

SCIENCE REVIEW:

PFAS, Covid-19, and the Immune System

In the midst of a global Covid-19 pandemic, the fact that there is almost universal exposure to PFAS chemicals that can harm the immune system is troubling. The potential links between these twin crises was summed up by Congressman Harley Rouda, House Oversight and Reform Environment Subcommittee Chairman:

“We know that PFAS exposure, which weakens immune systems, causes diseases like cancer, and is reported to reduce antibody responses to vaccines, could create the perfect Covid-19 storm in communities across the United States.”¹

Scientists don't understand all of the reasons why some individuals get Covid-19 and experience few or no symptoms while others fall gravely ill or die from the disease. It is unclear whether high PFAS exposure may or may not be playing a role in some cases. What we do know is that PFAS weakens the immune system, and people with weakened immune systems are likely to have worse outcomes from Covid-19 infection.

This document is intended to provide a high-level overview of the science around PFAS and how it intersects with the major public health threat posed by Covid-19.²



Immune System Basics

The immune system is how the human body prevents and limits infection from pathogens such as viruses, bacteria, and fungi that can cause disease. It also plays an important role in identifying and killing mutated cells. It is a highly complex and important system made up of organs, cells, and proteins that work together throughout our bodies.³ If the immune system is not functioning properly, this can lead to health problems.

People with weakened immune systems are more likely to get sick from infectious diseases and can experience lowered response from vaccines. A hypersensitive immune system can lead to allergies, asthma, or autoimmune diseases.^{4,5} PFAS exposures have been linked to each of these immune system disorders, and all of which pose unique concerns as we face the Covid-19 global pandemic.

PFAS can lower resistance to infectious diseases

PFAS can weaken the immune system and make people more likely to catch infectious diseases like colds, stomach bugs—and potentially Covid-19. This is suggested by several studies finding people with higher exposures to PFAS are at increased risk of communicable diseases.

In one study of Norwegian families, children born to mothers with higher levels of the PFAS chemicals PFOA and PFNA had more colds in early childhood and children with higher levels of PFOA and PFHxS had more gastroenteritis (stomach flu).⁶ In Japan, mothers with higher blood measurements of PFOS during pregnancy reported more infectious illness among their children and young girls whose mothers had higher PFHxS levels also had more infectious illness.⁷

In Denmark, mothers with higher levels of PFOA and PFOS were more likely to have children who developed fever during the

study period, which is notable since fever is a marker of a variety of kinds of infections.⁸ The authors of this study also noted that this “finding is in agreement with an immune-suppressive effect of prenatal exposure to PFAS. The wider implications for childhood infectious disease deserve attention.”

There has been enough concern around how PFAS chemicals impact the immune system that the Centers for Disease Control and Prevention (CDC) issued a statement on the “Potential Intersection between PFAS Exposure and Covid-19”, which acknowledged that PFAS exposure “may reduce infectious disease resistance.”⁹

While we don’t have direct evidence that PFAS exposure increases people’s risks of coming down with Covid-19, there is real reason to believe that this is likely, and we urgently need more research into this question.

PFAS can reduce vaccine effectiveness

Antibody production is an important component of the immune system. Vaccines work by training the immune system: when the body senses the presence of a virus, bacteria, or other pathogen that it has been vaccinated for, it produces proteins known as antibodies that attack that particular type of foreign invader (the measles virus, for example). If the body consistently produces enough effective antibodies after vaccination, then that person is considered “immune” and very likely won’t get sick from a disease.

However, not everyone who is vaccinated will become immune. According to the World Health Organization, most routine childhood vaccines are effective for 85% to 95% of recip-

ients.¹⁰ People whose bodies don’t produce enough antibodies after vaccination are more likely to fall ill from that particular disease.

What is highly concerning is that nearly a dozen studies have found significant decreases in antibody production in people with higher levels of PFAS exposure. These studies measure antibodies a person produces in response to common vaccines, and consistently find people with higher PFAS measurements have lower antibody levels—by as much as a 50%—for a number of different vaccine-prevented illnesses such as tetanus, diphtheria, rubella, mumps, and the flu. (See the table below for a summary of some of the key research.)

Scientific studies showing that PFAS reduces vaccine effectiveness

Population	Finding	Study
Faroe island children	Lower antibody response to tetanus and diphtheria vaccines	Grandjean 2012 ¹¹
Norwegian children	Lower antibody response to rubella vaccine	Granum 2013 ¹²
German 1 year olds	Lower antibody response to flu, tetanus, and diphtheria vaccines	Abraham 2020 ¹³
West African children	Lower antibody response to measles vaccine	Timmermann 2020 ¹⁴
US adolescents	Lower antibody response to rubella and mumps vaccines	Stein 2016 ¹⁵
US adults	Lower antibody response to flu vaccine	Looker 2014 ¹⁶
US adults	Lower antibody response to diphtheria and tetanus booster	Kielsen 2016 ¹⁷
US adults	Lower antibody response to rubella vaccine in adults, no such effect found for adolescents	Pilkerton 2018 ¹⁸

One scientific paper that looked at children in the Faroe islands concluded: “Our findings show that PFAS exposure may inhibit the formation of antibodies and cause more children to be unprotected despite a full regimen of vaccinations.... the strongly decreased antibody concentrations reflect a severe immunological deficit.”¹⁹

In a 2016 review of PFAS immunotoxicity, the National Toxicology Program concluded that two of the most studied members of the large class of PFAS chemicals, PFOA and PFOS, are “an immune hazard to humans based on a high level of evidence from animal studies that PFOA and PFOS suppressed the antibody response and a moderate level of evidence from studies in humans. The evidence that these chemicals affect multiple aspects of the immune system supports the overall conclusion that both PFOA and PFOS alter immune functions in humans.”²⁰

Such findings raise concerns that similar effects from PFAS would be seen after a future Covid-19 vaccination, diminishing its effectiveness in some populations. Since antibody production is an important aspect of a healthy immune response, weakened antibody production could also have a direct effect on a person’s ability to ward off infection with the Covid-19 virus as well as their ability to recover quickly.

Historically vaccines have been critical to protecting the public from communicable diseases.²¹ It is deeply concerning that pollutants like PFAS, which have such intense and lasting effects on our immune systems, could reduce the power of this important public health tool.

Can PFAS worsen the outcome of a Covid-19 infection?

This is a hard question to answer without conclusive data, but the answer is likely yes for several reasons. First, the CDC has stated that “people with weakened immune systems are at higher risk of getting severely sick” from Covid-19.²² We know that people with high PFAS exposure often have weaker immune systems, which can make them less able to fight off viral infections and become more severely ill when they do get infected.

Second, some studies have also linked high PFAS exposure to autoimmune diseases such as ulcerative colitis and rheumatoid arthritis.^{23,24,25} The CDC has warned that people

taking immune-suppressing medications for these kinds of autoimmune diseases are at increased risk for incidence and severity of Covid-19 infection.²⁶

Third, while there are no studies directly looking at PFAS exposure and Covid-19 mortality, it is becoming clear that some of the same diseases that are linked to PFAS are associated with higher death rates from Covid-19. For example, PFAS exposure is linked to liver damage, asthma, cancer, and certain kinds of cardiovascular conditions, according to a 2018 review of research conducted by the CDC/Agency for Toxic Substances and

Disease Registry.²⁷ A recent large study more than 5600 Covid-19 deaths in the United Kingdom found that people with liver disease, severe asthma, cancer, cardiovascular disease, as well as other health conditions are more likely to die of the infection.²⁸ The CDC has also acknowledged that these same diseases may increase the risk of severe illness from Covid-19.²⁹ While no research has evaluated these disease linkages, their similar patterns indicates that such studies are urgent. The concern is that people with high exposures to PFAS could be more likely to experience more serious infections or die of Covid-19 because they already are more likely to suffer from these aggravating conditions.

Fourth, PFAS can impact the fine tuning of the immune systems, which can cause hypersensitivities like asthma and food allergies, as well as increase risk of developing autoimmune diseases.^{30,31} One type of immune overreaction some people experience during a Covid-19 infection is a “cytokine storm” and

it is one of the most deadly conditions related to the virus, causing extensive damage to the lungs. While not very well understood, the tendency for PFAS to lead to immune system overreaction in some people and the fact that immune overreactions in Covid-19 patients can be deadly raises important questions. This is also an area where there have been no studies directly linking these health endpoints but is a key area for further study.

Concerns about the ability for PFAS exposure to worsen health outcomes for Covid-19 have also been raised by [Dr. Philippe Grandjean](#), Harvard T.H. Chan School of Public Health, who stated: “Given that PFAS are toxic to the immune system, exposure to these persistent chemicals may well worsen the consequences of a Covid-19 infection. Just like [recent studies have shown that areas with more severe air pollution](#) have more severe Covid-19 cases and greater mortality, we should also examine if the same applies to communities with PFAS-contaminated drinking water.”³²

PFAS immune system risks to general population

People with high levels of PFAS chemicals in their bodies due to contaminated drinking water, their diet, or other intense exposures are more likely to experience immune system harm and other adverse health effects. Most human studies have focused on communities with elevated exposures, but the fact is that nearly every American has measurable amounts of PFAS in their bodies. While there are still many things that we don’t know, several studies of the general population in the United States or other places of presumably

lower exposures suggest that PFAS-related immune system problems are not limited to those people who have been exposed to high levels of PFAS drinking water or foods.

One study of randomly selected adolescents from the general population (age 12-19) in the large CDC NHANES study showed impacts on both rubella and mumps antibodies compared to those with lower concentrations of PFOS in their blood samples.³³ Another study of NHANES participants found an

association between rubella antibodies and PFOS for American adult men.³⁴ Researchers who looked at PFAS levels in the blood of Norwegian mothers right after birth and compared it to health outcomes in their children up to age 3 also found troubling results. The scientists found that “PFAS concentrations were associated with reduced antibody levels to the rubella vaccine and increased number of episodes of common cold and gastroenteritis, suggesting that pre-natal exposure to various PFAS may lead to immunosuppression in early childhood.”³⁵ These three studies are all pointing to PFAS-related immune system impacts in the general population.

Due to widespread contamination of food and water with PFAS and other persistent organic pollutants, the concern is that many people in the US and worldwide could have weaker immune systems, including potentially a poorer response to a future Covid-19 vaccine. Notably, about one-quarter of the US population has blood levels that exceed a safety level for PFOS and PFOA set by the German government to ensure exposures are low enough to protect people from PFAS-related health problems including risks to fertility and pregnancy, immune system problems, and thyroid disruption.^{36,37} (It should be noted, of course, that the US is not subject to the German safety level and has set health advisories for drinking water that are quite weak.³⁸)

A second independent assessment also suggests that many Americans have risky levels of exposure to PFAS. Scientists looking at both animal studies together with research on how PFAS chemicals impact the human immune system calculated “benchmark dose” levels of PFOS and PFOA lower than the average blood levels in the US population in 2000.³⁹ (A benchmark dose is the exposure level of a chemical that produces a predetermined change in the response rate, typically

either 5% or 10%, of an adverse effect; this study used a 5% benchmark response.)

With these results, the authors Grandjean and Budtz-Jørgensen went on to state that “the recent evidence on PFC immunotoxicity in humans and toxicity in animal models suggests that current limits for drinking water contamination are too permissive and must be decreased substantially,” and that the “current limits appear to be several hundred fold too high.”⁴⁰ Since 2000 the levels of both PFOA and PFOS have declined, but the latest NHANES data from 2016 indicates that the benchmark dose level calculated by Grandjean and Budtz-Jørgensen is still significantly lower than the average levels of these two chemicals in the blood of Americans (0.3 ng/mL vs. 1.6 ng/mL for PFOA and 1.3 ng/mL vs. 4.8 ng/mL for PFOS).⁴¹

It is also important to recognize that science evolves and often what used to be considered safe is later realized to be unsafe. For example, the “safe” blood level of lead was 60 µg/dl in the 1960s, but this was lowered to 10 µg/dl in 1991 after there was mounting evidence of harm at lower levels.⁴² This trend has continued: today there is no level of lead that is considered safe and a blood lead level of 5 µg/dl is considered elevated.⁴³ Therefore, what is considered to be a “safe” level of PFAS in our bodies today may not be considered safe a decade from now when we have had more time to study the impacts of current exposures. In fact, we have already seen this trend take place with certain PFAS chemicals over the last ten or twenty years: state and federal drinking water guidelines for PFOA and PFOS have decreased significantly over this time period.⁴⁴

The bottom line is there is scientific evidence that the immune system impacts of PFAS do extend to the general population and could make some people more vulnerable to Covid-19 and other infectious diseases.

Covid-19 + toxic chemicals + chronic disease + racial justice

PFAS aren't the only chemicals that have been shown to interfere with antibody response to vaccines, correlate with higher rates of infectious diseases, or adversely affect the immune system in other ways. Such impacts have been detected in people with higher levels of exposure to heavy metals like mercury, arsenic and lead, and other persistent organic pollutants including PCBs, DDT, dioxin, and organochlorine pesticides.^{45,46,47,48,49}

Many of these same toxic chemicals affect people of color and low-income communities disproportionately. For example, a study of more than 30,000 women from the NHANES cohort found significant racial disparities in exposure to heavy metals and pesticides.⁵⁰ Black communities tend to have poorer air quality and Black children are much more likely to have severe lead poisoning.^{51,52} A recent study by NRDC, Coming Clean, and the Environmental Justice Health Alliance for Chemical Policy Reform found that the rate of drinking water violations was higher in communities of color, low-income communities, and areas with higher numbers of non-English speakers.⁵³ This analysis also showed that drinking water systems that had repeated violations year after year were 40 percent more common in places with higher percentages of residents who were people of color.

These findings, of course, are just the tip of the iceberg and mean that communities of color and low-income communities are often experiencing higher exposures to many different chemicals that can impact their immune systems and their health. Like other pollution hotspots, people in PFAS-impacted communities live in "fence-line communities"

where some people bear the brunt of industrial pollution, facing many of the consequences and none of the benefits.

While many factors affect the spread of the Covid-19 virus, the existing data show dramatically higher, disproportionate impacts to Black, Latinx, and Indigenous communities in the United States. This is likely the cumulative toll of many factors, and the increased burden of exposure to pollution may play a part.

Native populations living in Arctic regions are at particular risk for cumulative effects given that persistent contaminants are concentrated in northern latitudes and accumulate in higher levels in the fat of seafood and marine mammals. The rate of infectious disease among Inuit children is quite high and there have been three studies showing that infants with higher exposures to organochlorine compounds are more likely to experience acute respiratory, ear, and gastrointestinal infections.^{54,55,56} Since it is now known that exposure to PFAS chemicals are also elevated in the Arctic, one question worth noting is whether they could be causing additive or synergistic effects on the immune system as this was not examined in earlier studies looking at organochlorine exposure.

These findings underscore the need to look beyond just PFAS and prevent the continued use of toxic chemicals more generally. This is critical to protect the health of our communities, and the health of our immune systems. It is also a reminder that when it comes to persistent pollutants, highly impacted populations can extend to the furthest reaches of the globe and include indigenous communities. ■

Endnotes

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