ICU + SARS ED $M = 37.6$ $SD = 8.8$	84% Female	HPs (mainly nurses) from non-SARS units $M = 35.7$ $SD = 9.2$	89% Female	3 months after the first case	p-tss[n]	160	88
N-total											2060	1802

Post-traumatic stress symptoms (p-tss). Anxiety. Depression.

[a] HR = High-risk.
[b] LR = Low-risk.
[c] HPs = Health Professionals.
[d] SARS = Severe Acute Respiratory Syndrome.
[e] NR = Not Reported.
[f] ICU = Intensive Care Unit.
[g] ED = Emergency Department.
[h] CCU = Coronary Care Unit.
[i] PTSD Symptom Scale.
[j] Impact of Event Scale.
[k] PTSD Symptom Scale/modified.
[l] Davidson Trauma Scale.
[m] PTSD 10-question Survey.
[n] Impact of Event Scale-Revised.
[o] General Health Questionnaire/anxiety scale.
[p] Beck's Anxiety Inventory.
[q] Symptom Check List-90/anxiety scale.
[r] Depression Anxiety Stress Scales-21/anxiety scale.
[s] Hospital Anxiety and Depression Scale/anxiety scale.
[t] State Trait Anxiety Inventory.
[u] General Health Questionnaire/depression scale.
[v] Beck's Depression Inventory.
[w] Symptom Check List-90/depression scale.
[x] Depression Anxiety Stress Scales-21/depression scale.
[y] Hospital Anxiety and Depression Scale/depression scale.

Tsang, Sham et al., 2007; Styra et al., 2008; Su, Lien, Yang, Su, Wang, Tsai et al., 2007).

To measure anxiety and depression, six and five different validated questionnaires were used, respectively. The anxiety and depression scales are not explicitly directed to a certain incident (an overview of all questionnaires is given below Table 1).

Statistical heterogeneity

Heterogeneity was high ($I^2 = 82\%$) among the eleven studies that examined the association between critical incidents and post-traumatic stress symptoms (Chan & Huak, 2004; Chen et al., 2005; Kerasiotis & Motta, 2004; Lin et al., 2007; Luce et al., 2002; Maunder et al., 2006; McAlonan et al., 2007; Mealer et al., 2007; Styra et al., 2008; Su et al., 2007; Weiniger et al., 2006), as well as among the six studies that examined the association between critical incidents and anxiety ($I^2 = 84\%$) and depression ($I^2 = 83\%$) (Chan & Huak, 2004; Chen et al., 2005; Kerasiotis & Motta, 2004; McAlonan et al., 2007; Mealer et al., 2007; Su et al., 2007). As a result of considerable heterogeneity for all outcome variables, the random effects procedure was followed.

When, in subgroup analysis, the two relatively lower quality studies (score $< 75\%$) (Kerasiotis & Motta, 2004; Lin et al., 2007) were eliminated, heterogeneity remained high ($I^2 = 82\%$, $I^2 = 86\%$, and $I^2 = 83\%$) among the remaining high quality studies that examined the association of critical incidents and post-traumatic stress symptoms (Chan & Huak, 2004; Chen et al., 2005; Luce et al., 2002; Maunder et al., 2006; McAlonan et al., 2007; Mealer et al., 2007; Styra et al., 2008; Su et al., 2007; Weiniger et al., 2006), anxiety (Chan & Huak, 2004; Chen et al., 2005; McAlonan et al., 2007; Mealer et al., 2007; Su et al., 2007), and depression, respectively (Chan & Huak, 2004; Chen et al., 2005; McAlonan et al., 2007; Mealer et al., 2007; Su et al., 2007). Heterogeneity also remained high ($I^2 = 80$) among the two lower quality studies that examined post-traumatic stress symptoms. Only one lower quality study reported on anxiety and depression.

When the character of the critical incident was considered, among the seven studies that examined the association between 'treating SARS patients' and post-traumatic stress symptoms (Chan & Huak, 2004; Chen et al., 2005; Lin et al., 2007; Maunder et al., 2006; McAlonan et al., 2007; Styra et al., 2008; Su et al., 2007), heterogeneity was between moderate and high ($I^2 = 63\%$); among the four studies that reported on the association between 'treating SARS patients' and anxiety or depression (Chan & Huak, 2004; Chen et al., 2005; McAlonan et al., 2007; Su et al., 2007), heterogeneity was high ($I^2 = 82\%$, and $I^2 = 84\%$, respectively). Heterogeneity was also high ($I^2 = 92\%$) among the remaining studies reporting the association between 'treating victims of terror or patients in critical care units' and post-traumatic stress symptoms (Kerasiotis & Motta, 2004; Luce et al., 2002; Mealer et al., 2007; Weiniger et al., 2006). Among the studies reporting the association with anxiety (Kerasiotis & Motta, 2004; Mealer et al., 2007), heterogeneity was absent ($I^2 = 0\%$). Finally, heterogeneity was moderate to high ($I^2 = 61\%$) among the studies reporting on the association of critical incidents with depression (Kerasiotis & Motta, 2004; Mealer et al., 2007).

When the timing of data collection was taken into account, two groups were distinguished: studies collecting data in the first 4 weeks after the critical incident (Chan & Huak, 2004; Chen et al., 2005; Kerasiotis & Motta, 2004; Mealer et al., 2007; Styra et al., 2008; Su et al., 2007; Weiniger et al., 2006) and studies collecting data from 4 weeks to 26 months after the incident (Lin et al., 2007; Luce et al., 2002; Maunder et al., 2006; McAlonan et al., 2007). Because the SARS period (which continued for about 4 months) was ongoing at the time of data collection, three studies that collected data up to 3 months after the first case of SARS (Chan & Huak, 2004; Styra et al., 2008; Su et al., 2007) were assigned to the first group though. Among the seven studies reporting on post-traumatic stress symptoms in the first 4 weeks after the critical incident (Chan & Huak, 2004; Chen et al., 2005; Kerasiotis & Motta, 2004; Mealer et al., 2007; Styra et al., 2008; Su et al., 2007; Weiniger et al., 2006) heterogeneity was considered moderate to high ($I^2 = 68\%$), among the five studies on anxiety levels (Chan & Huak, 2004; Chen et al., 2005; Kerasiotis & Motta, 2004; Lin et al., 2007; Su et al., 2007) heterogeneity was moderate ($I^2 = 45\%$), and among the five studies on depression levels (Chan & Huak, 2004; Chen et al., 2005; Kerasiotis & Motta, 2004; Lin et al., 2007; Su et al., 2007), heterogeneity was moderate to high ($I^2 = 63\%$). Heterogeneity was high ($I^2 = 75\%$) among the studies reporting data from 4 weeks to 26 months after the incident on post-traumatic stress symptoms (Lin et al., 2007; Luce et al., 2002; Maunder et al., 2006; McAlonan et al., 2007). Only one study in this subgroup reported on the effect of critical incidents on anxiety and depression.

Meta-analysis of effect size

Effect sizes in the primary studies (reported as standardized mean difference [SMD] in this manuscript) ranged from −.26 to .68 for the effect of critical incidents on post-traumatic stress symptoms. For the separate study with the smallest effect size (−.26) this means for instance that the mean scores (standard deviations) on the PTSD Symptom Scale-Revised were 14.11 (14.57) and 18.63 (23.53) for the intervention group and the control group respectively, a mean difference of −4.52 points. For the largest effect found (effect size .68 on the PTSD Symptom Scale), the mean scores (standard deviations) were 10.40 (9.13) and 5.06 (6.80) respectively, a mean difference of +5.34 points.

Effect sizes in the primary studies ranged from −.24 to .85 for the effect of critical incidents on anxiety. The mean differences in the separate studies with the smallest and largest effect size were −1.71 points (on Beck Anxiety Inventory) and +2.80 points (on the Depression Anxiety Stress Scales-21) respectively.

Effect sizes in the primary studies ranged from −.36 to .75 for the effect of critical incidents on depression. The mean differences in the separate studies with the smallest and largest effect size were −2.70 points (on Beck Depression Inventory) and +2,20 points (on the Depression Anxiety Stress Scales-21) respectively.

Standardized mean difference for the pooled association of critical incidents and post-traumatic stress symptoms was considered small to medium (.32). SMD was considered small for the association of critical incidents and anxiety (.19) as well as for the association of critical incidents and depression (.20) (Normand, 1999).

In the studies that scored ≥75% on study quality (Chan & Huak, 2004; Chen et al., 2005; Luce et al., 2002; Maunder et al., 2006; McAlonan et al., 2007; Mealer et al., 2007; Styra et al., 2008; Su et al., 2007; Weiniger et al., 2006), SMDs for the association of critical incidents and post-traumatic stress symptoms, anxiety, and depression were considered small to medium for all three outcomes (.36, .27, and .29, respectively).

SMD that was .32 for all studies that reported on the association of critical incidents and post-traumatic stress symptoms was only .08 for the two lower quality studies (Kerasiotis & Motta, 2004; Lin et al., 2007). Only one study in this subgroup reported on the effect of critical incidents on anxiety and depression.

SMDs in the subgroup of studies that examined the association between *treating SARS patients* and post-traumatic stress symptoms, anxiety, and depression were between small and medium (.37, .38, and .37, respectively). In the remaining studies on the association of *treating victims of terror and patients in critical care units* and the three outcomes, SMD was small for post-traumatic stress symptoms (.19) and appeared to have even a small negative effect for anxiety

and depression (−.13, and −.14, respectively); it can be questioned however whether general floor nurses were a representative 'low-risk' control group (Kerasiotis & Motta, 2004).

In the subgroup of studies collecting data in the first 4 weeks after the critical incident (Chan & Huak, 2004; Chen et al., 2005; Kerasiotis & Motta, 2004; Mealer et al., 2007; Styra et al., 2008; Su et al., 2007; Weiniger et al., 2006) SMDs were considered small for post-traumatic stress symptoms (.20) and very small for anxiety and depression (.04, and .07, respectively). In the studies collecting data between 4 weeks and 26 months after the incident (Lin et al., 2007; Luce et al., 2002; Maunder et al., 2006; McAlonan et al., 2007) the magnitude of the SMD for post-traumatic stress symptoms was medium (.52). Only one study in this subgroup reported on the effect of critical incidents on anxiety and depression.

Discussion and conclusion

This meta-analysis demonstrates that critical incidents are positively related to post-traumatic stress symptoms, anxiety, and depression in hospital-based health professionals (Fig. 2). The studies included were relatively recent, all having been published between 2002 and 2009. A plausible explanation for this finding is that earlier research focused on the relationship between chronic stressors and burnout (Bakker, Schaufeli, Sixma, Bosveld, & Van Dierendonck, 2000); researchers only recently began to investigate the impact of critical incidents on post-traumatic stress symptoms (Kleber & Van der Velden, 2003).

Pooled results for post-traumatic stress symptoms were consistent with ten out of the eleven primary studies investigated. These ten studies reported on the effects of treating SARS patients, treating victims of terror, or treating patients in critical care units with high morbidity and mortality. The outcomes reported for post-traumatic stress symptoms are consistent with effects reported in ambulance and emergency workers (Alexander & Klein, 2001; Jonsson et al., 2003; Marmar et al., 1996). For example: in an empirical study on ambulance workers (Alexander & Klein, 2001), means (and SD) on the Impact of Event Scale was 15.5 (15.7) after a work-related disturbing incident, compared to 19.8 (13.4) in a study among nurses who treated SARS patients (Chen

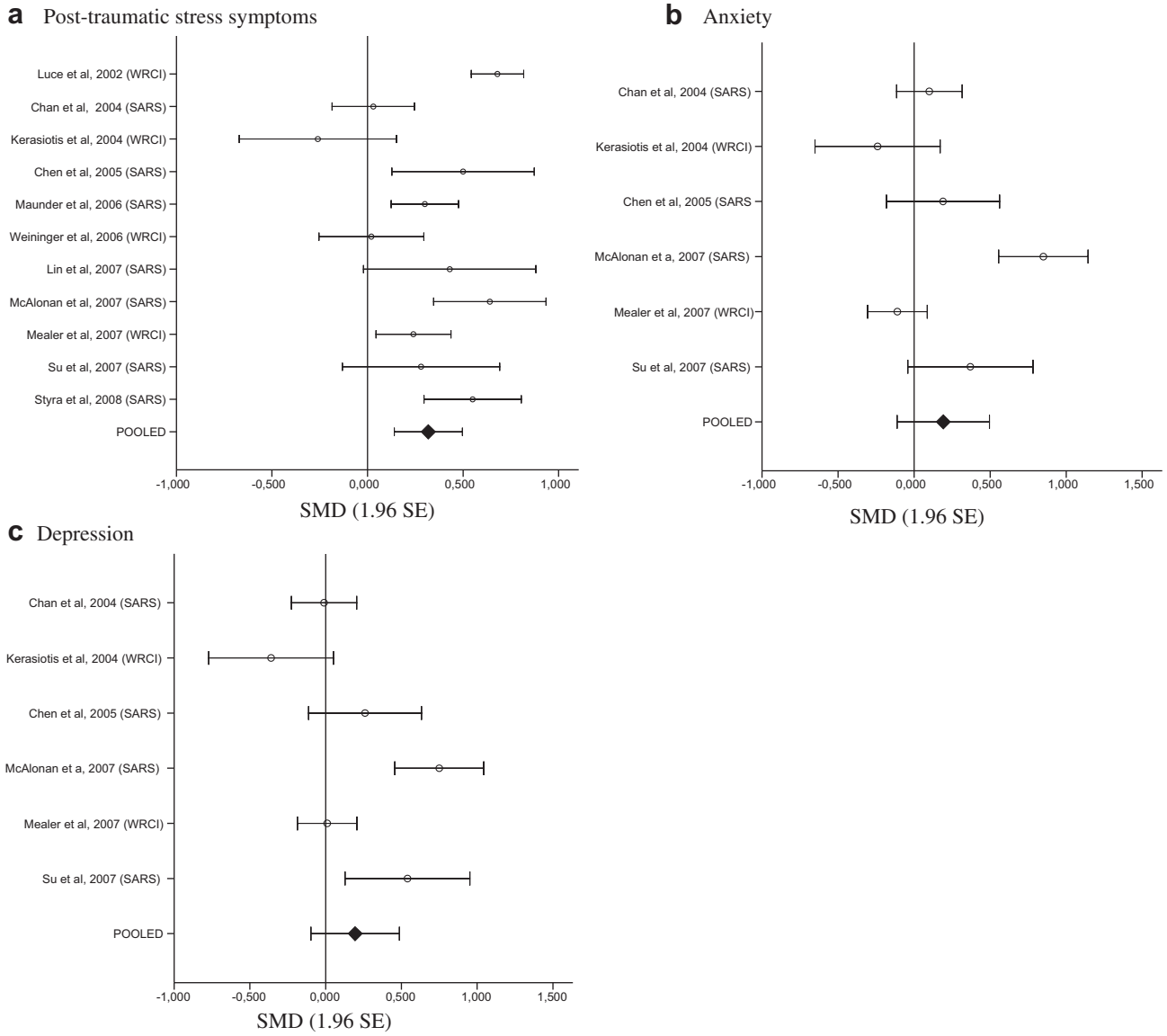

Fig. 2. a–c Effect size, in terms of standardized mean differences (*SMDs*) with 95% Confidence Intervals, of work-related critical incidents on post-traumatic stress symptoms ($k = 11$), anxiety ($k = 6$), and depression ($k = 6$), as well as the pooled effect on the three outcomes.

et al., 2005). One study on the effect of critical incidents (Kerasiotis & Motta, 2004) had inconsistent results (*SMD* = −.26). In this study however, the observed negative effect implies that critical incidents not only have an impact on critical care nurses, pooled for intensive care unit and emergency department, but also on the control group comprising general floor nurses, and that the impact on general floor nurses may even be larger. Comparison of the three separate groups showed that both emergency and general floor nurses had higher scores than intensive care nurses, although this difference was not significant. We hypothesize that working in a highly structured ward and being well trained and prepared, as intensive care nurses are, may reduce the impact of critical incidents. In general medicine however, these incidents are less common, and thus relatively unexpected and potentially more influential. Uncommonness of critical incidents does not explain any difference between intensive care and emergency nurses, but unexpectedness may also play a more prominent role in the emergency nurses. However, in the other study comparing intensive care nurses and general medical/surgical nurses (Mealer et al., 2007) being an intensive care nurse was the only variable that remained significantly associated with post-traumatic stress symptoms after controlling for confounding variables.

Of the six primary studies reporting on the effects of SARS, four were consistent with the pooled results reported for anxiety. The remaining two studies (Kerasiotis & Motta, 2004; Mealer et al., 2007), which both investigated critical incidents in general, demonstrated higher outcome scores in the control groups (general floor nurses) than in the participant groups (intensive care and emergency nurses). However, these differences were non-significant in one study (Mealer et al., 2007) and all three groups had markedly elevated anxiety scores in the other (Kerasiotis & Motta, 2004). Nevertheless, both general floor nurses and emergency nurses had significantly higher anxiety scores than intensive care nurses in this last study.

Pooled results for depression were consistent with four out of the six primary studies. The study of Chan and colleagues (Chan & Huak, 2004) on treating SARS patients had inconsistent result (*SMD* = −.01), as did the study of Kerasiotis and Motta (2004) on critical incidents in general (*SMD* = −.36). In the latter study, all nurses had elevated depression scores, but both general floor nurses and emergency nurses had significantly higher scores for depression than intensive care nurses. Hence, in critical care nurses the effect of critical incidents in general on anxiety and depression is not unambiguous and needs further study. Overall, the mental health effects of treating SARS patients are fairly straightforward. The somewhat ambiguous effects of more regular critical incidents however were confounded by the control group chosen, which appeared not to be 'low-risk' at all. The impact of critical incidents on general floor nurses may be at least as big as on emergency and intensive care nurses. In addition, effect sizes could also have been influenced by the questionnaires used; in SARS studies the Davidson Trauma Scale and the Impact of Event Scale (15 and 22 item versions) were used; in the other four studies the PTSD Symptom Scale (modified) and the PTSD 10-Question Survey were used.

Subgroup analysis of the two papers that scored <75% on study quality (Kerasiotis & Motta, 2004; Lin et al., 2007) demonstrated that *SMD* for the association of critical incidents and post-traumatic stress symptoms that was .32 for all 11 studies, was only .08 for these 2 studies. This effect, however, may be largely explained by the inverse relationship mentioned before in the study of Kerasiotis and Motta (Kerasiotis & Motta, 2004) rather than by study quality.

When the character of the incident is considered, *SMD*s are .37, .38, and .37 in the studies on the association between treating SARS patients and post-traumatic stress symptoms, anxiety, and depression, respectively. In the remaining studies on the association of treating victims of terror or patients in critical care units, *SMD*s were remarkably lower for post-traumatic stress symptoms (.19) and even negative for anxiety and depression (−.13 and −.14, respectively). One reason for the larger impact of treating SARS patients may be that, because much about the disease was unknown, health professionals initially were insufficiently equipped to treat these patients. Another explanation may be that the threat of SARS was not restricted to patients, but also involved colleagues, health professionals themselves, and even their family members. Luce et al. (2002) demonstrated that people who were only professionally involved with victims of a bomb attack had much lower scores on the PTSD Symptom Scale than those with both professional and civilian involvement at the same time. These results are consistent with the idea that professionals are resilient to critical incidents to a certain extent. However, personalization and identification with patients or their family members may change their evaluation and thereby change the impact of the concerning incident (De Boer et al., submitted for publication).

Timing of data collection did influence the effect of critical incidents on post-traumatic stress symptoms. This influence was small in the first 4 weeks after the incident (*SMD* = .20) (Chan & Huak, 2004; Chen et al., 2005; Kerasiotis & Motta, 2004; Mealer et al., 2007; Styra et al., 2008; Su et al., 2007; Weiniger et al., 2006), compared to medium (*SMD* = .52) in the period ranging from 4 weeks to 26 months after the incident (Lin et al., 2007; Luce et al., 2002; Maunder et al., 2006; McAlonan et al., 2007). This is remarkable, as short-term effects after critical incidents are often larger than longer-term effects (Bonanno, 2004); also without treatment, most people spontaneously recover over time (Sijbrandij et al., 2007). The cumulative effect of regular exposure to critical incidents possibly contributes to this higher longer-term effect (Michael & Jenkins, 2001; van der Ploeg & Kleber, 8/2003). An alternative explanation may be that health professionals in the control groups of short-term SARS studies (four of the seven short-term studies) did not treat SARS patients but nevertheless believed that living in a SARS-affected area was very risky. This would reduce the difference between these intervention and control groups. In the long-term studies, health professionals in the control groups of SARS studies (three of four long-term studies) are more likely to be confident that they had been at low-risk during the outbreak.

Some limitations of this review must be considered. The results are predominantly based on cross-sectional, questionnaire-based studies using different instruments, which could explain partly the high heterogeneity observed. Response rates ranged from 26% to 95%, which may have induced selection bias. However, because the response is expected to be lower among people with more post-traumatic stress symptoms, it is unlikely that the observed response rates would invalidate the demonstrated effects.

Factors like (family) psychiatric history, or childhood abuse may mediate the relationship between critical incidents and PTSD (Brewin et al., 2000). Because pre-exposure levels of distress were measured only in some of the included studies, bias may have emerged. Health professionals' experience and training level can be important in this respect as well. In a study among emergency medical residents, post-traumatic symptoms increased with years of training/exposure (Mills & Mills, 2004), while relatively untrained general floor nurses had more post-traumatic stress symptoms than intensive care and emergency nurses (Kerasiotis & Motta, 2004). The latter result can be compared with findings from the burnout literature, where the incidence of burnout in physicians decreased with age (Peisah, Latif, Wilhelm, & Williams, 2009). This may be due to training and/or professional experience, but may also be a 'survivor' effect; those who had more problems may have left before reaching seniority. In future studies, the influence of these possible mediators in the relationship between critical

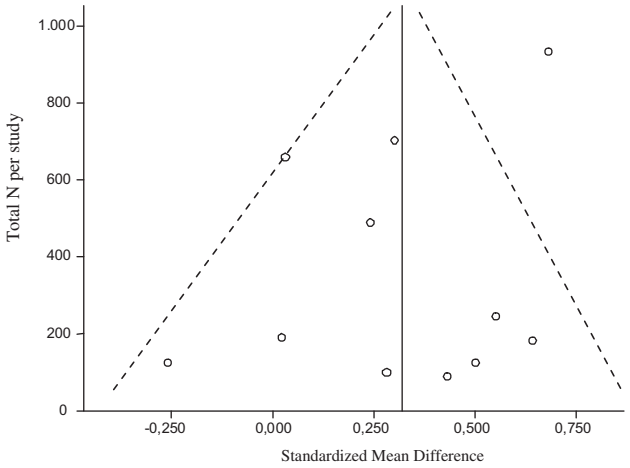

Fig. 3. Funnel plot with total *N*/study on the *y*-axis, effect size for PTSD on the *x*-axis and an indicator line for the pooled Standardized Mean Difference.

incidents and post-traumatic stress symptoms in hospital-based health professionals should be established (Fig. 3).

The notably asymmetric shape of the funnel plot suggests publication bias, in that unpublished manuscripts are unexpectedly located in the right upper part of the funnel plot. However, given the effect size of the hypothetically unpublished studies, this would not lead to overestimation of the true effect size; a spurious relationship is therefore not plausible.

For clinical practice, the findings of this meta-analysis indicate that health professionals and their supervisors should be aware of the harmful effects of critical incidents that could cause impairment in social, occupational, or other important areas of functioning. This in turn may be reason to reduce work hours or to switch jobs (Laposa & Alden, 2003; Laposa et al., 2003), and cause poor behavior toward patients (Jonsson et al., 2003). The effects are not only evident among emergency and intensive care personnel, but also among staff of seemingly 'lower-stress' departments, who are often less prepared, which may increase the distress experienced. Preventive measures to be taken by supervisors are to acknowledge the need for support and establish a climate that allows workers to express their feelings and health concerns. In addition health professionals' need for support must be sufficiently met by promoting peer support, which has been demonstrated to be valued above support by supervisors (Ørner, 2003).

The present results are likely to generalize to the Western and Asian countries, as the studies included comprise participants from Europe (UK), Canada, the USA, Taiwan, China (Hong Kong), Singapore, and Israel. Generalizability however to other parts of the world, like sub-Saharan Africa, is questionable. One could infer however, that health professionals in these countries are more vulnerable, because living there is relatively dangerous due to high rates of sexual abuse, war, and terrorist threat. In addition, 'man-made' incidents may have higher impact than natural disasters. In a review, prevalence of PTSD after terrorist attacks for example, was estimated to be approximately 28% (Gidron, 2002). Awareness of the consequences of working and living in an 'unsafe' environment and taking preventive measures seems necessary in African countries as well.

Some questions remain to be addressed in future research with proper control groups and longitudinal designs. Firstly, the relative impact of different kinds of incidents needs further research. It seems that treating SARS patients has more impact than other incidents. Effects of rare incidents however are less likely to accumulate than frequently occurring critical incidents. In addition, the smaller effect found for 'frequently occurring incident in the critical care environment' was not in line with the effect found in one study with a control group of general floor nurses who had even higher scores than intensive care and emergency nurses (Kerasiotis & Motta, 2004). Secondly, the varying effects on different health professionals must be further explored. In one study among physicians, effect size for post-traumatic stress symptoms was almost absent (.02) (Weiniger et al., 2006). In another study the frequency of 'scores >30' on the Impact of Event Scale (indicating PTSD) was almost equal between nurses and physicians (19.4% and 18.8% respectively; $p = 1.00$) (Chan & Huak, 2004). Between nurses and different 'other workers', median scores on the Impact of Event Scale did not differ in one study ($p = .16$) (Maunder et al., 2006), but differed significantly among (eight) groups in another study (scores on PTSD Symptom Scale; $p < .01$) (Luce et al., 2002). Thirdly, the relationship of critical incidents with anxiety and depression did not hold in subgroup analysis, and thus requires additional research with subgroups that are large enough to allow firm statistical inferences. Finally, the influence of possible mediators in the relationship between critical incidents and post-traumatic stress symptoms/PTSD in health professionals should be established by including pre-exposure symptom levels, as well as variables that may increase vulnerability like psychiatric (family) history, previous trauma, social support, and additional life stress (Brewin et al., 2000).

In conclusion, a positive relationship between critical incidents and post-traumatic stress symptoms in health care professionals has been demonstrated in this meta-analysis. The overall positive relationship with anxiety and depression does not hold in subgroup analysis; treating SARS patients was even more strongly related to anxiety and depression, but the positive relationship between treating victims of terror or patients in critical care units and anxiety and depression no longer existed. Health professionals and their supervisors should be aware of the harmful long-term effects of critical incidents and take preventive measures.

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