PFASS, Contamination and Risk

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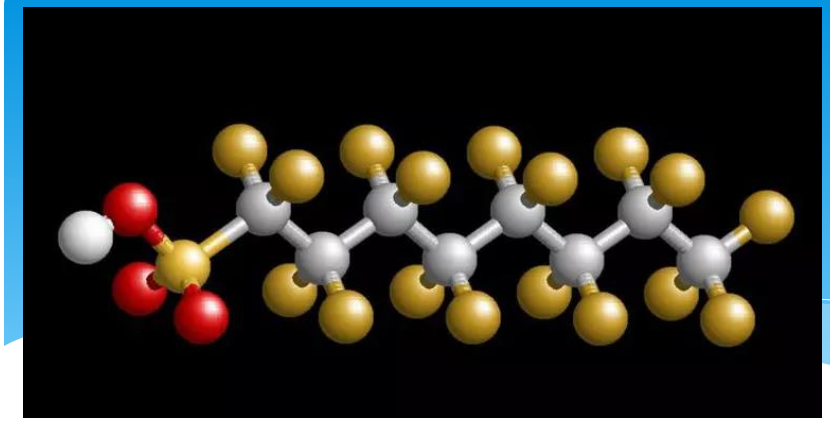

A quick background

* Per- and Polyfluoroalkyl Substances (PFASs)
* Highly fat soluble
* Slow to breakdown
  * Persists in the human body and accumulates
  * Can take 5 years for half an ingested dose of PFAS to be removed
* Used in a variety of industrial processes
  * Stain resistant fabrics
  * Fire fighting foams

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More background

* Firefighting foams
  * Complex mixtures of Various PFASs
  * perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) usually, but not always, present
* PFASs started to be phased out in 2000
* PFASs firefighting foams were withdrawn from service within FRNSW in 2007
* Defence department replaced PFASs firefighting foams by 2012
* South Australia
  * Began phasing out PFOS in 2007 and PFOA in 2014
  * banned PFASs firefighting foams in 2018

Health effects and health concerns

* Major reviews of the impact of PFASs on health
* Persistent Organic Pollutants Review Committee 2015
* Australian Expert Health Panel for PFAS Report 2018
* Potential health issues of relevance to firefighters
  * increased levels of cholesterol in the blood
  * increased levels of uric acid in the blood
  * reduced kidney function
  * alterations in some indicators of immune response
  * altered levels of thyroid hormones and sex hormones
  * earlier menopause

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Sources for PFAS exposure in firefighters

* Use of the PFAS foams themselves
  * Breaching safety equipment
  * Exposure during clean down
* Contaminated dust/vapor from training sites
* Contamination of food plants grown on sites using PFAS
* Exposure from diet and water as part of the general population.

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What are the levels in SA firefighters?

* Little available information
* 2013 Airservices Exposure Study – 149 firefighters mostly from QLD
  * Some firefighters had very high levels of PFOS in blood
  * Peak values ranged from 391 ng/ml to 180 ng/ml PFOS
  * Median values PFOS 66 ng/mL firefighters (178)
  * Median values PFOS 6.8 ng/mL general public Australia
  * Median PFOA same as general public in Australia
  * Levels increased with years of service
  * ten years after the phase out of 3M AFFF, PFOS serum levels remained above 100 ng/mL and 200 ng/mL in 27% and 3% of the participating firefighters, respectively
* BUT no correlation of PFASs with important disease biomarkers
  * Cholesterol, serum lipid
  * Uric acid

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What are the levels in SA firefighters (2)?

* MFS - Fifteen of 329 firefighters tested across SA for PFAS had extremely high levels
  * About 41 per cent of all those tested had levels above 10 ng/ml
    * Which PFAS is not specified in the reports available to me.
    * Assuming PFOS, compared to median Australian values of ~ 5 ng/ml and 95% quartile of ~10 ng/ml in 2016/17 a bit high
    * Guideline values PFOA and for PFOS of 2 ng/ml and 5 ng/ml, respectively
  * 15 had above 100 ng/ml
  * 13 from Largs North
    * Possibly linked to bilge contamination in boat
  * Difficult to compare with Airservices data (6% above 100 ng/ml vs 27% in Airservices if we assume PFOS)

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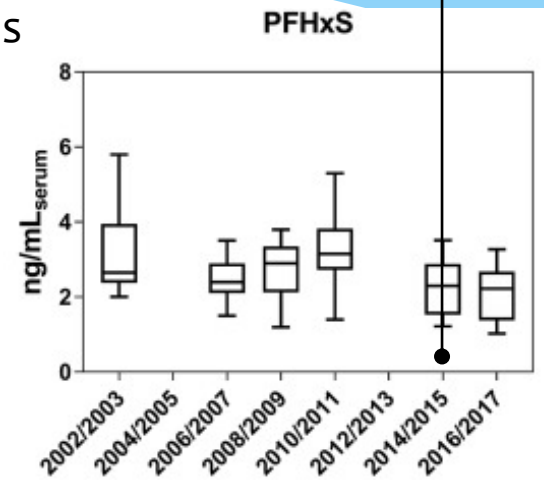
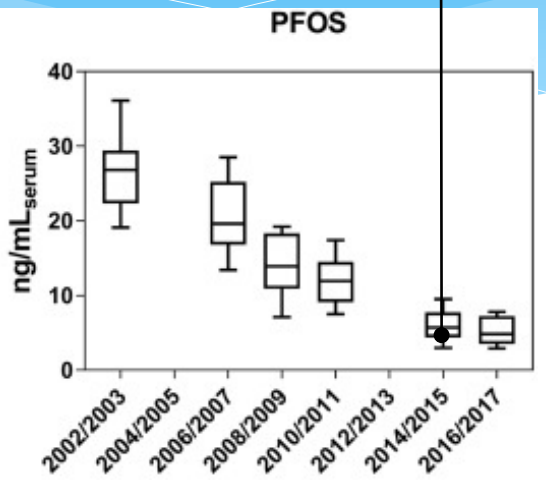
Comparisons with general population

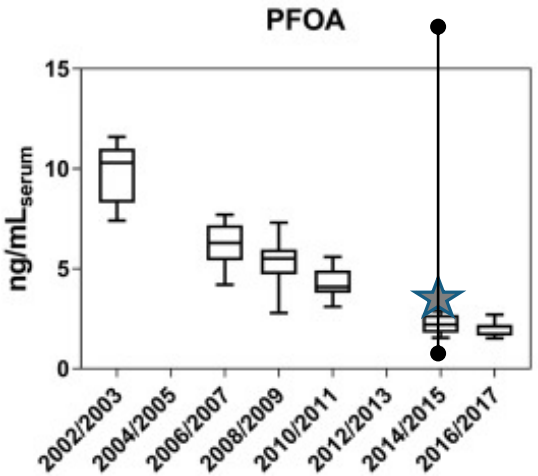
Medians from Airservices Study compared with General Australian population ★

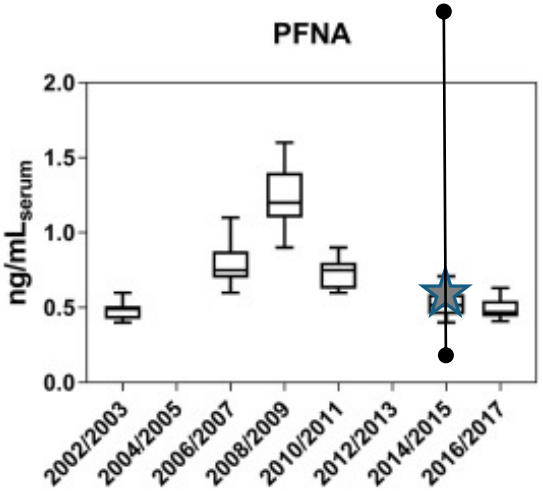
Rotander A, Toms LM, Aylward L, Kay M, Mueller JF. Elevated levels of PFOS and PFHxS in firefighters exposed to aqueous film forming foam (AFFF). Environ Int. 2015 Sep;82:28-34.

Toms LML, Bräunig J, Vijayasarathy S, Phillips S, Hobson P, Aylward LL, Kirk MD, Mueller JF. Per- and polyfluoroalkyl substances (PFAS) in Australia: Current levels and estimated population reference values for selected compounds. Int J Hyg Environ Health. 2019 Apr;222(3):387-394.









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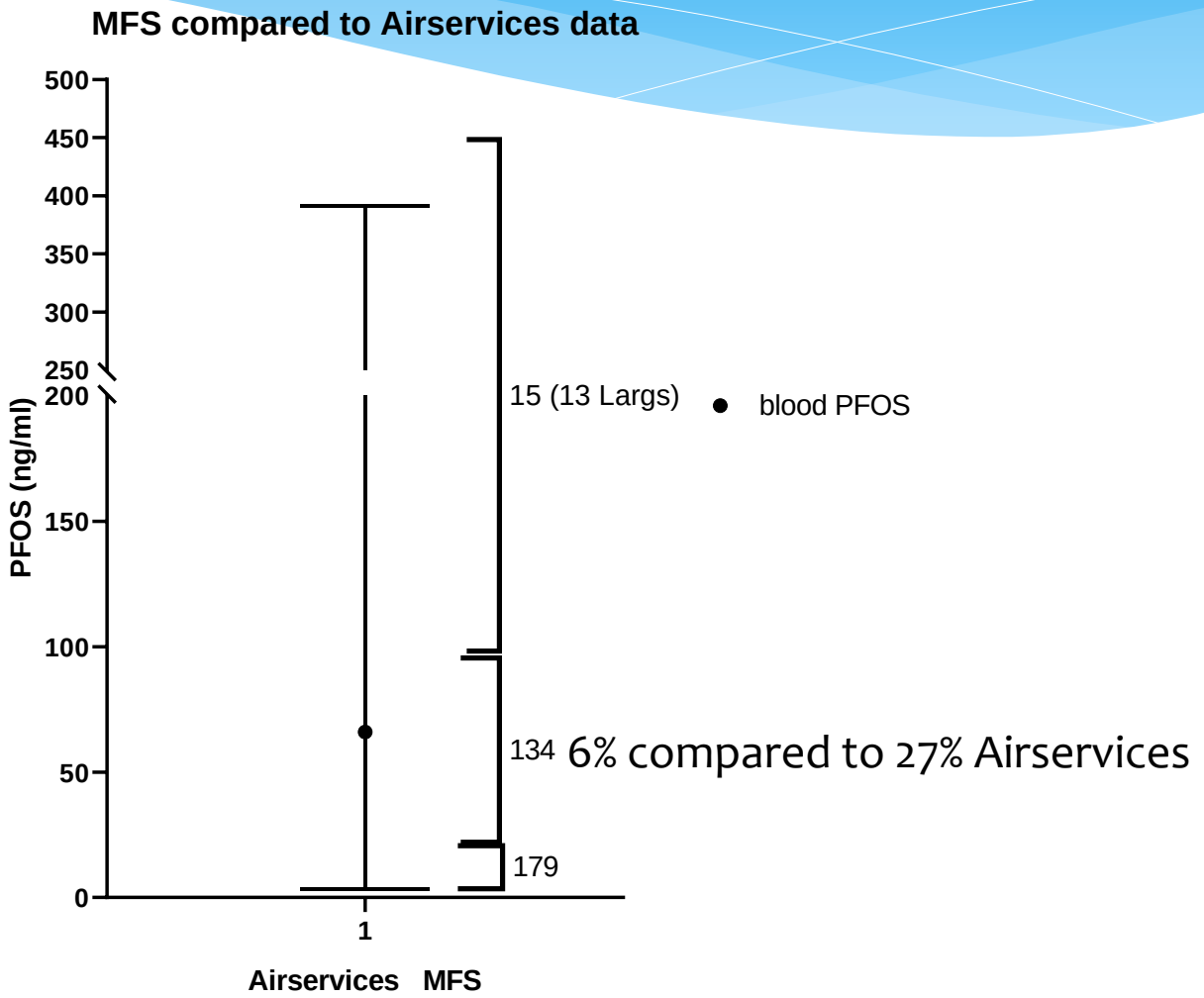
MFS data compared to Airservices



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Compairing the Airservices data with 3M workers

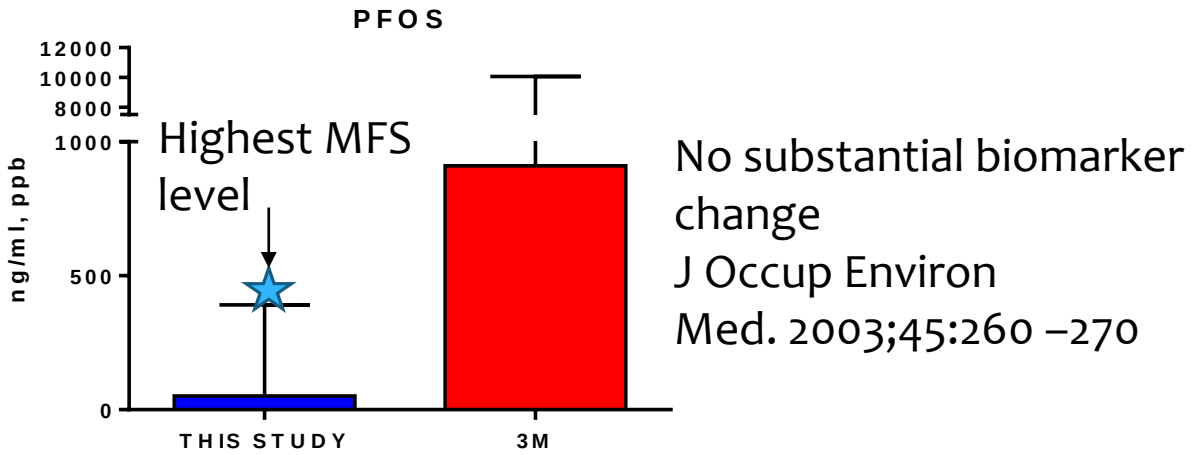

Figure S3. Geometric mean serum concentrations of PFOS (ng/mL) in 149 firefighters and in highly exposed fluorosurfactant manufacturing workers (sera extracted and analyzed in 2000) from the 3M plant in Decatur, Alabama, USA (n=263) (Olsen et al., 2003). The whiskers indicate maximum concentrations. Notice the different scales on the Y-axis.

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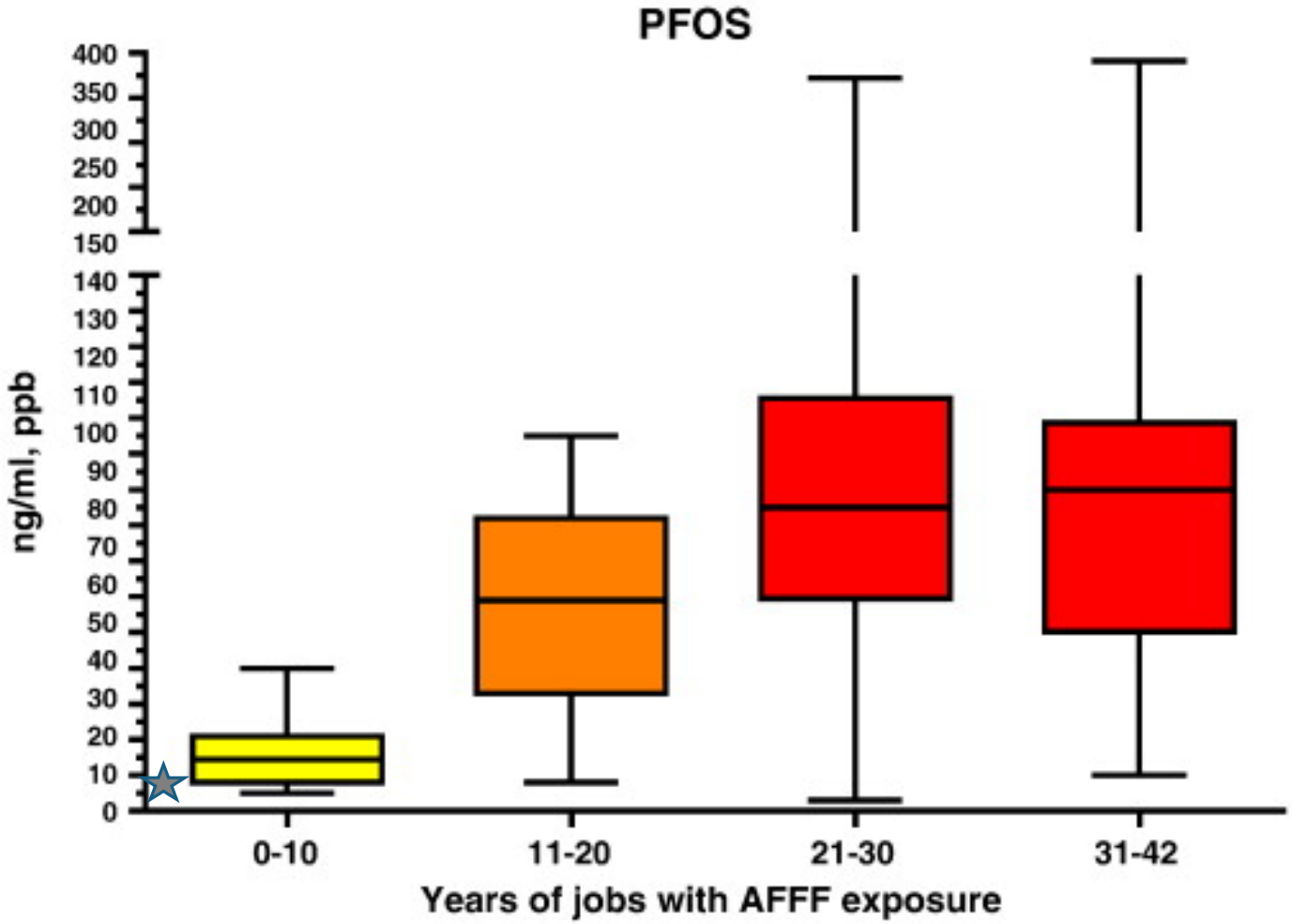
Length of Service and PFOS

Rotander A, Toms LM, Aylward L, Kay M, Mueller JF. Elevated levels of PFOS and PFHxS in firefighters exposed to aqueous film forming foam (AFFF). Environ Int. 2015 Sep;82:28-34.



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Health implications of these levels

* Difficult to determine
* Firefighting foams are complex mixtures
  * Depends on application
* Different PFASs may have different effects
  * A recent study on thyroid hormones showed that PFOS; and PFOA and PFHxS had opposite effects on thyroid hormones.
  * Effects will depend not only on levels but ratios of different components.

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Some technical guff (sorry)

* PFASs (particularly PFOA and PFOS) bind to a class of receptors for fats called peroxisome proliferator activation receptors.
* These can alter fat metabolism, and potentially have effects on heart function and foetal development.

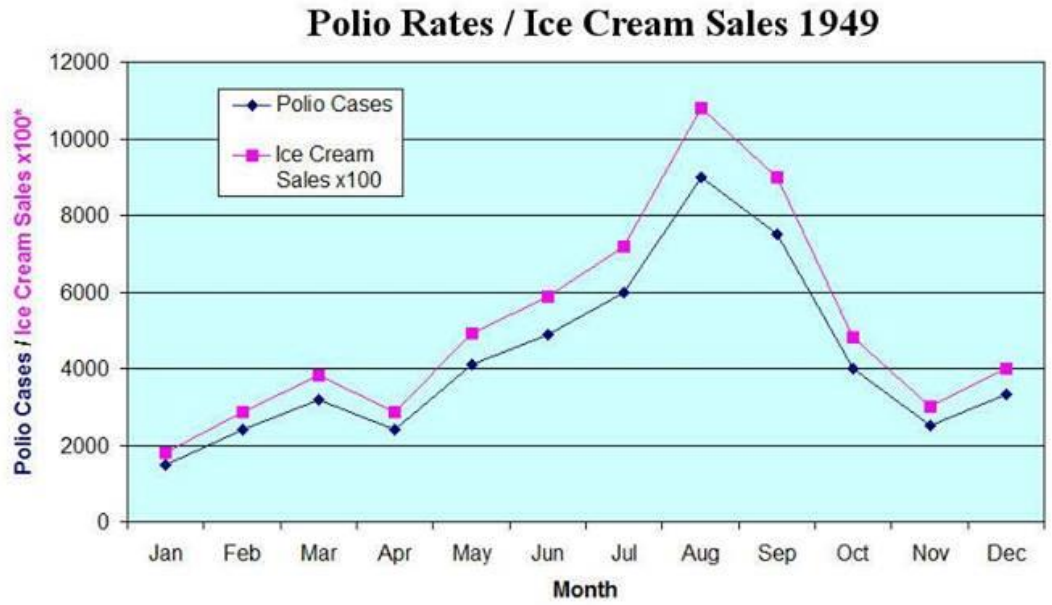
How do we test for health effects?

* Studies on animals
  * Indicative but can be misleading
  * effects on the peroxisome proliferation receptors in rodents occur at concentrations typically a **thousand times** higher than average human blood concentrations and around **100 times** the blood concentrations in contaminated workers.
  * human PPAR less sensitive than mouse receptors
    * mouse and rat studies may overestimate human toxicity
* human community studies
  * Issues with other influences and lack of good exposure monitoring
* studies of industrial workers exposed to high environmental levels.
  * No consistent biomarker changes found (eg J Occup Environ Med. 2003;45:260 –270)

Correlation

Important but not covered today

The Real Cause of Polio!



In the late 1940s, before there was a polio vaccine, public health experts in America noted that polio cases increased in step with the consumption of ice cream and soft drinks, Eliminating such treats was even recommended as part of an anti-polio diet. It turned out that polio outbreaks were most common in the hot months of summer, when people naturally ate more ice cream, showing only an association.

http://www.nytimes.com/2009/08/06/technology/06stats.html

** Ice cream sales for illustration purposes only*

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RtAVM

But first, what's on everyone's mind: what about cancer?

* Studies on cancer in general conflicting
* Animal studies
  * in rats long-term exposure to high levels of PFOA induces benign liver tumors
  * BUT mechanisms of cancer in rodents via PPAR not relevant to humans
* Human studies
  * General community and worker exposure monitored
  * studies are inconsistent in terms of both degree of exposure, dose-response and site of cancer
  * One study found exposure to PFOA **decreased** the incidence of bowel cancer.
  * Expert health panel report (2018) "**there is no current evidence that suggests an increase in overall cancer risk**"

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Heart and Blood Vessel disease

* Reasonably good evidence that PFASs alter lipid metabolism (eg cholesterol)
* Cholesterol and other lipids are biomarkers for heart and blood vessel disease, suggesting a possible increase in risk
* BUT while Perfluorooctanoic acid (PFOA) results in PPAR mediated hypolipidemia in rats and mice this doesn't happen in monkeys.
* BUT studies in industrial workers with PFOA levels up to 92.03 **µg/ml** showed no effect on blood lipids (mean 2.21 µg/ml)
* BUT Airport study showed no link disturbance of blood lipids with PFASs levels > 100 ng/ml well below the industrial study
* Perhaps other environmental effects stronger, or the weak response of human PPAR means effects on blood lipids are less

Heart and blood vessel disease continued

* Other markers of heart and blood vessel disease (eg width of blood vessel walls) show no consistent changes
* Studies of people who have been chronically exposed to significant levels of PFOA have not show statistically significant increases in cardiovascular disease
* Expert health panel report (2018) "**Evidence to date does not establish** whether PFAS at exposure levels seen in Australia might increase risks of cardiovascular disease… Established risk factors … are likely to be of a much greater magnitude than those potentially caused by PFAS."

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Other health effects

- Liver function
  - The scientific evidence does not support an association between PFAS and specific liver conditions, such as hepatitis, cirrhosis or fatty liver
- Kidney function
  - Good link between PFASs and uric acid levels
  - BUT not in the Airservice firefighter data
  - ALSO there is not strong support for a link between PFAS exposure and kidney pathology
- Thyroid effects
  - No consistent associations
- Respiratory effects
  - No known respiratory effects
- Obesity, overweight and BMI
  - Evidence inconsistent
- Diabetes, glycaemic control and metabolic syndromes
  - No consistent findings
- Immunological effects
  - Again, evidence inconsistent
  - strong potential for confounding by other persistent organic pollutants with immune effects

The Final Word?

* Expert health panel report (2018)
* Summarizing the biomarker responses
* "The Panel concluded there is mostly limited or no evidence for any link with human disease from these observed differences. Importantly, there is no current evidence that supports a large impact on a person's health as a result of high levels of PFAS exposure. However, the Panel noted that even though the evidence for PFAS exposure and links to health effects is very weak and inconsistent, important health effects for individuals exposed to PFAS cannot be ruled out based on the current evidence."

Treatment of PFASs

* There is no available treatment for PFASs exposure beyond removal from the source and letting levels decline naturally
* Community PFOA and PFOS levels have fallen over 75% since 2002/2003
* This suggests firefighters who have blood levels of PFASs above 10 ng/ml but below 100ng/ml may become normalized in around 5 years, in the 100ng/ml range this will require decades
* Watching brief my be appropriate

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Treatment of PFASs (2)

* Expert health panel report (2018)
* "After considering all the evidence, the Panel's advice to the Minister on this public health issue is that the evidence does not support any specific health or disease screening or other health interventions for highly exposed groups in Australia, except for research purposes."

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CONCLUSION

* PFASSs have been found in levels greater than the 95th population percentile in firefighters in both Airservices and MFS
* These levels were seen several years after use of PFASs were ceased
* It is thus likely that some firefighters in the CFS may have been exposed to PFASs and some proportion may still have elevated levels
* No disease has been consistently linked to PFASs exposure
  * But health effects cannot be excluded
* The Airservices study showed no consistent elevations in biomarkers for heart and kidney disease in firefighters who may represent a more extreme exposure scenario than with the CFS
* Voluntary monitoring of blood PFASs may be appropriate

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References

* Expert Health Panel for Per- and Poly-Fluoroalkyl Substances (PFAS) 2018 http://www.health.gov.au/internet/main/publishing.nsf/Content/ohp-pfas-expert-panel.htm
* Stockholm Convention on Persistent Organic Pollutants, Persistent Organic Pollutants Review Committee, September 2016,
* Rotander A, Toms LM, Aylward L, Kay M, Mueller JF. Elevated levels of PFOS and PFHxS in firefighters exposed to aqueous film forming foam (AFFF). Environ Int.2015 Sep;82:28-34.
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* Ellen T. Chang, Hans-Olov Adami, Paolo Boffetta, Philip Cole, Thomas B. Starr & Jack S. Mandel (2014) A critical review of perfluorooctanoate and perfluorooctanesulfonate exposure and cancer risk in humans, Critical Reviews in Toxicology, 44:sup1, 1-81,
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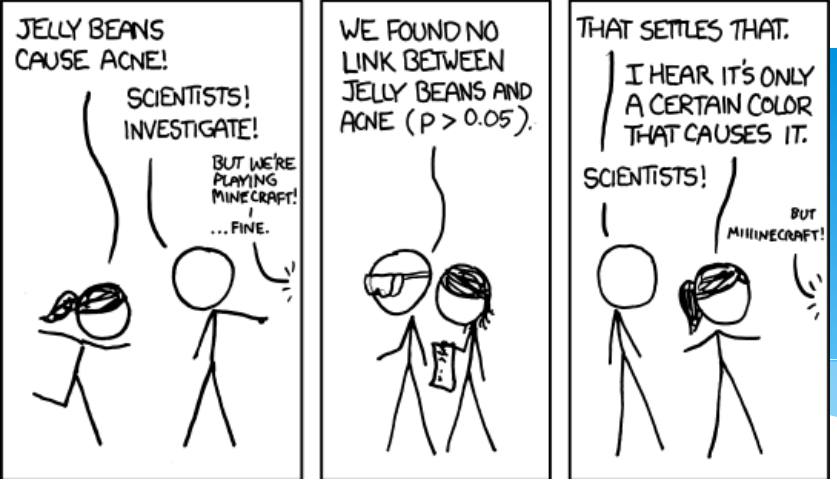
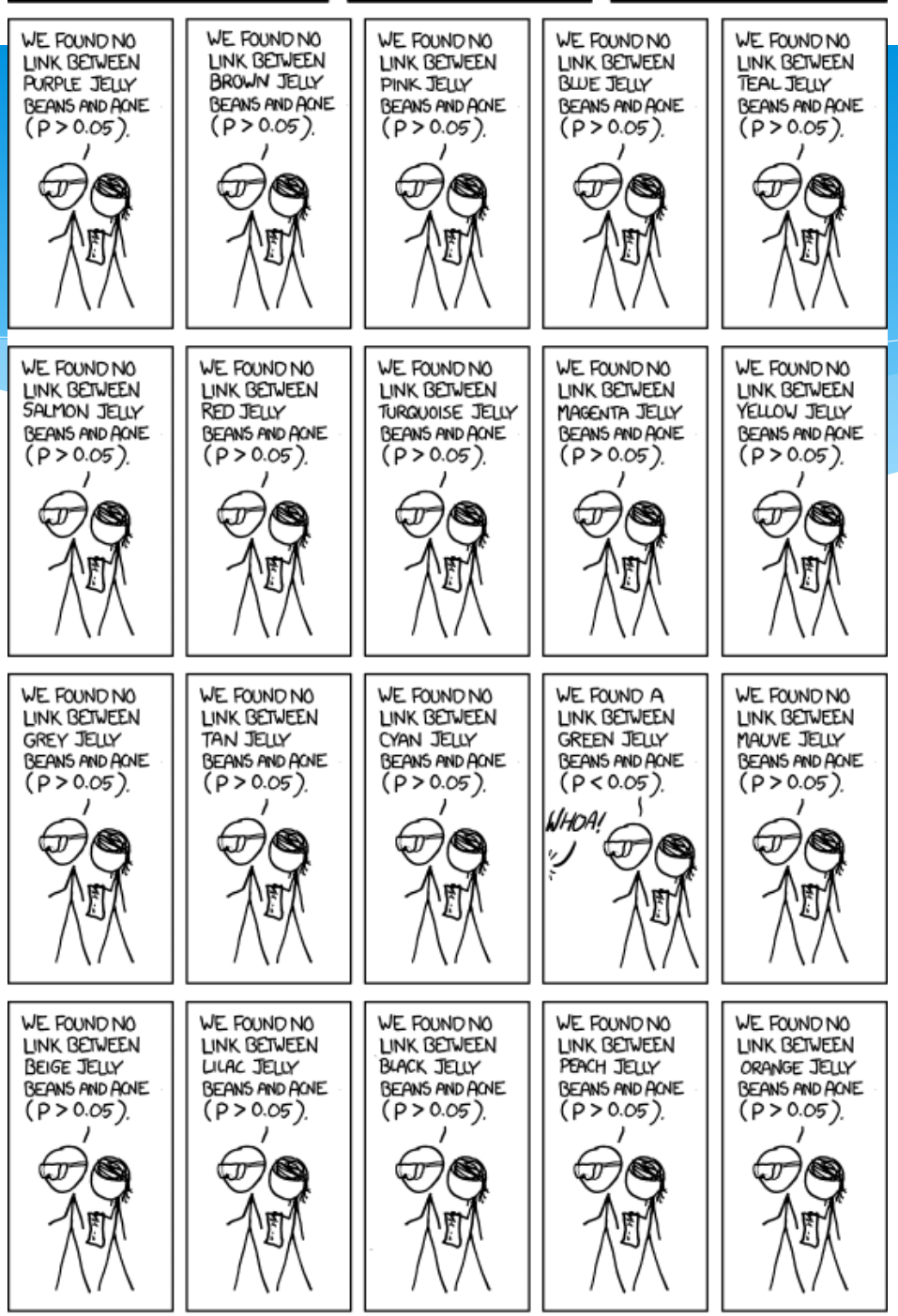

JELLY BEANS CAUSE ACNE!
SCIENTISTS! INVESTIGATE!
BUT WE'RE PLAYING MINECRAFT!
... FINE.
WE FOUND NO LINK BETWEEN JELLY BEANS AND ACNE (P > 0.05).
THAT SETTLES THAT.
I HEAR IT'S ONLY A CERTAIN COLOR THAT CAUSES IT.
SCIENTISTS!
BUT MIIINECRAFT!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WHOA!
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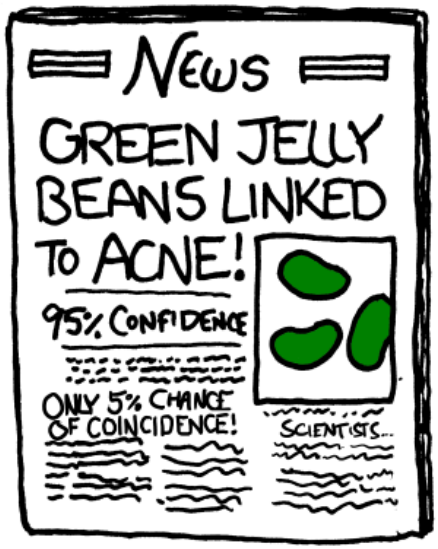
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GREEN JELLY BEANS LINKED TO ACNE!
95% CONFIDENCE
ONLY 5% CHANCE OF COINCIDENCE!
SCIENTISTS...