

## Not All Storms are Hurricanes

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Normally the immune system is a wonderful network of biological processes in our bodies made up of organs, cells and chemicals that allow our bodies to fight off infections. The organs involved that have immune function include the lymph nodes and the draining system that

connects them, the spleen, the thymus and the bone marrow. Our white blood cells make antibodies to attack viruses, bacteria and other invaders that try to infect our bodies. And then there are a whole host of chemicals called cytokines that participate in the immune response.

If a young child were to get a cold, rhinovirus would invade their body through the nose. In order to fight off the infection, the child might get a low grade fever, a runny nose, and inflamed nasal passages to fight the infection. This is a normal immune response. The reason we never become immune to the common cold is because there are over 90 versions of the common cold in Colorado alone. While you develop immunity to the ones you have had in the past, there are so many out there that you will inevitably get a cold again and again in your lifetime.

Sometimes the immune system thinks that your own body is the invader and it will attack itself. This occurs in autoimmune diseases like rheumatoid arthritis, lupus, crohn's disease, ulcerative colitis and many more diseases.

With COVID-19, the body's immune system reacts to the invading virus, but in some people it reacts more strongly than necessary. In doing so it damages (usually temporary) more healthy organs than it should. This is technically different from when the body intentionally attacks itself as it

### **All Possible Symptoms From Cytokine Storm**

Pneumonitis - inflamed lungs  
Pulmonary edema - water on the lungs  
Dyspnea -shortness of Breath  
Hypoxia - low oxygen  
Lymphadenopathy - swollen glands  
Hepatomegaly - enlarged liver  
Transaminitis - elevated liver enzymes  
Hypoalbuminemia - low protein levels  
Liver injury  
Cholestasis - sludge in the bile ducts  
Liver failure  
Acute kidney injury  
Kidney failure  
Confusion  
Delirium  
Aphasia - unable to speak or understand  
Seizures  
Hearing loss  
Fever  
Anorexia - loss of appetite  
Fatigue  
Hypotension - low blood pressure  
Tachycardia - high heart rate  
Cardiomyopathy - enlarged heart  
Vasculitis - inflamed blood vessels  
Arthritis  
Nausea  
Vomiting  
Diarrhea  
Ascites - fluid in the abdomen  
Rash  
Edema - swelling under the skin  
Cytopenias - low blood counts  
Coagulopathy - blood clots  
Shock  
Hemorrhage - bleeding

does with auto immune diseases. When the chemicals overreact to an invader, like COVID-19, it is called a cytokine storm.

The onset and duration of the cytokine storm varies depending on the cause and the treatment of the disease, in this case COVID-19. The most common symptoms are fever, fatigue, loss of appetite, headache, muscle and joint aches, and neuropsychiatric symptoms (i.e. foggy head, confusion, depression, numbness and tingling). Some have diarrhea or a rash. When it affects the lungs, patients can experience cough, shortness of breath and chest pain, which can progress to hospitalization and admission to the intensive care unit. Worse case scenario, patient also get blood clots (disseminated intravascular coagulation), bleeding, low oxygen levels and severely low blood pressure.

So when you get sick from an infection, your symptoms are a combination of those produced by the invader and those caused by your own body trying to get rid of the invader. In this chart, I've included all possible symptoms of the cytokine storm, as we have seen patient with every possible manifestation. Sometimes the symptoms are mild like a spring sun shower, other times like a drenching downpour and at its worst a category 5 hurricane. Some of the symptoms like fatigue, memory fog and hearing loss have lingered, like puddles and washed out gulleys.

For the scientists, during a cytokine storm there are elevations in chemicals called interferon gamma, interleukin-6, interleukin-10, and soluble interleukin-2 receptor alpha, a marker of T cell activation. Most of the medications that have been tried to prevent COVID-19 deaths block these molecules from working. Emapalumab blocks interferon gamma. Anakinra, siltuximab, and tocilizumab all try to block pathways around interleukin-6.

Now, let's turn to the vaccine. The purpose of getting a vaccine is to coerce the body into producing an immune response to a protein that looks identical to the invader that you are trying to avoid. So with the COVID-19 vaccine, it produces a protein that can't give you COVID-19 but can trick the immune system into reacting so that your body can build protection against future exposures. As a result you may feel mild common symptoms from the cytokines as your body fights off the vaccine and also builds antibodies. If you have not had COVID-19, the first vaccine will likely give you a brief sore arm and some fatigue. The second vaccine will likely give you a brief sore arm, fever, chills, body aches and fatigue. If you have had COVID-19, the first shot is really your second exposure to the virus so it will hit you harder than your friends who did not have COVID-19. Your first vaccine will likely give you a brief sore arm, fever, chills, body aches, and fatigue with the second shot being more mild. But then voilá! You are protected.