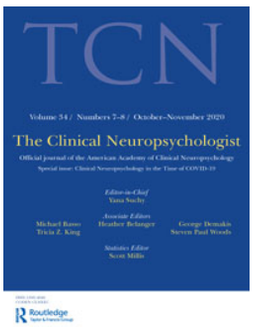

The Clinical Neuropsychologist

ISSN: 1385-4046 (Print) 1744-4144 (Online) Journal homepage: https://www.tandfonline.com/loi/ntcn20

Post-traumatic stress disorder: A differential diagnostic consideration for COVID-19 survivors

Erin T. Kaseda & Andrew J. Levine

To cite this article: Erin T. Kaseda & Andrew J. Levine (2020) Post-traumatic stress disorder: A differential diagnostic consideration for COVID-19 survivors, The Clinical Neuropsychologist, 34:7-8, 1498-1514, DOI: 10.1080/13854046.2020.1811894

To link to this article: https://doi.org/10.1080/13854046.2020.1811894

Published online: 26 Aug 2020.

THE CLINICAL NEUROPSYCHOLOGIST
2020, VOL. 34, NOS. 7–8, 1498–1514
https://doi.org/10.1080/13854046.2020.1811894

Routledge
Taylor & Francis Group

Post-traumatic stress disorder: A differential diagnostic consideration for COVID-19 survivors

Erin T. Kaseda[a] and Andrew J. Levine[b]

[a]Department of Psychology, Rosalind Franklin University of Medicine and Science, North Chicago, IL, USA; [b]Department of Neurology, David Geffen School of Medicine, University of California, Los Angeles, Los Angeles, CA, USA

ABSTRACT

Objective: SARS-CoV-2 infection and its oft-associated illness COVID-19 may lead to neuropsychological deficits, either through direct mechanisms (i.e., neurovirulance) or indirect mechanisms, most notably complications caused by the virus (e.g., stroke) or medical procedures (e.g., intubation). The history of past human coronavirus outbreaks resulting in similar health emergencies suggests there will be a substantial prevalence of post-traumatic stress disorder (PTSD) among COVID-19 survivors. To prepare neuropsychologists for the difficult task of differentiating PTSD-related from neuropathology-related deficits in the oncoming wave of COVID-19 survivors, we integrate research across a spectrum of related areas.

Methods: Several areas of literature were reviewed: psychiatric, neurologic, and neuropathological outcomes of SARS and MERS patients; neurological outcomes in COVID-19 survivors; PTSD associated with procedures common to COVID-19 patients; and differentiating neuropsychological deficits due to PTSD from those due to acquired brain injuries in other patient groups.

Conclusions: Heightened risk of PTSD occurred in MERS and SARS survivors. While data concerning COVID-19 is lacking, PTSD is known to occur in patient groups who undergo similar hospital courses, including ICU survivors, patients who are intubated and mechanically ventilated, and those that experience delirium. Research with patients who develop PTSD in the context of mild traumatic brain injury further suggests that PTSD may account for some or all of a patient's subjective cognitive complaints and neuropsychological test performance. Recommendations are provided for assessing PTSD in the context of COVID-19.

ARTICLE HISTORY
Received 4 June 2020
Accepted 13 August 2020
Published online 27 August 2020

KEYWORDS
COVID-19; medical trauma; PTSD differential diagnoses

Introduction

Infection with severe acute respiratory syndrome due to coronavirus-2 (SARS-CoV-2) leads to coronavirus disease – 2019 (COVID-19) in an unknown percentage of individuals. Considering the ever-growing reports of neurologic complications due to

CONTACT Erin T. Kaseda erin.kaseda@my.rfums.org Department of Psychology, Rosalind Franklin University of Medicine and Science, 3333 Green Bay Road, North Chicago, IL 60064, USA

COVID-19, neuropsychologists can expect a substantial number of survivors to present for neuropsychological evaluation in coming months and years. Such evaluations will likely involve questions of disability and be driven by patients' reports of subjective impairment. While early evidence from COVID-19 case series studies suggests that these survivors may present with a variety of neurocognitive deficits stemming from serious neurologic conditions related to the illness or its treatment, including large vessel stroke, hypoxic brain injury, encephalopathies, encephalitis, acute disseminated encephalomyelitis, and others (Ashrafi et al., 2020; Fan et al., 2020; Paterson et al., 2020), the ability to discern true (objective) from subjective deficits is likely to be complicated by psychiatric comorbidities. Indeed, research from past coronavirus outbreaks, including severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS), indicate a high likelihood of psychiatric symptoms and disorders in COVID-19 survivors, most notably post-traumatic stress symptoms (PTSS) and post-traumatic stress disorder (PTSD) (Jeong et al., 2016; Lee et al., 2007, 2019; Mak et al., 2009, 2010; Wu et al., 2005). Evidence of the neuropsychological impact of COVID-19 is just beginning to emerge and a full understanding of the long-term side effects of the disease and its treatment may take years to catalogue. Still, as neuropsychologists prepare to evaluate COVID-19 survivors, a discussion of the neurocognitive and psychiatric sequelae of past human coronaviruses, as well as the frequent co-occurrence PTSD and acquired brain injuries, may be instructive.

Neurocognitive sequalae of COVID-19 illness

Studies of past human coronaviruses (HCoV) and a steady stream of recent reports suggest that SARS-CoV-2 can affect the central nervous system (CNS) and subsequent neuropsychological functioning via direct and indirect routes. Concerning the former, like several other HCoVs (Glass et al., 2004; Li et al., 2016; Talbot et al., 1993), SARS-CoV-2 appears to be both neuroinvasive and neurovirulent. That is, it can breech the blood-brain barrier or gain entry to the CNS via other routes, where its presence can potentially lead to both acute and long-term neurological and neuropsychological sequelae (Arbour et al., 1999; Cristallo et al., 1997; Fazzini et al., 1992; Johnson-Lussenburg & Zheng, 1987; Morfopoulou et al., 2016; Murray et al., 1992; Stewart et al., 1992; Yeh et al., 2004). Among the indirect routes to neurologic and neuropsychological complications posed by the virus is its systemic effects. It is now established that a small minority of COVID-19 patients develop severe neurologic complications, such as infectious toxic encephalopathy, viral encephalitis, and stroke (Asadi-Pooya & Simani, 2020; Wu et al., 2020), perhaps due to the virus's potential to cause coagulopathy, thrombosis, and inflammation (Mehta et al., 2020; Zhang et al., 2020). Neurologic and neuropsychological symptoms may also arise secondary to atypical acute respiratory distress syndrome (ARDS; Dreher et al., 2020; Gattinoni et al., 2020). For example, prior research has established that ARDS survivors exhibit deficits in memory, attention, verbal fluency, processing speed, and executive function, with between 30 and 80% of patients continuing to exhibit cognitive impairment a year after ARDS (Herridge et al., 2016; Hopkins et al., 1999; Mikkelsen et al., 2012). Finally, a disproportionate number of severe COVID-19 cases have pre-existing medical

conditions that are also associated with neuropsychological deficits, including hypertension, diabetes, cardiovascular disease, cancer, and chronic respiratory illness (Ahles & Root, 2018; Bennett & Sauvé, 2003; Janelsins et al., 2018; Novak & Hajjar, 2010; Reijmer et al., 2011; Schou et al., 2012; van den Berg et al., 2010). Therefore, it will be a necessary and difficult task for neuropsychologists to consider complex factors and medical complications experienced by COVID-19 survivors. In short, while the exact nature and scope of the neuropsychological deficits experienced by COVID-19 survivors has yet to be established, outcomes will likely vary widely according to a number of clinical factors and individual differences.

PTSD among COVID-19 survivors

A careful consideration of the neuropsychological implications associated with COVID-19 must also consider the impact of trauma experienced by survivors. However, little information has been reported regarding potential psychiatric outcomes. PTSD is defined as the development of symptoms related to intrusion, avoidance, negative alterations in cognitions and mood, and arousal and reactivity following exposure to a traumatic event (Shalev et al., 2017). Even among those who do not meet full diagnostic criteria, post-traumatic stress symptoms (PTSS) have also been associated with functional impairment (Westphal et al., 2011; Varela et al., 2011). Based on the information garnered from past human coronavirus outbreaks, specifically SARS and MERS, providers can anticipate an elevated incidence of PTSD and PTSS in COVID-19 survivors. For example, 42% of MERS survivors scored above a clinical cut-off for PTSD one year after the outbreak, with nearly 27% remaining above the cut-off after 18 months (Lee et al., 2019). Similarly, nearly 26% of SARS survivors met full diagnostic criteria for PTSD 30 months after treatment, and all identified SARS infection as their index trauma (Mak et al., 2010). These prevalence rates are far above the population average and suggest that providers should be prepared to evaluate and make recommendations regarding elevated PTSS in COVID-19 survivors. In the current pandemic, several causes of PTSD in the context of COVID-19 can be expected, as discussed next.

Near death experience

Patients with severe COVID-19 frequently present with respiratory symptoms which may progress to respiratory failure (Xie et al., 2020). Treatment for COVID-19 may involve extreme stressors for patients, including fear of death from life-threatening illness, pain from medical interventions such as endotracheal intubation, limited ability to communicate, and feelings of loss of control (Asimakopoulou & Madianos, 2014; Davydow et al., 2008; Gosselin et al., 2018). One patient described the sensation of COVID-19 respiratory infection as "it feels like you're drowning … you think you're going to die" (Buxbaum, 2020), and a respiratory therapist described shock at the severity of pink, frothy secretions occluding patient's breathing tubes (Presser, 2020). Even patients with moderate illness severity who do not require hospitalization describe fear of death – one patient stated, "I did not go to sleep for three days because I was scared … I wouldn't wake up" (Brodsky, 2020). These anecdotes illustrate

how COVID-19 illness constitutes exposure to threatened death or serious injury, fulfilling the first diagnostic criteria for PTSD. Additionally, given that there is evidence of infection clusters within family units (Qian et al., 2020), survivors may have also experienced trauma related to witnessing severe illness or death of close family members.

Delirium

Another potential cause of PTSD in COVID-19 survivors is delirium. Of particular interest to neuropsychologists, delirium has been investigated as one of the modifiable clinical risk factors for PTSD in patients who receive intensive care unit (ICU) treatment. COVID-19 patients may be at a particularly elevated risk for delirium due to a confluence of the likely neuroinvasive and neurovirulent properties of the virus itself, CNS inflammation in response to other organ system failures, the high percentage of severe COVID-19 patients who are also older adults, and ICU-specific factors such as intubation and ventilation, sedation, and prolonged isolation (Kotfis et al., 2020, O'Hanlon & Inouye, 2020). In elderly and mechanically ventilated populations, delirium may occur in up to 80% of ICU patients (Ely et al., 2004), again suggesting that survivors of severe COVID-19, who are likely to be older adults and require ventilation (Liu et al., 2020), may be at particularly high risk for delirium. Notably, prolonged delirium duration (>40 days) has been associated with higher PTSS (Bashar et al., 2018), but the presence of delirium has not been reliably associated with PTSD post-recovery (Svenningsen et al., 2015; Wolters et al., 2016). Other research has suggested that it is not delirium per say, but the recall of distressing in-ICU delusional memories that contribute to the development of PTSD in ICU survivors (Davydow et al., 2008; DiMartini et al., 2007; Jones et al., 2007).

ICU-related trauma

Post-traumatic stress has been well-documented in survivors of ICU treatment (Cuthbertson et al., 2004; Griffiths et al., 2007; Patel et al., 2016; Taylor et al., 2019). Invasive ventilation and longer duration of mechanical ventilation in particular have been associated with an increased risk for PTSS (Shaw et al., 2009; Twigg et al., 2008). In Wuhan, China, the earliest epicenter of the outbreak, approximately 3.2% of COVID-19 patients required intubation and invasive ventilation (Meng et al., 2020).

Estimates of the prevalence of PTSD following ICU stays vary widely, ranging from 0-75%, with median scores falling in the high teens, well above the population prevalence of PTSD (Wade et al., 2013, Jones, 2010, Hatch et al., 2011). Risk of developing PTSD appears to depend on a number of factors including patient characteristics (e.g., age and preexisting comorbidities), and clinical treatment variables (e.g., use of sedation, restraint, and antipsychotic medications; Davydow et al., 2008; Davydow et al., 2009; Girard et al., 2007; Jones, 2010; Wade et al., 2013). Of particular note when considering COVID-19 survivors, some studies have found that patients treated in ICUs for ARDS may have even higher PTSD rates post-treatment as compared to other ICU patients, with higher prevalence of PTSD in ARDS survivors as compared to survivors of general medical ICU and cardiac surgery (Griffiths et al., 2007). PTSS appear to be present in between 30 and 40% of ARDS survivors, even months after treatment

(Mikkelsen et al., 2012; Shaw et al., 2001; Wade et al., 2013). More generally, estimates of PTSD in intubated and mechanically ventilated patients range from 14 to 51% (Gosselin et al., 2018). Among patients who require mechanical ventilation in the ICU, the most common symptoms include feelings of guilt, mood swings, sleep disturbance, and memories of panic and suffocation (Girard et al., 2007). Thus, as COVID-19 survivors who were treated in ICUs begin to present for neuropsychological evaluation, PTSS should be assessed as a part of a complete evaluation.

The intersection between PTSD and neurocognitive functioning in COVID-19

Characterizing the cognitive profiles of COVID-19 survivors may be a complex task, as it will be difficult to disentangle the myriad potential etiologies of cognitive dysfunction in this patient population. This task will be further complicated by the possible primacy or comorbidity in a substantial proportion of survivors of PTSD/PTSS which is associated with a range of both subjective cognitive complaints (Mattson et al., 2019; Samuelson et al., 2017) and objective cognitive deficits in domains of verbal memory, sustained attention, and executive function (Aupperle et al., 2012; Brewin et al., 2007; DiGangi et al., 2017; Johnsen & Asbjørnsen, 2008; Malarbi et al., 2017; Polak et al., 2012; Vasterling et al., 2002). Considering the substantial possibility of neurologic symptomology and sequelae among COVID-19 patients, and of PTSD as a primary or secondary diagnostic consideration, understanding how PTSD manifests in other types of acquired brain injury may be instructive.

Survivors of severe COVID-19 are more likely to have a history of hypoxia and resulting acquired brain injury. These have also been associated with both cognitive and psychiatric impairments (Schultz et al., 2018) and progressive brain deterioration more than a decade after the original injury (Tobe, 2012). Both persistent neurocognitive deficits and declining mental health have been observed in ARDS survivors two years after hospital discharge (Hopkins et al., 2005), and cognitive impairment has been associated with worse health-related quality of life and greater disability status in ARDS survivors (Rothenhäusler et al., 2001). Furthermore, 79% of ARDS patients treated in an ICU recalled vivid nightmares and hallucinations (Larson et al., 2007). Other estimates suggest that between one quarter and one half of all ICU patients have limited or no memory of their treatment. In ARDS patients specifically, having no recall of ICU treatment was associated with higher rates of, and more significant, cognitive impairment up to one year after discharge (Larson et al., 2007).

Sleep dysfunction is another complicating factor considering its relationship to PTSD. Poor sleep, typically characterized by wakefulness, a high proportion of time spent in shallow sleep, and a relative low proportion of time spent in REM sleep, is a common complaint among survivors of ICU treatment (Friese et al., 2007; Weinhouse et al., 2009), and sleep problems can persist even after discharge (Dhooria et al., 2016; Lee et al., 2009). Thus, sleep dysfunction can be expected to be seen in a subset of survivors of severe COVID-19 who are treated in the ICU. Decreased sleep quality has also been documented even in non-patients during the COVID-19 lockdowns, associated with stress and anxiety (Marelli et al., 2020; Xiao et al., 2020). Sleep dysfunction

commonly occurs in both PTSD, acquired brain injury, and critical illness (Altman et al., 2017; Meeker et al., 2019; Tanev et al., 2014). Importantly, sleep quality may also contribute to cognitive deficits beyond the effects of PTSD (Gilbert et al., 2015), and has been shown to independently negatively impact cognition (Martindale et al., 2017). Poor sleep efficiency after ICU discharge may contribute to post-ICU cognitive impairment (Wilcox et al., 2013). Notably, sleep deprivation in the ICU is a potentially modifiable risk factor for delirium (Litton et al., 2016; Weinhouse et al., 2009), although findings are mixed (Kamdar et al., 2013).

Delirium, another potential cause of PTSD in COVID-19 patients, is also associated with persistent cognitive impairment and subjective memory decline several years after discharge from the hospital (Bickel et al., 2008). Diagnosis of delirium has also been linked with higher risk of later developing dementia (Jackson et al., 2004; MacLullich et al., 2009; Sprung et al., 2017). This adds an additional level of difficulty for neuropsychologists in attempting to determine the etiology of cognitive impairment in COVID-19 survivors with experienced ICU delirium.

Another consideration which includes those patients with history of mild or uncomplicated illness is the role of expectation of cognitive effects in survivors of COVID-19. Given the media coverage of neurological involvement in COVID-19 and the yet unknown disease effects on cognition, it is possible that patients may experience iatrogenic effects. The impact of negative illness perception and symptom expectation on cognition has been documented in mild traumatic brain injury (mTBI), such that negative beliefs about an injury and its effects are independently associated with persistent post-concussion symptoms (PCS) and cognitive deficits (Hou et al., 2012; Mittenberg et al., 1992; Whittaker et al., 2007). Studies of patients with comorbid PTSD and mTBI suggest that subjective cognitive complaints are greater than in patients with mTBI alone (Spencer et al., 2010). Persistent post-concussive symptoms have also been shown to be mediated by the presence of PTSD, suggesting that the experience of PCS such as subjective memory complaints arise from PTSD and not from the mTBI (Pietrzak et al., 2009; Polusny et al., 2011; Porter et al., 2018; Schneiderman et al., 2008). In the context of COVID-19, it may be several years before we are able to disentangle the contribution of PTSD versus brain injury to cognitive functioning, as there may not be clear evidence of brain damage without detailed neuropathological examination.

Recommendations for the neuropsychological assessment of COVID-19 survivors with psychological trauma

In the coming months and years, COVID-19 survivors may seek neuropsychological evaluations due to subjective cognitive complaints. A subset of these patients may have been treated in ICUs, been intubated or mechanically ventilated, experienced periods of delirium, or may have experienced direct neurological impacts such as stroke. For these patients, the task for neuropsychologists will be to differentiate whether their cognitive complaints are related to psychological traumatic, premorbid deficits, non-credible effort, neurologic insult, or a combination of the above. As described above, survivors of severe COVID-19 may be more likely to have direct

neurological involvement and elevated risk for PTSD/PTSS from their illness and treatment, as compared to those with more mild illness. However, patients who recover from more mild COVID-19 may still be at risk for psychiatric symptoms or negative expectancies that impact cognition, self-report, and perception of disability.

It may be particularly difficult to differentiate the long-term effects of neurologic insult and delirium from PTSD in COVID-19 survivors given that there is currently very little known about the CNS effects of COVID-19 or SARS-Cov-2 infection or what potential neuropathology secondary to the illness exists. Considering the high likelihood of psychological trauma in COVID-19 survivors, it is important that clinicians not attribute subjective cognitive complaints or objective cognitive impairment to acquired brain injury or other medical complications without considering the contribution of PTSD or other psychiatric etiologies. In addition, considering the inevitability of disability claims and perhaps civil lawsuits related to COVID-19, feigned impairment is also likely to be a key consideration.

While diagnosis of PTSD in COVID-19 survivors may be relatively straightforward, determining the relative contribution of such disorders and COVID-19-related neuropathology to neurocognitive deficits will be challenging. There are no published data on the neuropsychological profiles of survivors of COVID-19, and considering the myriad of indirect causes, a consistent profile is unlikely. Known deficits in attention, executive function, and memory seen in PTSD patients are likely to overlap with the cognitive impairments related to COVID-19. Furthermore, subjective cognitive complaints may be driven more by psychiatric symptoms and expectations rather than actual underlying neuropathology. Additionally, at least in the intermediate-term post-acute phase, individuals who undergo ICU treatment and experience severe medical complications such as respiratory failure or neurologic insult can be fatigued, irritable, anxious, and/or depressed, which also overlap with the non-cognitive clinical symptoms of PTSD (Dolan et al., 2012; Spadaro et al., 2020). Assessment of other specific ICU-related factors which have been linked to cognitive outcomes, such as recall of ICU treatment, experience of delirium, and use of sedatives and analgesics, may be an informative addition to the clinical interview (Jackson et al., 2009). Neuropsychologists must carefully evaluate patients who are at risk of both PTSD and neurologic insult, as is the case with COVID-19 survivors.

Due to the proliferation of media coverage related to COVID-19, including reports of neurological impact, patients may have expectations of poor cognitive performance and persistent neurological symptoms after illness. Clinical experience and empirical research of TBI patients indicates that expectations related to brain injury significantly impact symptom report and neuropsychological test performance (Suhr & Gunstad, 2005; Waldron-Perrine et al., 2015). Subjective cognitive complaints arising in the context of PTSD are likely to persist far longer than cognitive impairments directly resulting from mild brain injury, although patients may attribute symptoms to the acquired brain injury alone (Verfaellie et al., 2014). Trauma-focused psychotherapies, including cognitive-behavior therapy, cognitive processing therapy, and prolonged exposure, have been shown to improve cognitive performance (Walter et al., 2010). However, patients who believe that their experienced cognitive symptoms are due to acquired brain injury may have difficulty accepting alternative explanations and the possibility

of cognitive recovery following psychotherapy. Neuropsychologists should therefore be prepared that patients with expectancies related to acquired brain injury may be resistant to treatment appropriate for neuropsychiatric conditions (Porter et al., 2018). Normalization of psychiatric symptoms in survivors of ICU treatment may be an important first step.

It may be impossible for neuropsychologists to fully disentangle the complex and likely multiple etiologies of cognitive impairment and self-reported cognitive changes in COVID-19 survivors. Given that many survivors of severe COVID-19 will be older adults, these individuals may also have already had premorbid cognitive decline or may be experiencing new cognitive impairment, further complicating the diagnostic picture of these patients. Therefore, while certain recommendations such as cognitive rehabilitation and lifestyle changes may be warranted, referrals for psychotherapy to address PTSS/PTSD may be a valuable additional treatment recommendation. Clinical experience suggests that patients may be amenable to psychotherapy recommendations framed in such a way that suggests that there are multiple routes by which their cognitive symptoms can be addressed simultaneously, increasing the likelihood of improvement of functioning and quality of life. Finally, there will undoubtedly be patients whose cognitive symptoms have no psychiatric cause, but rather result solely from direct or indirect neurological effects of the virus as described above. As research on cognition in survivors of COVID-19 continues to emerge, neuropsychologists must adapt their conceptualizations to follow the evidence.

Conclusion

In sum, evidence from survivors of SARS and MERS, as well as groups similar to survivors of severe COVID-19 (e.g., ARDS patients and other ICU survivors), highlight the need for neuropsychologists to consider either comorbid or stand-alone PTSD in COVID-19 survivors and the consideration that post-traumatic stress may be responsible in part or in full for both subjective cognitive complaints and poor neuropsychological test performance. As evidence of the neurocognitive sequelae of COVID-19 emerges, psychological trauma should not be overlooked as an important contributor to the neuropsychological robustness and quality of life of patients seeking cognitive evaluations. Neuropsychologists working in inpatient settings may be in a position to advocate for follow-ups with patients to reduce likelihood of post-ICU PTSD.

Regardless of objective neuropsychological deficits, the subjective experience of cognitive impairment can also be very emotionally distressing to survivors and clinicians should carefully consider how both brain damage secondary to COVID-19 and secondary to PTSD may be impacting cognition. Neuropsychologists can then provide psychoeducation and treatment referrals appropriately targeted to the patient's needs to address these subjective cognitive complaints. Inpatient and rehabilitation neuropsychologists may be particularly well situated to recommend PTSS and sleep quality screenings and longitudinal psychiatric and cognitive follow-up. Psychiatric screening follow-up may be particularly important to identify those survivors whose symptoms persist beyond acute stress reactions to potentially meet full diagnostic criteria of PTSD (i.e., greater than one month after the trauma).

As a final note, the effects of psychological trauma will not be limited to the survivors themselves; frontline healthcare workers and family members may also experience PTSS and negative effects from stigmatization, as was documented in the SARS and MERS outbreaks (Lee et al., 2019; Maunder, 2004; Park et al., 2018). Neuropsychologists may also play a role in advocating for PTSS screenings and mental health outreach more broadly for frontline healthcare providers, families, and survivors of the COVID-19 pandemic.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Ahles, T. A., & Root, J. C. (2018). Cognitive effects of cancer and cancer treatments. *Annual Review of Clinical Psychology*, *14*, 425–451. https://doi.org/10.1146/annurev-clinpsy-050817-084903

Altman, M. T., Knauert, M. P., & Pisani, M. A. (2017). Sleep disturbance after hospitalization and critical illness: A systematic review. *Annals of the American Thoracic Society*, *14*(9), 1457–1468. https://doi.org/10.1513/AnnalsATS.201702-148SR

Arbour, N., Ekandé, S., Côté, G., Lachance, C., Chagnon, F., Tardieu, M., Cashman, N. R., & Talbot, P. J. (1999). Persistent infection of human oligodendrocytic and neuroglial cell lines by human coronavirus 229E. *Journal of Virology*, *73*(4), 3326–3337. https://doi.org/10.1128/JVI.73.4.3326-3337.1999

Asadi-Pooya, A. A., & Simani, L. (2020). Central nervous system manifestations of COVID-19: A systematic review. *Journal of the Neurological Sciences*, *413*, 116832. https://doi.org/10.1016/j.jns.2020.116832

Ashrafi, F., Zali, A., Ommi, D., Salari, M., Fatemi, A., Arab-Ahmadi, M., Behnam, B., Azhideh, A., Vahidi, M., Yousefi-Asl, M., Jalili Khoshnood, R., & Advani, S. (2020). COVID-19-related strokes in adults below 55 years of age: A case series. *Neurological Sciences*, *41*(8), 1985–1989. https://doi.org/10.1007/s10072-020-04521-3

Asimakopoulou, E., & Madianos, M. (2014). The Prevalence of Major depression-PTSD comorbidity among ICU survivors in five general hospitals of Athens: A cross-sectional study. *Issues in Mental Health Nursing*, *35*(12), 954–963. https://doi.org/10.3109/01612840.2014.924609

Aupperle, R. L., Melrose, A. J., Stein, M. B., & Paulus, M. P. (2012). Executive function and PTSD: Disengaging from trauma. *Neuropharmacology*, *62*(2), 686–694. https://doi.org/10.1016/j.neuropharm.2011.02.008

Bashar, F. R., Vahedian-Azimi, A., Hajiesmaeili, M., Salesi, M., Farzanegan, B., Shojaei, S., Goharani, R., Madani, S. J., Moghaddam, K. G., Hatamian, S., Moghaddam, H. J., Mosavinasab, S. M. M., Elamin, E. M., & Miller, A. C. (2018). Post-ICU psychological morbidity in very long ICU stay patients with ARDS and delirium. *Journal of Critical Care*, *43*, 88–94. https://doi.org/10.1016/j.jcrc.2017.08.034

Bennett, S. J., & Sauvé, M. J. (2003). Cognitive deficits in patients with heart failure: A review of the literature. *The Journal of Cardiovascular Nursing*, *18*(3), 219–242. https://doi.org/10.1097/00005082-200307000-00007

Bickel, H., Gradinger, R., Kochs, E., & Förstl, H. (2008). High risk of cognitive and functional decline after postoperative delirium. A three-year prospective study. *Dementia and Geriatric Cognitive Disorders*, *26*(1), 26–31. https://doi.org/10.1159/000140804

Brewin, C. R., Kleiner, J. S., Vasterling, J. J., & Field, A. P. (2007). Memory for emotionally neutral information in posttraumatic stress disorder: A meta-analytic investigation. *Journal of Abnormal Psychology*, *116*(3), 448–463. https://doi.org/10.1037/0021-843X.116.3.448

Brodsky, R. (2020, April 12). Former COVID-19 patients share their stories of survival. *Newsday*. https://www.newsday.com/news/health/coronavirus/coronavirus-survivors-1.43803627

Buxbaum, S. (2020, June 29). What is it like to recover from COVID-19 in the ICU? One patient shares their story. *Utah Public Radio*. https://www.upr.org/post/what-it-recover-covid-19-icu-one-patient-shares-their-story

Cristallo, A., Gambaro, F., Biamonti, G., Ferrante, P., Battaglia, M., & Cereda, P. M. (1997). Human coronavirus polyadenylated RNA sequences in cerebrospinal fluid from multiple sclerosis patients. *The New Microbiologica*, *20*(2), 105–114.

Cuthbertson, B. H., Hull, A., Strachan, M., & Scott, J. (2004). Post-traumatic stress disorder after critical illness requiring general intensive care. *Intensive Care Medicine*, *30*(3), 450–455. https://doi.org/10.1007/s00134-003-2004-8

Davydow, D. S., Gifford, J. M., Desai, S. V., Needham, D. M., & Bienvenu, O. J. (2008). Posttraumatic stress disorder in general intensive care unit survivors: A systematic review. *General Hospital Psychiatry*, *30*(5), 421–434. https://doi.org/10.1016/j.genhosppsych.2008.05.006

Davydow, D. S., Zatzick, D. F., Rivara, F. P., Jurkovich, G. J., Wang, J., Roy-Byrne, P. P., Katon, W. J., Hough, C. L., Kross, E. K., Fan, M.-Y., Joesch, J., & MacKenzie, E. J. (2009). Predictors of posttraumatic stress disorder and return to usual major activity in traumatically injured intensive care unit survivors. *General Hospital Psychiatry*, *31*(5), 428–435. https://doi.org/10.1016/j.genhosppsych.2009.05.007

Dhooria, S., Sehgal, I. S., Agrawal, A. K., Agarwal, R., Aggarwal, A. N., & Behera, D. (2016). Sleep after critical illness: Study of survivors of acute respiratory distress syndrome and systematic review of literature. *Indian Journal of Critical Care Medicine*, *20*(6), 323–331. https://doi.org/10.4103/0972-5229.183908

DiGangi, J. A., Kujawa, A., Aase, D. M., Babione, J. M., Schroth, C., Levy, D. M., Kennedy, A. E., Greenstein, J. E., Proescher, E., Walters, R., Passi, H., Langenecker, S. A., & Phan, K. L. (2017). Affective and cognitive correlates of PTSD: Electrocortical processing of threat and perseverative errors on the WCST in combat-related PTSD. *Progress in Neuro-Psychopharmacology & Biological Psychiatry*, *75*, 63–69. https://doi.org/10.1016/j.pnpbp.2017.01.004

DiMartini, A., Dew, M. A., Kormos, R., McCurry, K., & Fontes, P. (2007). Posttraumatic stress disorder caused by hallucinations and delusions experienced in delirium. *Psychosomatics*, *48*(5), 436–439. https://doi.org/10.1176/appi.psy.48.5.436

Dolan, S., Martindale, S., Robinson, J., Kimbrel, N. A., Meyer, E. C., Kruse, M. I., Morissette, S. B., Young, K. A., & Gulliver, S. B. (2012). Neuropsychological Sequelae of PTSD and TBI Following War Deployment among OEF/OIF Veterans. *Neuropsychology Review*, *22*(1), 21–34. https://doi.org/10.1007/s11065-012-9190-5

Dreher, M., Kersten, A., Bickenbach, J., Balfanz, P., Hartmann, B., Cornelissen, C., Daher, A., Stöhr, R., Kleines, M., Lemmen, S. W., Brokmann, J. C., Müller, T., Müller-Wieland, D., Marx, G., & Marx, N. (2020). The characteristics of 50 hospitalized COVID-19 patients with and without ARDS. *Deutsches Aerzteblatt International, 117(16), 271–278.* https://doi.org/10.3238/arztebl.2020.0271

Ely, E. W., Shintani, A., Truman, B., Speroff, T., Gordon, S. M., Frank, E., Harrell, J., Inouye, S. K., Bernard, G. R., & Dittus, R. S. (2004). Delirium as a predictor of mortality in mechanically ventilated patients in the intensive care unit. *JAMA*, *291*(14), 1753–1762. https://doi.org/10.1001/jama.291.14.1753

Fan, S., Xiao, M., Han, F., Xia, P., Bai, X., Chen, H., Zhang, H., Ding, X., Zhao, H., Zhao, J., Sun, X., Jiang, W., Wang, C., Cao, W., Guo, F., Tian, R., Gao, P., Wu, W., Ma, J., … Guan, H. (2020). Neurological manifestations in critically ill patients with COVID-19: A retrospective study. *Frontiers in Neurology*, *11*, 1–10. https://doi.org/10.3389/fneur.2020.00806

Fazzini, E., Fleming, J., & Fahn, S. (1992). Cerebrospinal fluid antibodies to coronavirus in patients with Parkinson's disease. *Movement Disorders: Official Journal of the Movement Disorder Society*, *7*(2), 153–158. https://doi.org/10.1002/mds.870070210

Friese, R. S., Diaz-Arrastia, R., McBride, D., Frankel, H., & Gentilello, L. M. (2007). Quantity and quality of sleep in the surgical intensive care unit: Are our patients sleeping? *The Journal of Trauma*, *63*(6), 1210–1214. https://doi.org/10.1097/TA.0b013e31815b83d7

Gattinoni, L., Coppola, S., Cressoni, M., Busana, M., Rossi, S., & Chiumello, D. (2020). COVID-19 does not lead to a "typical" acute respiratory distress syndrome. *American Journal of Respiratory and Critical Care Medicine*, *201*(10), 1299–1300. https://doi.org/10.1164/rccm.202003-0817LE

Gilbert, K. S., Kark, S. M., Gehrman, P., & Bogdanova, Y. (2015). Sleep disturbances, TBI and PTSD: Implications for treatment and recovery. *Clinical Psychology Review*, *40*, 195–212. https://doi.org/10.1016/j.cpr.2015.05.008

Girard, T. D., Shintani, A. K., Jackson, J. C., Gordon, S. M., Pun, B. T., Henderson, M. S., Dittus, R. S., Bernard, G. R., & Ely, E. W. (2007). Risk factors for post-traumatic stress disorder symptoms following critical illness requiring mechanical ventilation: A prospective cohort study. *Critical Care (London, England)*, *11*(1), R28. https://doi.org/10.1186/cc5708

Glass, W. G., Subbarao, K., Murphy, B., & Murphy, P. M. (2004). Mechanisms of host defense following severe acute respiratory syndrome-coronavirus (SARS-CoV) pulmonary infection of mice. *J. Immunol*, *173*(6), 4030–4039. https://doi.org/10.4049/jimmunol.173.6.4030

Gosselin, É., Gélinas, C., Bourgault, P., & Lavoie, S. (2018). Intervention for patients intubated and conscious to decrease peritraumatic distress (IPIC-PTD) – Acceptability and feasibility. *Science of Nursing and Health Practice*, *1*(2), 1-15. https://doi.org/10.31770/2561-7516.1019

Griffiths, J., Fortune, G., Barber, V., & Young, J. D. (2007). The prevalence of post traumatic stress disorder in survivors of ICU treatment: A systematic review. *Intensive Care Medicine*, *33*(9), 1506–1518. https://doi.org/10.1007/s00134-007-0730-z

Hatch, R., McKechnie, S., & Griffiths, J. (2011). Psychological intervention to prevent ICU-related PTSD: Who, when and for how long? *Critical Care (London, England)*, *15*(2), 141. https://doi.org/10.1186/cc10054

Herridge, M. S., Moss, M., Hough, C. L., Hopkins, R. O., Rice, T. W., Bienvenu, O. J., & Azoulay, E. (2016). Recovery and outcomes after the acute respiratory distress syndrome (ARDS) in patients and their family caregivers. *Intensive Care Medicine*, *42*(5), 725–738. https://doi.org/10.1007/s00134-016-4321-8

Hopkins, R. O., Weaver, L. K., Collingridge, D., Parkinson, R. B., Chan, K. J., & Orme, J. F. (2005). Two-year cognitive, emotional, and quality-of-life outcomes in acute respiratory distress syndrome. *American Journal of Respiratory and Critical Care Medicine*, *171*(4), 340–347. https://doi.org/10.1164/rccm.200406-763OC

Hopkins, R. O., Weaver, L. K., Pope, D., Orme, J. F., Bigler, E. D., & Larson-Lohr, V. (1999). Neuropsychological sequelae and impaired health status in survivors of severe acute respiratory distress syndrome. *American Journal of Respiratory and Critical Care Medicine*, *160*(1), 50–56. https://doi.org/10.1164/ajrccm.160.1.9708059

Hou, R., Moss-Morris, R., Peveler, R., Mogg, K., Bradley, B. P., & Belli, A. (2012). When a minor head injury results in enduring symptoms: A prospective investigation of risk factors for post-concussional syndrome after mild traumatic brain injury. *Journal of Neurology, Neurosurgery, and Psychiatry*, *83*(2), 217–223. https://doi.org/10.1136/jnnp-2011-300767

Jackson, J. C., Gordon, S. M., Hart, R. P., Hopkins, R. O., & Ely, E. W. (2004). The association between delirium and cognitive decline: A review of the empirical literature. *Neuropsychology Review*, *14*(2), 87–98. https://doi.org/10.1023/B:NERV.0000028080.39602.17

Jackson, J. C., Mitchell, N., & Hopkins, R. O. (2009). Cognitive functioning, mental health, and quality of life in ICU survivors: An overview. *Critical Care Clinics*, *25*(3), 615–628. https://doi.org/10.1016/j.ccc.2009.04.005

Janelsins, M. C., Heckler, C. E., Peppone, L. J., Ahles, T. A., Mohile, S. G., Mustian, K. M., Palesh, O., O'Mara, A. M., Minasian, L. M., Williams, A. M., Magnuson, A., Geer, J., Dakhil, S. R., Hopkins, J. O., & Morrow, G. R. (2018). Longitudinal trajectory and characterization of cancer-related cognitive impairment in a nationwide cohort study. *Journal of Clinical Oncology*, *36*(32), 3231–3239. https://doi.org/10.1200/JCO.2018.78.6624

Jeong, H., Yim, H. W., Song, Y.-J., Ki, M., Min, J.-A., Cho, J., & Chae, J.-H. (2016). Mental health status of people isolated due to Middle East Respiratory Syndrome. *Epidemiology and Health*, *38*, e2016048. https://doi.org/10.4178/epih.e2016048

Johnsen, G. E., & Asbjørnsen, A. E. (2008). Consistent impaired verbal memory in PTSD: A meta-analysis. *Journal of Affective Disorders*, *111*(1), 74–82. https://doi.org/10.1016/j.jad.2008.02.007

Johnson-Lussenburg, C. M., & Zheng, Q. (1987). Coronavirus and multiple sclerosis: Results of a case/control longitudinal serological study. *Advances in Experimental Medicine and Biology*, *218*, 421–429. https://doi.org/10.1007/978-1-4684-1280-2_51

Jones, C. (2010). Post-traumatic stress disorder in ICU survivors. *Journal of the Intensive Care Society*, *11*(2_suppl), 12–14. https://doi.org/10.1177/175114371001112S105

Jones, C., Backman, C., Capuzzo, M., Egerod, I., Flaatten, H., Granja, C., Rylander, C., & Griffiths, R. D, & RACHEL group, T. (2010). Intensive care diaries reduce new onset post traumatic stress disorder following critical illness: A randomised, controlled trial. *Critical Care (London, England)*, *14*(5), R168. https://doi.org/10.1186/cc9260

Jones, C., Bäckman, C., Capuzzo, M., Flaatten, H., Rylander, C., & Griffiths, R. D. (2007). Precipitants of post-traumatic stress disorder following intensive care: A hypothesis generating study of diversity in care. *Intensive Care Medicine*, *33*(6), 978–985. https://doi.org/10.1007/s00134-007-0600-8

Kamdar, B. B., King, L. M., Collop, N. A., Sakamuri, S., Colantuoni, E., Neufeld, K. J., Bienvenu, O. J., Rowden, A. M., Touradji, P., Brower, R. G., & Needham, D. M. (2013). The effect of a quality improvement intervention on perceived sleep quality and cognition in a medical ICU. *Critical Care Medicine*, *41*(3), 800–809. https://doi.org/10.1097/CCM.0b013e3182746442

Kotfis, K., Williams Roberson, S., Wilson, J. E., Dabrowski, W., Pun, B. T., & Ely, E. W. (2020). COVID-19: ICU delirium management during SARS-CoV-2 pandemic. *Critical Care (London, England)*, *24*(1), 176https://doi.org/10.1186/s13054-020-02882-x

Larson, M. J., Weaver, L. K., & Hopkins, R. O. (2007). Cognitive sequelae in acute respiratory distress syndrome patients with and without recall of the intensive care unit. *Journal of the International Neuropsychological Society*, *13*(4), 595-605. https://doi.org/10.1017/S1355617707070749

Lee, C. M., Herridge, M. S., Gabor, J. Y., Tansey, C. M., Matte, A., & Hanly, P. J. (2009). Chronic sleep disorders in survivors of the acute respiratory distress syndrome. *Intensive Care Med*, *35*(2), 314–320. https://doi.org/10.1007/s00134-008-1277-3

Lee, S. H., Shin, H.-S., Park, H. Y., Kim, J. L., Lee, J. J., Lee, H., Won, S.-D., & Han, W. (2019). Depression as a mediator of chronic fatigue and post-traumatic stress symptoms in Middle East respiratory syndrome survivors. *Psychiatry Investigation*, *16*(1), 59–64. https://doi.org/10.30773/pi.2018.10.22.3

Lee, A. M., Wong, J. G., McAlonan, G. M., Cheung, V., Cheung, C., Sham, P. C., Chu, C.-M., Wong, P.-C., Tsang, K. W., & Chua, S. E. (2007). Stress and psychological distress among SARS survivors 1 year after the outbreak. *The Canadian Journal of Psychiatry*, *52*(4), 233–240. https://doi.org/10.1177/070674370705200405

Li, K., Wohlford-Lenane, C., Perlman, S., Zhao, J., Jewell, A. K., Reznikov, L. R., Gibson-Corley, K. N., Meyerholz, D. K., & McCray, P. B. (2016). Middle East Respiratory Syndrome coronavirus causes multiple organ damage and lethal disease in mice transgenic for Human Dipeptidyl Peptidase 4. *The Journal of Infectious Diseases*, *213*(5), 712–722. https://doi.org/10.1093/infdis/jiv499

Litton, E., Carnegie, V., Elliott, R., & Webb, S. A. R. (2016). The efficacy of earplugs as a sleep hygiene strategy for reducing delirium in the ICU: A systematic review and meta-analysis*. *Critical Care Medicine*, *44*(5), 992–999. https://doi.org/10.1097/CCM.0000000000001557

Liu, K., Chen, Y., Lin, R., & Han, K. (2020). Clinical features of COVID-19 in elderly patients: A comparison with young and middle-aged patients. Journal *of Infection*, *80*(6), e14–e18. https://doi.org/10.1016/j.jinf.2020.03.005

MacLullich, A. M. J., Beaglehole, A., Hall, R. J., & Meagher, D. J. (2009). Delirium and long-term cognitive impairment. *International Review of Psychiatry (Abingdon, England))*, *21*(1), 30–42. https://doi.org/10.1080/09540260802675031

Mak, I. W. C., Chu, C. M., Pan, P. C., Yiu, M. G. C., & Chan, V. L. (2009). Long-term psychiatric morbidities among SARS survivors. *General Hospital Psychiatry*, *31*(4), 318–326. https://doi.org/10.1016/j.genhosppsych.2009.03.001

Mak, I. W. C., Chu, C. M., Pan, P. C., Yiu, M. G. C., Ho, S. C., & Chan, V. L. (2010). Risk factors for chronic post-traumatic stress disorder (PTSD) in SARS survivors. *General Hospital Psychiatry*, *32*(6), 590–598. https://doi.org/10.1016/j.genhosppsych.2010.07.007

Malarbi, S., Abu-Rayya, H. M., Muscara, F., & Stargatt, R. (2017). Neuropsychological functioning of childhood trauma and post-traumatic stress disorder: A meta-analysis. *Neuroscience and Biobehavioral Reviews*, *72*, 68–86. https://doi.org/10.1016/j.neubiorev.2016.11.004

Marelli, S., Castelnuovo, A., Somma, A., Castronovo, V., Mombelli, S., Bottoni, D., Leitner, C., Fossati, A., & Ferini-Strambi, L. (2020). Impact of COVID-19 lockdown on sleep quality in university students and administration staff. *Journal of Neurology*. https://doi.org/10.1007/s00415-020-10056-6

Martindale, S. L., Morissette, S. B., Rowland, J. A., & Dolan, S. L. (2017). Sleep quality affects cognitive functioning in returning combat veterans beyond combat exposure, PTSD, and mild TBI history. *Neuropsychology*, *31*(1), 93–104. https://doi.org/10.1037/neu0000312

Mattson, E. K., Nelson, N. W., Sponheim, S. R., & Disner, S. G. (2019). The impact of PTSD and mTBI on the relationship between subjective and objective cognitive deficits in combat-exposed veterans. *Neuropsychology*, *33*(7), 913–921. https://doi.org/10.1037/neu0000560

Maunder, R. (2004). The experience of the 2003 SARS outbreak as a traumatic stress among frontline healthcare workers in Toronto: Lessons learned. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *359*(1447), 1117–1125. https://doi.org/10.1098/rstb.2004.1483

Meeker, J., Wang, S., Perkins, A., Gao, S., Khan, S. h., Sigua, N., Manchanda, S., Boustani, M., & Khan, B. a. (2019). *Mental health symptoms are associated with sleep disturbances in intensive care unit survivors* [Paper presentation]. C103. CRITICAL Care: The Long Walk - Elucidating Outcomes: Death, Functional Status and Cognition (Vol. 1–296, pp. A5664–A5664). American Thoracic Society. https://doi.org/10.1164/ajrccm-conference.2019.199.1_MeetingAbstracts.A5664

Mehta, P., McAuley, D. F., Brown, M., Sanchez, E., Tattersall, R. S., & Manson, J. J, (2020). COVID-19: Consider cytokine storm syndromes and immunosuppression. *Lancet (London, England)*, *395*(10229), 1033–1034. https://doi.org/10.1016/S0140-6736(20)30628-0

Meng, L., Qiu, H., Wan, L., Ai, Y., Xue, Z., Guo, Q., Deshpande, R., Zhang, L., Meng, J., Tong, C., Liu, H., & Xiong, L. (2020). Intubation and ventilation amid the COVID-19 outbreak: Wuhan's experience. *Anesthesiology*, *132*(6), 1317–1332. https://doi.org/10.1097/ALN.0000000000003296

Mikkelsen, M. E., Christie, J. D., Lanken, P. N., Biester, R. C., Thompson, B. T., Bellamy, S. L., Localio, A. R., Demissie, E., Hopkins, R. O., & Angus, D. C. (2012). The adult respiratory distress syndrome cognitive outcomes study: Long-term neuropsychological function in survivors of acute lung injury. *American Journal of Respiratory and Critical Care Medicine*, *185*(12), 1307–1315. https://doi.org/10.1164/rccm.201111-2025OC

Mittenberg, W., DiGiulio, D. V., Perrin, S., & Bass, A. E. (1992). Symptoms following mild head injury: Expectation as aetiology. *Journal of Neurology, Neurosurgery, and Psychiatry*, *55*(3), 200–204. https://doi.org/10.1136/jnnp.55.3.200

Morfopoulou, S., Brown, J. R., Davies, E. G., Anderson, G., Virasami, A., Qasim, W., Chong, W. K., Hubank, M., Plagnol, V., Desforges, M., Jacques, T. S., Talbot, P. J., & Breuer, J. (2016). Human coronavirus OC43 associated with fatal encephalitis. *The New England Journal of Medicine*, *375*(5), 497–498. https://doi.org/10.1056/NEJMc1509458

Murray, R. S., Brown, B., Brian, D., & Cabirac, G. F. (1992). Detection of coronavirus RNA and antigen in multiple sclerosis brain. *Annals of Neurology*, *31*(5), 525–533. https://doi.org/10.1002/ana.410310511

Novak, V., & Hajjar, I. (2010). The relationship between blood pressure and cognitive function. *Nature Reviews. Cardiology*, *7*(12), 686–698. https://doi.org/10.1038/nrcardio.2010.161

O'Hanlon, S., & Inouye, S. K. (2020). Delirium: A missing piece in the COVID-19 pandemic puzzle. *Age and Ageing*, *49*(4), 497–498. https://doi.org/10.1093/ageing/afaa094

Park, J.-S., Lee, E.-H., Park, N.-R., & Choi, Y. H. (2018). Mental health of nurses working at a government-designated hospital during a MERS-CoV outbreak: A cross-sectional study. *Archives of Psychiatric Nursing*, *32*(1), 2–6. https://doi.org/10.1016/j.apnu.2017.09.006

Patel, M. B., Jackson, J. C., Morandi, A., Girard, T. D., Hughes, C. G., Thompson, J. L., Kiehl, A. L., Elstad, M. R., Wasserstein, M. L., Goodman, R. B., Beckham, J. C., Chandrasekhar, R., Dittus, R. S., Ely, E. W., & Pandharipande, P. P. (2016). Incidence and risk factors for intensive care unit–related post-traumatic stress disorder in veterans and civilians. *American Journal of Respiratory and Critical Care Medicine*, *193*(12), 1373–1381. https://doi.org/10.1164/rccm.201506-1158OC

Paterson, R. W., Brown, R. L., Benjamin, L., Nortley, R., Wiethoff, S., Bharucha, T., Jayaseelan, D. L., Kumar, G., Raftopoulos, R. E., Zambreanu, L., Vivekanandam, V., Khoo, A., Geraldes, R., Chinthapalli, K., Boyd, E., Tuzlali, H., Price, G., Christofi, G., Morrow, J., … Zandi, M. S. (2020). The emerging spectrum of COVID-19 neurology: Clinical, radiological and laboratory findings. Brain. https://doi.org/10.1093/brain/awaa240

Pietrzak, R. H., Johnson, D. C., Goldstein, M. B., Malley, J. C., & Southwick, S. M. (2009). Posttraumatic stress disorder mediates the relationship between mild traumatic brain injury and health and psychosocial functioning in veterans of Operations Enduring Freedom and Iraqi Freedom. *The Journal of Nervous and Mental Disease*, *197*(10), 748–753. https://doi.org/10.1097/NMD.0b013e3181b97a75

Polak, A. R., Witteveen, A. B., Reitsma, J. B., & Olff, M. (2012). The role of executive function in posttraumatic stress disorder: A systematic review. *Journal of Affective Disorders*, *141*(1), 11–21. https://doi.org/10.1016/j.jad.2012.01.001

Polusny, M. A., Kehle, S. M., Nelson, N. W., Erbes, C. R., Arbisi, P. A., & Thuras, P. (2011). Longitudinal effects of mild traumatic brain injury and posttraumatic stress disorder comorbidity on postdeployment outcomes in National Guard soldiers deployed to Iraq. *Archives of General Psychiatry*, *68*(1), 79–89. https://doi.org/10.1001/archgenpsychiatry.2010.172

Porter, K. E., Stein, M. B., Martis, B., Avallone, K. M., McSweeney, L. B., Smith, E. R., Simon, N. M., Gargan, S., Liberzon, I., Hoge, C. W., & Rauch, S. A. M. (2018). Postconcussive symptoms (PCS) following combat-related traumatic brain injury (TBI) in Veterans with posttraumatic stress disorder (PTSD): Influence of TBI, PTSD, and depression on symptoms measured by the Neurobehavioral Symptom Inventory (NSI). *Journal of Psychiatric Research*, *102*, 8–13. https://doi.org/10.1016/j.jpsychires.2018.03.004

Presser, L. (2020, March 15). A medical worker describes terrifying lung failure from COVID-19 – even in his young patients. *ProPublica*. https://www.propublica.org/article/a-medical-worker-describes–terrifying-lung-failure-from-covid19-even-in-his-young-patients

Qian, G., Yang, N., Ma, A. H. Y., Wang, L., Li, G., Chen, X., & Chen, X. (2020). COVID-19 transmission within a family cluster by presymptomatic carriers in China. *Clinical Infectious Diseases : An Official Publication of the Infectious Diseases Society of America*, *71*(15), 861–862. https://doi.org/10.1093/cid/ciaa316

Reijmer, Y. D., van den Berg, E., de Bresser, J., Kessels, R. P. C., Kappelle, L. J., Algra, A., & Biessels, G. J. (2011). Accelerated cognitive decline in patients with type 2 diabetes: MRI correlates and risk factors. *Diabetes/Metabolism Research and Reviews*, *27*(2), 195–202. https://doi.org/10.1002/dmrr.1163

Rothenhäusler, H.-B., Ehrentraut, S., Stoll, C., Schelling, G., & Kapfhammer, H.-P. (2001). The relationship between cognitive performance and employment and health status in long-term survivors of the acute respiratory distress syndrome: Results of an exploratory study. *General Hospital Psychiatry*, *23*(2), 90–96. https://doi.org/10.1016/S0163-8343(01)00123-2

Samuelson, K. W., Bartel, A., Valadez, R., & Jordan, J. T. (2017). PTSD symptoms and perception of cognitive problems: The roles of posttraumatic cognitions and trauma coping self-efficacy. *Psychological Trauma : Theory, Research, Practice and Policy*, *9*(5), 537–544. https://doi.org/10.1037/tra0000210

Schneiderman, A. I., Braver, E. R., & Kang, H. K. (2008). Understanding sequelae of injury mechanisms and mild traumatic brain injury incurred during the conflicts in Iraq and Afghanistan: Persistent postconcussive symptoms and posttraumatic stress disorder. *American Journal of Epidemiology*, *167*(12), 1446–1452. https://doi.org/10.1093/aje/kwn068

Schou, L., Østergaard, B., Rasmussen, L. S., Rydahl-Hansen, S., & Phanareth, K. (2012). Cognitive dysfunction in patients with chronic obstructive pulmonary disease-a systematic review. *Respiratory Medicine*, *106*(8), 1071–1081. https://doi.org/10.1016/j.rmed.2012.03.013

Schultz, I. Z., Sepehry, A. A., & Greer, S. C. (2018). Anoxia-hypoxia in forensic neuropsychological assessment: cognitive impact of pulmonary injuries, respiratory distress, cerebral blood hypoperfusion, and major surgeries. *Psychological Injury and Law*, *11*(2), 153–170. https://doi.org/10.1007/s12207-018-9319-9

Shalev, A., Liberzon, I., & Marmar, C. (2017). Post-traumatic stress disorder. *The New England Journal of Medicine*, *376*(25), 2459–2469. https://doi.org/10.1056/NEJMra1612499

Shaw, R. J., Harvey, J. E., Bernard, R., Gunary, R., Tiley, M., & Steiner, H. (2009). Comparison of short-term psychological outcomes of respiratory failure treated by either invasive or non-invasive ventilation. Psychosomatics, *50*(6), 586–591. https://doi.org/10.1016/S0033-3182(09)70860-6

Shaw, R. J., Harvey, J. E., Nelson, K. L., Gunary, R., Kruk, H., & Steiner, H. (2001). Linguistic analysis to assess medically related posttraumatic stress symptoms. *Psychosomatics*, *42*(1), 35–40. https://doi.org/10.1176/appi.psy.42.1.35

Spadaro, S., Capuzzo, M., & Volta, C. A. (2020). Fatigue of ICU survivors,no longer to be neglected. *Chest*, S0012-3692(20), 31404-31405. https://doi.org/10.1016/j.chest.2020.05.521

Spencer, R. J., Drag, L. L., Walker, S. J., & Bieliauskas, L. A. (2010). Self-reported cognitive symptoms following mild traumatic brain injury are poorly associated with neuropsychological performance in OIF/OEF veterans. *Journal of Rehabilitation Research and Development*, *47*(6), 521–530. https://doi.org/10.1682/jrrd.2009.11.0181

Sprung, J., Roberts, R. O., Weingarten, T. N., Nunes Cavalcante, A., Knopman, D. S., Petersen, R. C., Hanson, A. C., Schroeder, D. R., & Warner, D. O. (2017). Postoperative delirium in elderly patients is associated with subsequent cognitive impairment. *British Journal of Anaesthesia*, *119*(2), 316–323. https://doi.org/10.1093/bja/aex130

Stewart, J. N., Mounir, S., & Talbot, P. J. (1992). Human coronavirus gene expression in the brains of multiple sclerosis patients. Virology, *191*(1), 502–505. https://doi.org/10.1016/0042-6822(92)90220-J

Suhr, J. A., & Gunstad, J. (2005). Further exploration of the effect of "diagnosis threat" on cognitive performance in individuals with mild head injury. *Journal of the International Neuropsychological Society: Jins*, *11*(1), 23–29. https://doi.org/10.1017/S1355617705050010

Svenningsen, H., Egerod, I., Christensen, D., Tønnesen, E. K., Frydenberg, M., & Videbech, P. (2015). Symptoms of posttraumatic stress after intensive care delirium. *BioMed Research International*, *2015*, 876947–876949. https://doi.org/10.1155/2015/876947

Talbot, P. J., Ekandé, S., Cashman, N. R., Mounir, S., & Stewart, J. N. (1993). Neurotropism of human coronavirus 229E. *Advances in Experimental Medicine and Biology*, *342*, 339–346. https://doi.org/10.1007/978-1-4615-2996-5_52

Tanev, K. S., Pentel, K. Z., Kredlow, M. A., & Charney, M. E. (2014). PTSD and TBI co-morbidity: Scope, clinical presentation and treatment options. *Brain Injury*, *28*(3), 261–270. https://doi.org/10.3109/02699052.2013.873821

Taylor, A. K., Fothergill, C., Chew-Graham, C. A., Patel, S., & Krige, A. (2019). Identification of post-traumatic stress disorder following ICU. *The British Journal of General Practice : The Journal of the Royal College of General Practitioners*, *69*(680), 154–155. https://doi.org/10.3399/bjgp19X701765

Tobe, E. (2012). Progressive neuropsychiatric and brain abnormalities after smoke inhalation. Case *Reports*, *2012*(aug07 1), bcr0220125945–bcr0220125945. https://doi.org/10.1136/bcr-02-2012-5945

Twigg, E., Humphris, G., Jones, C., Bramwell, R., & Griffiths, R. D. (2008). Use of a screening questionnaire for post-traumatic stress disorder (PTSD) on a sample of UK ICU patients. *Acta Anaesthesiologica Scandinavica*, *52*(2), 202–208. https://doi.org/10.1111/j.1399-6576.2007.01531.x

van den Berg, E., Reijmer, Y. D., de Bresser, J., Kessels, R. P. C., Kappelle, L. J., & Biessels, G. J. (2010). A 4 year follow-up study of cognitive functioning in patients with type 2 diabetes mellitus. *Diabetologia*, *53*(1), 58–65. https://doi.org/10.1007/s00125-009-1571-9

Varela, V. S., Ng, A., Mauch, P., & Recklitis, C. J. (2011). Posttraumatic stress disorder (PTSD) in survivors of Hodgkin's lymphoma: Prevalence of PTSD and partial PTSD compared with sibling controls: PTSD in survivors of Hodgkin's lymphoma. *Psycho-Oncology*, *22*(2), 434–440. https://doi.org/10.1002/pon.2109

Vasterling, J. J., Duke, L. M., Brailey, K., Constans, J. I., Allain, A. N., & Sutker, P. B. (2002). Attention, learning, and memory performances and intellectual resources in Vietnam veterans: PTSD and no disorder comparisons. *Neuropsychology*, *16*(1), 5–14. https://doi.org/10.1037/0894-4105.16.1.5

Verfaellie, M., Lafleche, G., Spiro, A., & Bousquet, K. (2014). Neuropsychological outcomes in OEF/OIF veterans with self-report of blast exposure: Associations with mental health, but not MTBI. *Neuropsychology*, *28*(3), 337–346. https://doi.org/10.1037/neu0000027

Wade, D., Hardy, R., Howell, D., & Mythen, M. (2013). Identifying clinical and acute psychological risk factors for PTSD after critical care: A systematic review. *Minerva Anestesiologica*, *79*(8), 944–963.

Waldron-Perrine, B., Tree, H. A., Spencer, R. J., Suhr, J., & Bieliauskas, L. (2015). Informational literature influences symptom expression following mild head injury: An analog study. *Brain Injury*, *29*(9), 1051–1055. https://doi.org/10.3109/02699052.2015.1004742

Walter, K. H., Palmieri, P. A., & Gunstad, J. (2010). More than symptom reduction: Changes in executive function over the course of PTSD treatment. *Journal of Traumatic Stress*, *23*(2), 292–295. https://doi.org/10.1002/jts.20506

Weinhouse, G. L., Schwab, R. J., Watson, P. L., Patil, N., Vaccaro, B., Pandharipande, P., & Ely, E. W. (2009). Bench-to-bedside review: Delirium in ICU patients—Importance of sleep deprivation. *Critical Care (London, England)*, *13*(6), 234. https://doi.org/10.1186/cc8131

Westphal, M., Olfson, M., Gameroff, M. J., Wickramaratne, P., Pilowsky, D. J., Neugebauer, R., Lantigua, R., Shea, S., & Neria, Y. (2011). Functional impairment in adults with past posttraumatic stress disorder: Findings from primary care. *Depression and Anxiety*, *28*(8), 686–695. https://doi.org/10.1002/da.20842

Whittaker, R., Kemp, S., & House, A. (2007). Illness perceptions and outcome in mild head injury: A longitudinal study. *Journal of Neurology, Neurosurgery, and Psychiatry*, *78*(6), 644–646. https://doi.org/10.1136/jnnp.2006.101105

Wilcox, M. E., Brummel, N. E., Archer, K., Ely, E. W., Jackson, J. C., & Hopkins, R. O. (2013). Cognitive dysfunction in ICU patients: Risk factors, predictors, and rehabilitation interventions. *Critical Care Medicine*, *41*(9 Suppl 1), S81–S98. https://doi.org/10.1097/CCM.0b013e3182a16946

Wolters, A. E., Peelen, L. M., Welling, M. C., Kok, L., de Lange, D. W., Cremer, O. L., van Dijk, D., Slooter, A. J. C., & Veldhuijzen, D. S. (2016). Long-term mental health problems after delirium in the ICU*. *Critical Care Medicine*, *44*(10), 1808–1813. https://doi.org/10.1097/CCM.0000000000001861

Wu, K. K., Chan, S. K., & Ma, T. M. (2005). Posttraumatic stress after SARS. *Emerging Infectious Diseases*, *11*(8), 1297–1300. https://doi.org/10.3201/eid1108.041083

Wu, Y., Xu, X., Chen, Z., Duan, J., Hashimoto, K., Yang, L., Liu, C., & Yang, C. (2020). Nervous system involvement after infection with COVID-19 and other coronaviruses. *Brain, Behavior, and Immunity*, *87*, 18–22. https://doi.org/10.1016/j.bbi.2020.03.031

Xiao, H., Zhang, Y., Kong, D., Li, S., & Yang, N. (2020). Social capital and sleep quality in individuals who self-isolated for 14 days during the coronavirus disease 2019 (COVID-19) outbreak in January 2020 in China. *Medical Science Monitor: International Medical Journal of Experimental and Clinical Research*, *26*, e923921. https://doi.org/10.12659/MSM.923921

Xie, J., Tong, Z., Guan, X., Du, B., Qiu, H., & Slutsky, A. S. (2020). Critical care crisis and some recommendations during the COVID-19 epidemic in China. *Intensive Care Medicine*, *46*(5), 837–840. https://doi.org/10.1007/s00134-020-05979-7

Yeh, E. A., Collins, A., Cohen, M. E., Duffner, P. K., & Faden, H. (2004). Detection of coronavirus in the central nervous system of a child with acute disseminated encephalomyelitis. *Pediatrics*, *113*(1 Pt 1), e73–e76. https://doi.org/10.1542/peds.113.1.e73

Zhang, Y., Xiao, M., Zhang, S., Xia, P., Cao, W., Jiang, W., Chen, H., Ding, X., Zhao, H., Zhang, H., Wang, C., Zhao, J., Sun, X., Tian, R., Wu, W., Wu, D., Ma, J., Chen, Y., Zhang, D., … Zhang, S. (2020). Coagulopathy and antiphospholipid antibodies in patients with COVID-19. *The New England Journal of Medicine*, *382*(17), e38. https://doi.org/10.1056/NEJMc2007575