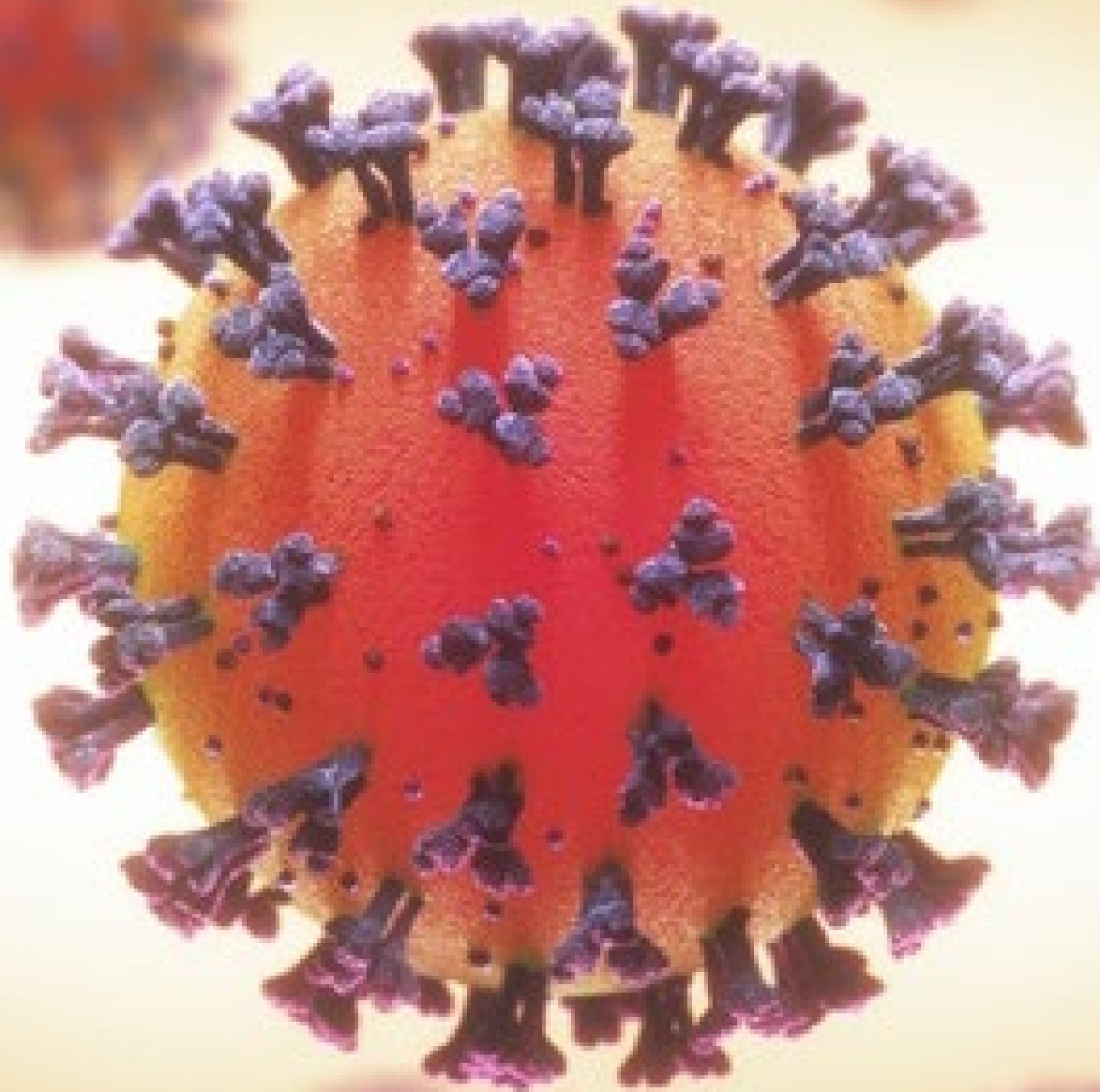


**PROT✕ and  
COVID-19**



April 1, 2020  
<http://protxx.com>

# PROTXX and COVID-19

**1. Challenge: Patients and healthcare workers with potential COVID-19 neurological infections need to be identified earlier in order to receive appropriate treatment and rehabilitation.**

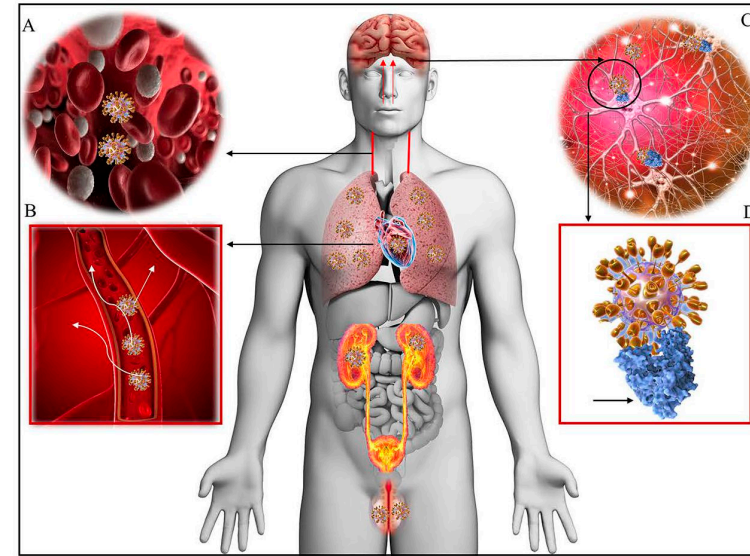
- Neurological infection is the most common extra-respiratory complication in COVID-19 patients.
- COVID-19 neurological infections lead to impairments of multiple physiological systems, including the central nervous system, peripheral nervous system, and musculo-skeletal system.
- Neurological symptoms are significantly more prevalent in severe COVID-19 cases, and carry poorer prognoses, higher mortality rates, and shorter times to death.

**2. PROTXX Solution. The PROTXX physiological tremor sensor (PTS) enables rapid, non-invasive, and highly sensitive identification and quantification of potential neurological impairments in COVID-19 patients and healthcare workers, providing a *comprehensive picture of each patient's unique impairment signature and each patient's unique recovery trajectory.***

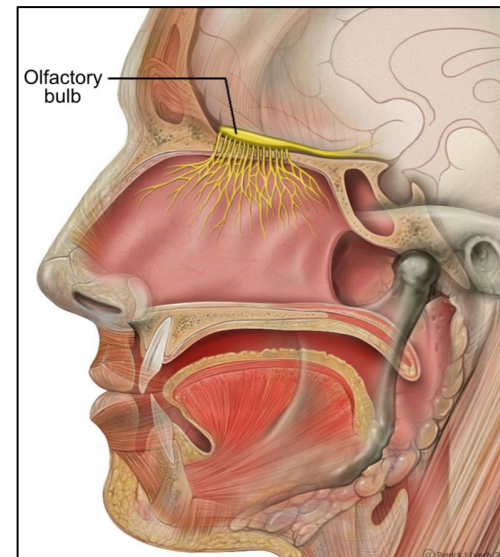
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# Background: COVID-19 and Neurological Impairments

- **COVID-19 patients with neurological infection have worse outcomes and higher mortality rates.**
  - Widely documented studies of the pathology of human influenza reveal that **central nervous system (CNS) infection is the most common extra-respiratory complication** [1], and evidence exists for influenza virus CNS invasion along the olfactory route, especially in immuno-compromised individuals [2, 3].
  - **Neurological and respiratory tract infections in Coronavirus patients have been observed to show distinct features** [4], and influenza viruses have been linked to neurodegenerative sequelae including Parkinson's symptoms, postencephalitis Parkinson's disease [5].
  - Published evidence now exists for COVID-19 targeting the CNS [6], and CNS infection may be the major cause of death even when low levels of the virus are detected in the lungs [3]. Published studies of infected patients in China also reveal how the neuro-invasive potential of the SARS-CoV2 virus that causes COVID-19 may accelerate respiratory failure [7].
  - COVID-19 neurological symptoms fall into three categories [8]: **central nervous system (CNS) symptoms** or diseases (headache, dizziness, impaired consciousness, ataxia, acute cerebrovascular disease, including ischemic stroke and cerebral hemorrhage, and epilepsy), **peripheral nervous system (PNS) symptoms** (hypogeusia, hyposmia, hypopsia, and neuralgia), and **skeletal muscular symptoms**.
  - Neurological symptoms were significantly more common in severe COVID-19 cases as compared with non-severe cases, and carried poorer prognoses, higher mortality rates, and shorter times to death [8].



*Dissemination of COVID-19 virus throughout the body via the blood stream. The lungs, heart, kidneys, intestines, brain, and testicles are well-known to express ACE2 receptors and are possible targets of COVID-19 [6].*



*CNS infection may occur via circulation and/or an upper nasal transcribrial route that enables the COVID-19 to reach the brain via neurons in the nose (olfactory bulb) [2]. The virus can then rapidly spread to connecting nerve cells and bind and engage with ACE2 receptors, resulting in extensive nerve damage. CNS infection can be the major cause of death even when low levels of the virus are detected in the lungs [3].*

# Background: COVID-19 and Neurological Impairments

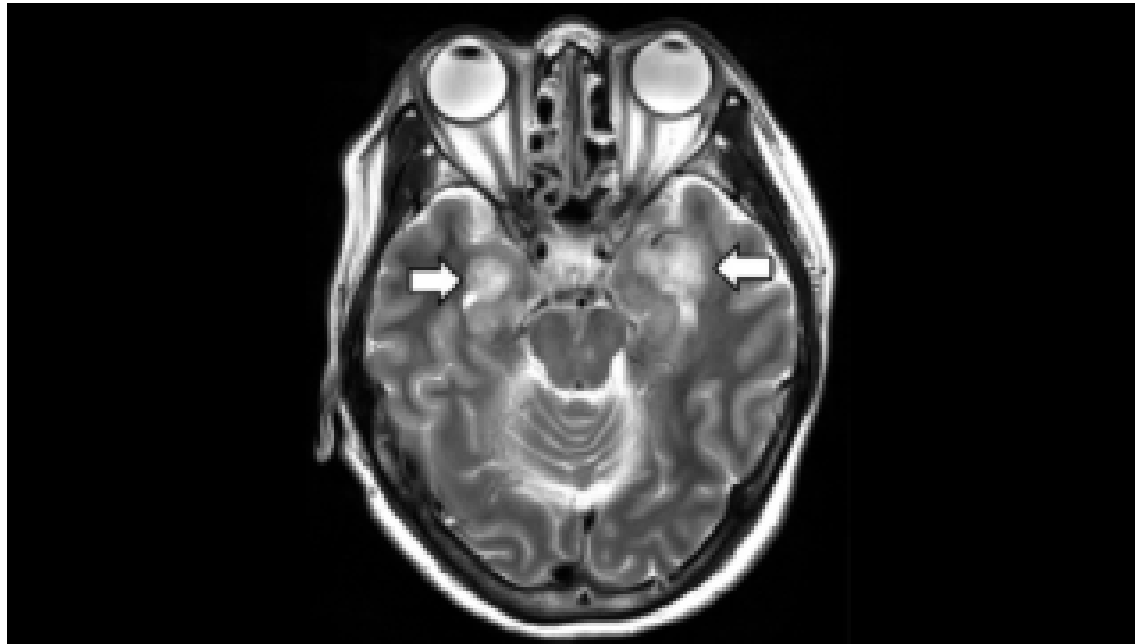
## References:

- [1] *"Pathology of Human Influenza Revisited."* Kuiken T et al. Vaccine. 2008; 26(Suppl 4): D59–D66.
- [2] *"Evidence for Influenza Virus CNS Invasion along the Olfactory Route."* van Riel D et al. Journal of Infectious Diseases. 2014; 210: 419–423.
- [3] *"Severe Acute Respiratory Syndrome Coronavirus Infection Causes Neuronal Death in the Absence of Encephalitis in Mice Transgenic for Human ACE2."* Netland J et al. Journal of Virology. 2008; 82(15): 7264–7275.
- [4] *"Coronavirus Infections in the Central Nervous System and Respiratory Tract Show Distinct Features."* Li Y et al. Intervirology. 2016; 59: 163–169.
- [5] *"Parkinson's disease or Parkinson symptoms following seasonal influenza."* Toovey S et al. Influenza and Other Respiratory Viruses. 2011; 5(5): 328–333.
- [6] *"Evidence of the COVID-19 Virus Targeting the CNS: Tissue Distribution, Host–Virus Interaction, and Proposed Neurotropic Mechanisms."* Baig AM et al. <https://pubs.acs.org/doi/10.1021/acscchemneuro.0c00122>
- [7] *"The Neuroinvasive Potential of SARS-CoV2 May Play a Role in the Respiratory Failure of COVID-19 Patients."* J Med Virol. 2020; 1–4. doi: 10.1002/jmv.25728
- [8] *"Neurological Manifestations of Hospitalized Patients with COVID-19 in Wuhan, China: a Retrospective Case Series Study."* Mao L et al, medRxiv 2020. doi: <https://doi.org/10.1101/2020.02.22.20026500>.

# COVID-19 Neurological Impairments in the News

## ***“Some Coronavirus Patients Show Signs of Brain Ailments”***

**New York Times – 4/1/2020:** <https://www.nytimes.com/2020/04/01/health/coronavirus-stroke-seizures-confusion.html>



## ***“In Some Cases, COVID-19 May Harm the Brain”***

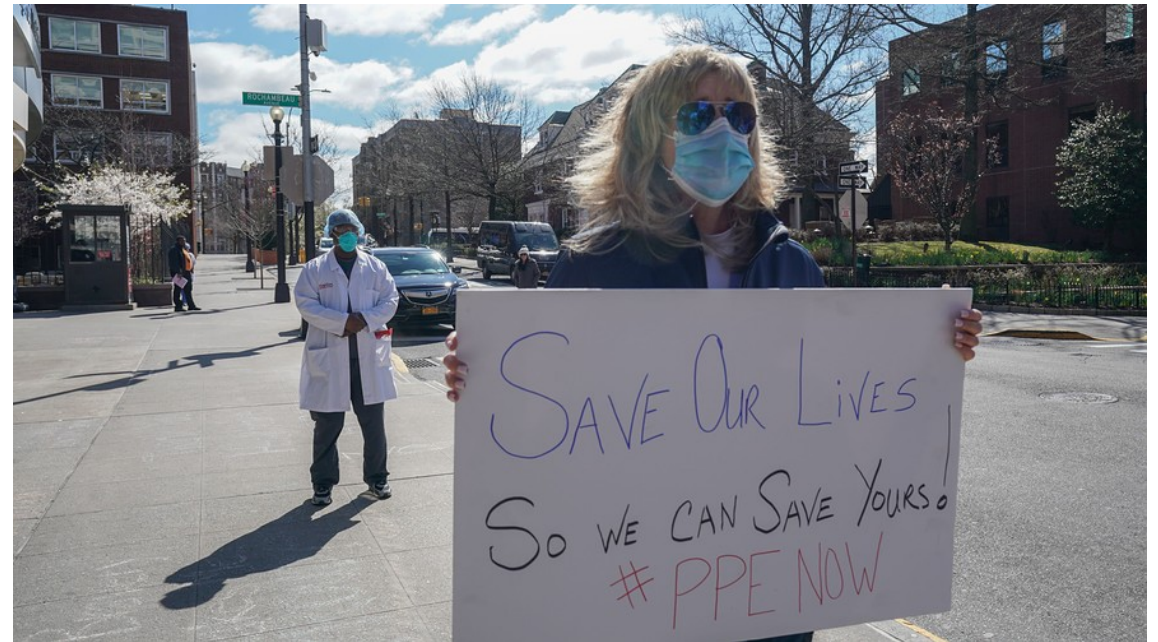
**WebMD – 4/2/2020:** <https://www.webmd.com/lung/news/20200402/in-some-cases-covid-19-may-harm-the-brain#1>



# Healthcare Workers at Risk as Well

***“Covid-19 hits doctors, nurses and EMTs, threatening health system”***

Washington Post – 3/17/2020: [https://www.washingtonpost.com/health/covid-19-hits-doctors-nurses-emts-threatening-health-system/2020/03/17/f21147e8-67aa-11ea-b313-df458622c2cc\\_story.html](https://www.washingtonpost.com/health/covid-19-hits-doctors-nurses-emts-threatening-health-system/2020/03/17/f21147e8-67aa-11ea-b313-df458622c2cc_story.html)



***“COVID-19: protecting health-care workers”***

The Lancet – 3/21/2020: [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(20\)30644-9/fulltext](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)30644-9/fulltext)

# A Call to Action from the American Academy of Neurology

- American Academy of Neurology call for papers on neurologic aspects of COVID-19 infection:  
<https://www.neurology.org/covid>

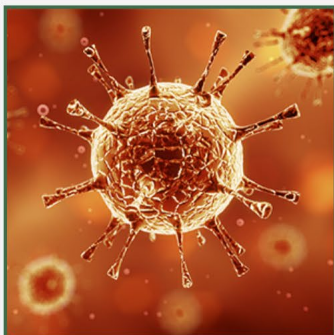
## Neurology<sup>®</sup> Journals



### COVID-19 and neurologic disease

#### Call for Papers!

Expedited Peer Review and Online Publication



*Neurology* is interested in papers that address the neurologic aspects of COVID-19 infection and challenges to the management of patients with chronic neurologic conditions who have, or are at risk for, the infection. Papers that pass internal review will undergo expedited peer review and online publication. We will consider papers posted in preprint servers. Submit observational studies and clinical trials as Articles, and case series and case reports as Clinical/Scientific Notes.

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# PROTXX PTS and COVID-19

- ***There will not be a one-size-fits-all solution for COVID-19. Patients with potential neurological infections need to be identified earlier and will require specialized therapeutic treatments and longer rehabilitation times.***
- The PROTXX sensor can be utilized for rapid, non-invasive, and highly sensitive identification and quantification of neurological impairments in ***COVID-19 patients and healthcare workers.***
- PROTXX sensor data provide a comprehensive picture of each patient's ***unique neurological impairment signature*** at the time of presentation and each patient's ***unique recovery trajectory*** throughout treatment.
- The PROTXX sensor is already utilized to identify and quantify neurological impairments resulting from age-related disorders (e.g. stroke), disease (e.g. Parkinson's), injuries (e.g. concussions and sub-concussive head impact exposure), and medical treatment (e.g. invasive neurosurgeries) based upon their ***unique underlying physiological impairment signatures.***