Research identified physical changes in the blood of airline crews and passengers who breathed oil-contaminated air onboard

A newly published scientific study has identified physical changes to the blood of airline crew members and passengers exposed to toxic oil fumes during normal flights.[1]

Background: Most commercial airliners are designed to extract very hot air from either the main engine compressors or from an auxiliary compressor in the tail. This so-called "bleed air" is cooled and routed to the cabin and flight deck for ventilation and pressurization. Aircraft engines are lubricated with oils that contain organophosphate (OP) additives to improve performance. When oil is heated in an aircraft engine, it decomposes into hundreds of chemical compounds, along with a complex mixture of OPs. The problem is that this bleed air used for onboard ventilation is typically unfiltered. So, during otherwise normal flights, **oil-contaminated ventilation air** can be supplied to the cabin and flight deck, often described as smelling like dirty socks. Although the health and flight safety consequences of breathing these oil fumes have been widely documented, it is hard for crews and passengers to confirm an exposure. Also, except for the B787 aircraft, the industry has not modified its bleed air designs, such that people continue to get sick.

To address this, Professor Clement Furlong led a research team at the University of Washington to develop a new approach to document exposure to the blend of OP chemicals in engine oil fumes. He worked to identify and quantify modifications to the structure of a blood protein called **butyrylcholinesterase (BChE)**.

BChE is an enzyme primarily produced in the liver and released into the plasma. It plays a role in the breakdown of certain neurotransmitters and medications, and it also helps to detoxify certain substances, including OPs. Some studies suggest that it might play a role in the development of Alzheimer's disease.

Results and discussion: The plasma BChE from the blood of **82 subjects** (37 cabin crew, 27 pilots, and 18 passengers) who had reported an oil fume event was extracted, purified, and analyzed for structural changes consistent with exposure to the OP blends added to most engine oils.

The most dominant and consistent addition ("adduct") to the BChE protein in the plasma samples of fume-exposed people has a molecular mass of 154 Daltons (Da.). This is unexpected. It does not match the mass of the metabolites of the OP chemicals anticipated to be in human blood after breathing oil fumes, based on what has been identified in lab studies. Presumably, that is because this research examined a protein in plasma samples donated by people who – days or weeks earlier -- had **inhaled oil fumes**. This is not the same as examining animals or cells exposed to a liquid sample of oil or oil additives.

Fifty-four people who donated blood had been exposed to oil fumes prior to 2012. In this group, the average measure of how much their BChE was modified by the 154 Da. adduct was, on average, 7.8 times higher than in control subjects who had not reported a fume event or flown in at least three months. The data reported for the BChE modifications in the fume-exposed plasma was conservative because it was not corrected for the time lag between the reported exposure to oil fumes and the blood draw. This matters because a person's plasma BChE is steadily being replenished; after about 12 days, half of a person's BChE – some of which may have been modified by oil fume additives – will have been replaced.

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[1] Furlong, CE; Richter, R; Marsillach, J. et al. Investigating biomarkers of exposure to jet aircraft oil fumes using mass spectrometry, medRxiv 2025, https://www.medrxiv.org/content/medrxiv/early/2025/04/30/2025.04.17.25326021.full.pdf

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Plasma samples from the remaining **28 people** who were exposed to oil fumes from 2016-2024 only showed the 154Da. modification at background levels, like control subjects. This was also unexpected. One explanation for the difference in the measured BChE modifications over time is that the 154Da. adduct could be a product of exposure to an OP called trixylyl phosphate (TXP) which was effectively phased out of engine oil formulations between 2012 and 2016 because of toxicity concerns.

Closing statements: This research identified physical changes to the plasma BChE of crewmembers and passengers exposed to oil fumes. BChE plays an important role in metabolizing certain chemicals, including those in oil fumes. Physical changes to BChE could render it less efficient and, thus, lower a person's tolerance to certain chemicals. People with a genetic variant that results in BChE deficiency may be more at risk of ill effects from exposure to oil fumes on aircraft. Investigation into other blood protein biomarkers correlated with exposure to the current aviation engine oil additives is warranted. The most satisfactory solution would be to eliminate the exposure hazard by implementing bleed-free systems like the B787 or, at a minimum, to develop less toxic oil formulations, suitable bleed air filters, and modified designs.

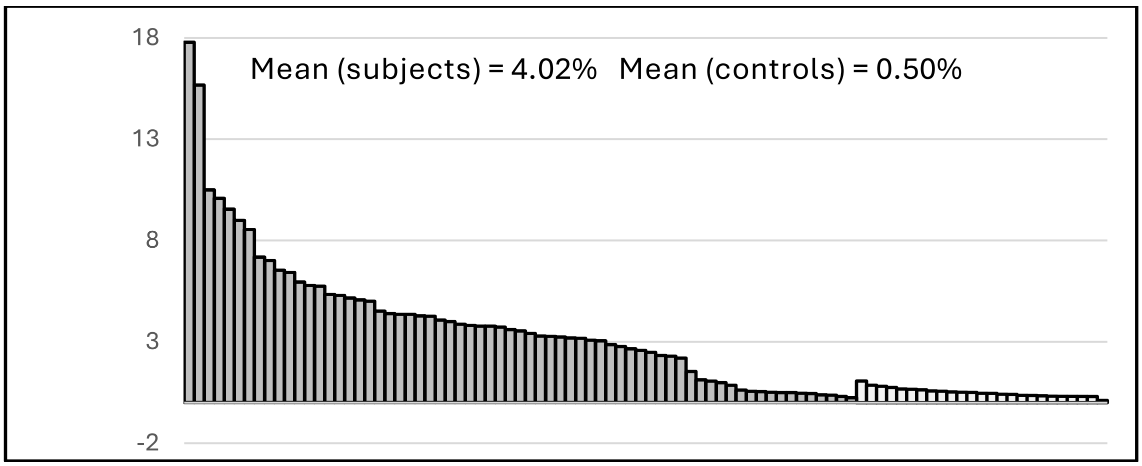

Figure 1: Histogram of "normalized peak area" of the 154 Da. mod. to BChE, reported as a percentage. Solid bars = fume-exposed subjects; Open bars = control subjects. (Reproduced from manuscript.)

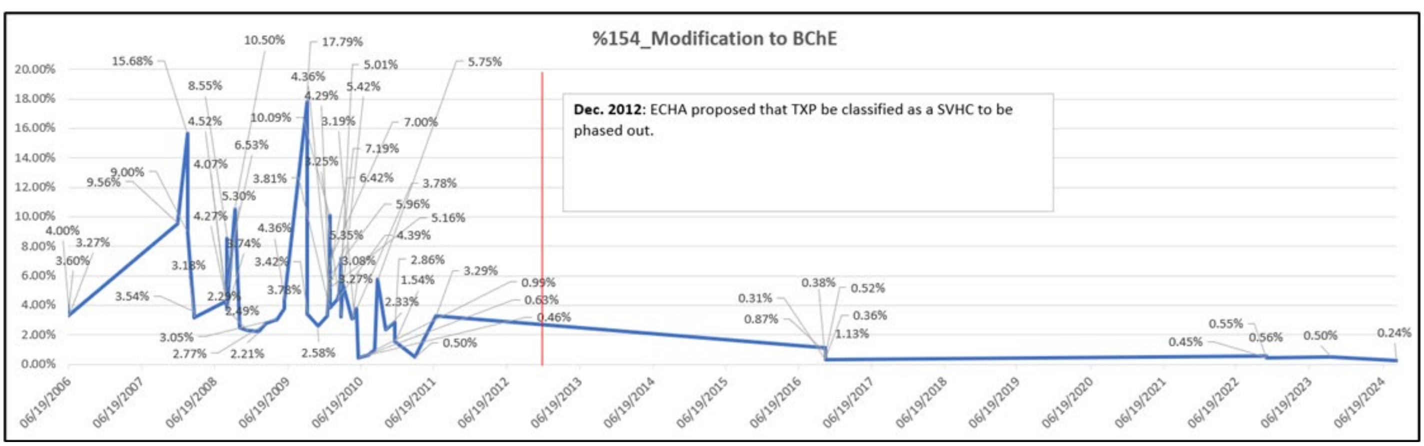

Figure 2. NPA of the 154 Da. mod to BChE (y-axis) as a function of date of exposure to oil fumes (x-axis). (Reproduced from manuscript.)