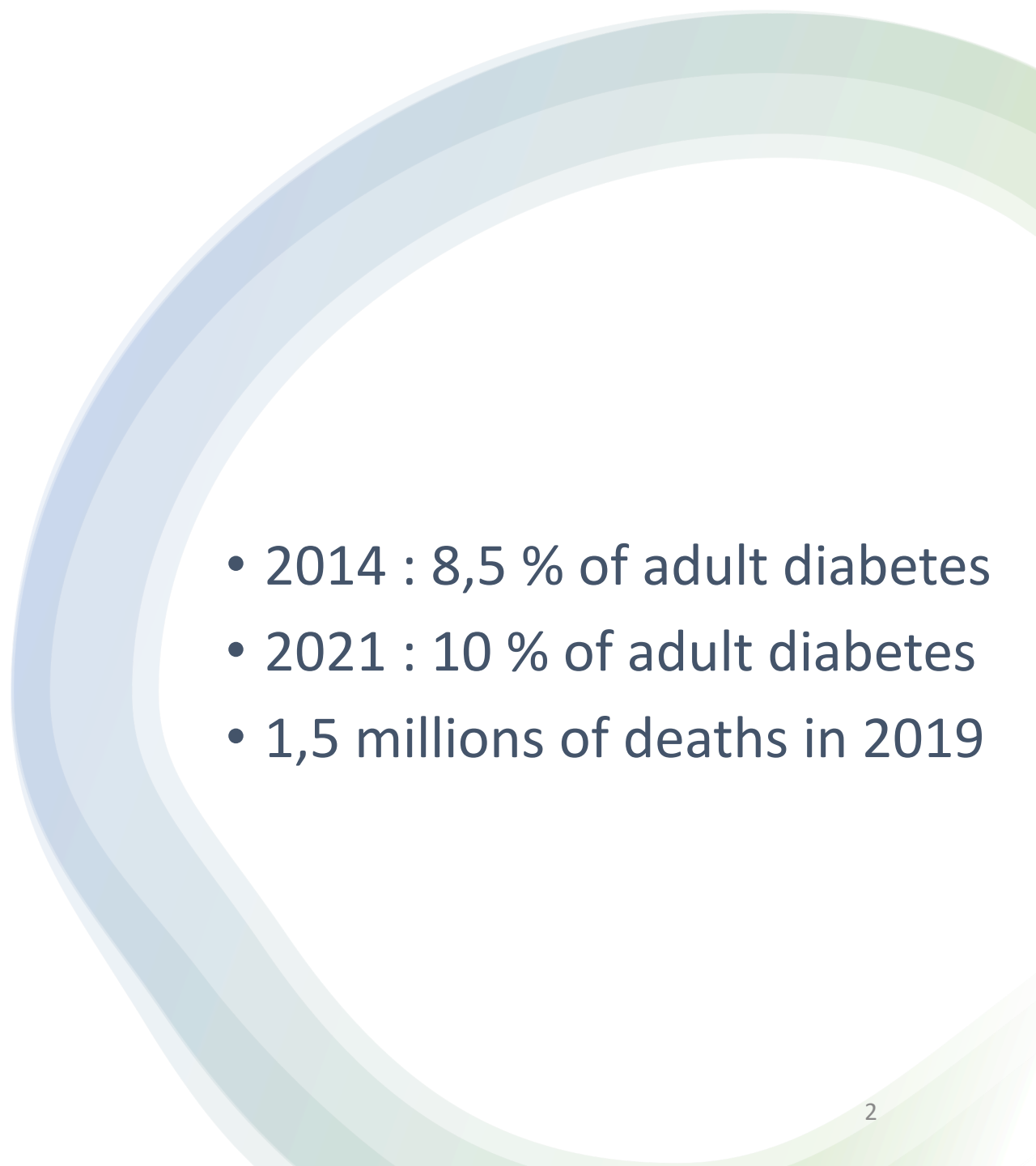# PFAS and their impacts on human health:
An example of a study of PFAS exposure and blood glucose control in older American adults with type 2 diabetes

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Axe Diabetes Obesity Cardiovascular complication– Département ommunity health
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Diabetes key fact :

- 2014 : 8,5 % of adult diabetes
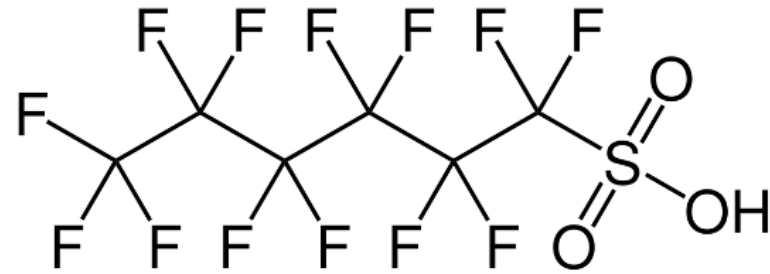- 2021 : 10 % of adult diabetes
- 1,5 millions of deaths in 2019

Sources : WHO, 2022
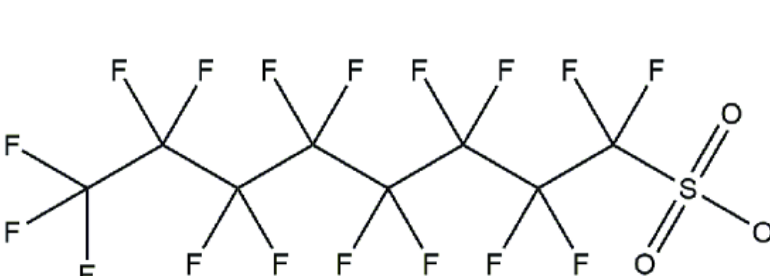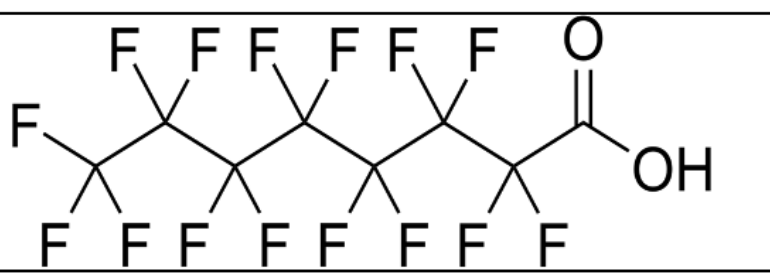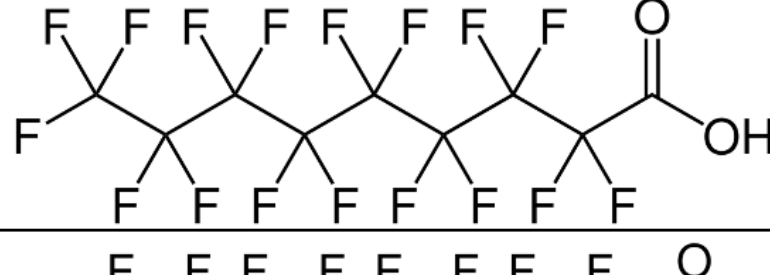
Diabetes and ageing

5 years less life expectancy

PFAS

5000 to 10,000 compounds

PFHxS (C=6)	
PFOS (C=8)	
PFOA (C=8)	
PFNA (C=9)	
PFDeA (C=10)	

Sources of PFAS ?
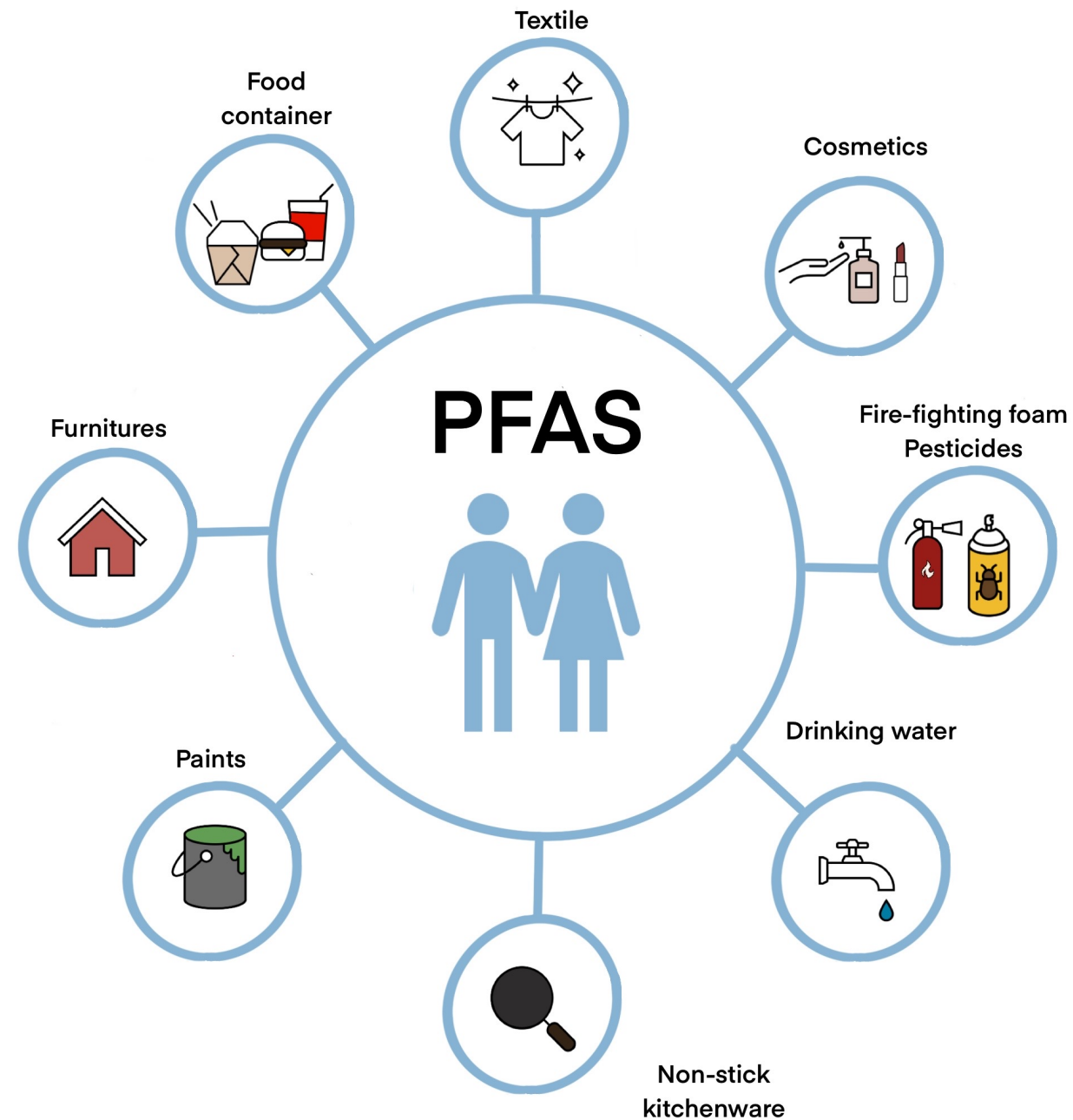
Problematic :

Does the presence of PFAS in the blood influence the chances of achieving good blood glucose control in people aged 65 and over?

- Bi-annual survey

- Since 1960 and continuous study from 1999

- Examines at least 5000 people each year

- 4575 participants for our study

Statistics :

- Linear mixed models : GLIMMIX procedure in the SAS statistical package (version 9.4. SAS)

- The PFAS distributions categorized into quartiles

- For the association of PFAS with poor glycemic control : Adjusted odds ratio (aOR)

Results :

	Distribution of pre- and polyfluoroalkyl substances in US adults aged 65 years and more, NHANES 1999-2018				
	Mean (SD)[a]	p25	p50	p75	p90
Overall					
PFDeA	0.36 (0.42)	0.14	0.20	0.40	0.70
PFNA	1.04 (1.20)	0.50	0.74	1.30	2.00
PFOA	3.64 (3.81)	1.87	3.00	4.30	6.30
PFOS	20.14 (22.0)	7.70	14.50	24.90	40.80
PFHxS	2.39 (2.71)	0.90	1.70	2.60	4.80
ΣPFAS	14.8 (21.4)	2.30	5.80	20.70	37.7
Men					
PFDeA	0.38 (0.44)	0.16	0.20	0.40	0.80
PFNA	1.06 (0.95)	0.50	0.80	1.30	1.90
PFOA	3.82 (4.82)	1.80	2.90	4.17	6.40
PFOS	21.91 (25.92)	8.90	15.40	26.10	43.70
PFHxS	2.76 (3.15)	1.20	1.90	3.00	5.30
ΣPFAS	15.31 (23.41)	2.70	5.60	20.37	36.82
Women					
PFDeA	0.34 (0.41)	0.10	0.20	0.40	0.70
PFNA	1.03 (1.43)	0.40	0.70	1.20	2.10
PFOA	3.47 (2.39)	1.87	3.04	4.39	6.29
PFOS	18.37 (16.92)	6.81	13.70	23.40	39.70
PFHxS	1.97 (2.03)	0.90	1.40	2.20	3.70
ΣPFAS	13.92 (18.50)	2.00	5.80	20.60	37.59

Results :

(A) poor glycemic control defined as HbA1c ≥ 7.0% in 65–74 years of age and ≥8.0% in order;

(B) poor glycemic control defined as HbA1c ≥ 7.5% in 65–74 years of age and ≥8.0% in older.

(A)

< Q1 (reference)	Adjusted OR (95% CI)
Perfluorodecanoic acid	
Q1-Q2	0.84 (0.30-2.36)
Q2-Q3	**0.46 (0.29-0.77)**
≥ Q3	1.19 (0.71-2.00)
Perfluorononanoic acid	
Q1-Q2	**0.41 (0.23-0.71)**
Q2-Q3	1.23 (0.71-2.14)
≥ Q3	1.52 (0.87-2.68)
Perfluorooctanoic acid	
Q1-Q2	0.61 (0.26-1.44)
Q2-Q3	0.94 (0.39-2.23)
≥ Q3	**0.29 (0.12-0.73)**
Perfluorooctanesulfonic acid	
Q1-Q2	1.34 (0.60-2.97)
Q2-Q3	1.41 (0.57-3.47)
≥ Q3	1.33 (0.52-3.41)
Perfluorohexanesulfonic acid	
Q1-Q2	1.01 (0.60-1.67)
Q2-Q3	**0.56 (0.32-0.96)**
≥ Q3	1.32 (0.77-2.26)
∑PFAS	
Q1-Q2	**1.85 (1.16-2.95)**
Q2-Q3	0.88 (0.43-1.80)
≥ Q3	0.90 (0.35-2.31)

(B)

Adjusted OR (95% CI)
0.84 (0.30-2.36)
0.47 (0.29-0.77)
1.19 (0.71-2.00)
0.55 (0.31-0.98)
2.30 (1.25-4.21)
0.92 (0.37-2.30)
0.48 (0.18-1.26)
2.81 (1.11-7.14)
2.70 (0.95-7.66)
3.00 (0.98-8.92)
2.87 (1.56-5.30)
2.29 (1.40-3.77)
0.59 (0.26-1.36)
0.91 (0.31-2.26)

PFNA — Perfluorononanoic acid

PFHxS — Perfluorohexanesulfonic acid

Results :

Odds ratio (95% confidence intervals) for the associations between pre- and polyfluoroalkyl substances and poor glycemic control in US men aged 65 years and older

(B) poor glycemic control defined as HbA1c ≥ 7.5% in 65–74 years of age and ≥8.0% in older.

2023-06-13

Men		(B)		
	Q1 (Reference)	Q1-Q2	Q2-Q3	≥Q3
Model 1[a]				
PFDeA	1	2.26 (0.16-36.70)	2.55 (0.88-7.37)	7.59 (2.61-22.06)
PFNA	1	0.17 (0.07-0.44)	0.57 (0.23-1.41)	1.74 (0.72-4.20)
PFOA	1	0.18 (0.04-0.76)	0.40 (0.11-1.51)	0.33 (0.08-1.32)
PFOS	1	1.56 (0.36-6.72)	1.22 (0.28-5.34)	3.39 (0.74-15.49)
PFHxS	1	6.14 (2.69-14.05)	0.58 (0.24-1.41)	6.47 (2.70-15.46)
ΣPFAS	1	1.22 (0.65-2.27)	0.35 (0.12-1.02)	0.45 (0.11-1.81)
Model 2[b]				
PFDeA	1	2.72 (0.17-43.51)	4.44 (1.78-11.07)	6.13 (2.42-15.50)
PFNA	1	0.27 (0.12-0.61)	0.51 (0.24-1.09)	0.90 (0.43-1.88)
PFOA	1	0.16 (0.04-0.62)	0.35 (0.10-1.23)	0.30 (0.08-1.12)
PFOS	1	0.89 (0.24-3.26)	0.94 (0.25-3.47)	2.13 (0.56-8.11)
PFHxS	1	5.46 (2.50-11.93)	0.58 (0.24-1.39)	3.80 (1.73-8.33)
ΣPFAS	1	1.10 (0.62-1.98)	0.33 (0.12-0.86)	0.41 (0.11-1.44)
Model 3[c]				
PFDeA	1	2.49 (0.17-36.55)	2.83 (1.32-6.06)	7.11 (3.13-16.13)
PFNA	1	0.52 (0.26-1.05)	1.20 (0.58-2.48)	2.75 (1.30-5.81)
PFOA	1	0.32 (0.11-0.93)	0.31 (0.10-0.97)	0.29 (0.09-0.92)
PFOS	1	1.01 (0.36-2.86)	1.17 (0.36-2.86)	1.25 (0.40-3.93)
PFHxS	1	5.88 (2.91-11.91)	0.83 (0.40-1.75)	5.46 (2.65-11.26)
ΣPFAS	1	1.54 (0.86-2.78)	1.41 (0.62-3.23)	0.85 (0.28-2.59)
Model 4[d]				
PFDeA	1	2.42 (0.15-38.35)	2.79 (0.98-7.96)	8.50 (2.98-24.28)
PFNA	1	0.18 (0.07-0.46)	0.62 (0.25-1.52)	1.96 (0.83-4.62)
PFOA	1	0.20 (0.05-0.80)	0.46 (0.12-1.66)	0.39 (0.10-1.49)
PFOS	1	1.45 (0.35-5.97)	1.11 (0.26-4.81)	3.42 (0.76-15.35)
PFHxS	1	5.87 (2.63-13.10)	0.60 (0.25-1.44)	6.84 (2.92-16.02)
ΣPFAS	1	1.24 (0.67-2.29)	0.37 (0.12-1.08)	0.51 (0.13-2.05)

Strengths :

- 1st study to focus on elderly populations and glycemic control in cases of known diabetes
- Large sample size and heterogeneous population in terms of race/ethnicity

Limits :

- Residual confounding
- Causal inference
- Multiple co-exposure
- Treatments not taken into account
- No consideration for food

Conclusion

This is the first study to assess glycemic control in relation to PFAS exposure in older populations with known diabetes.

PFNA
PFHxS
PFDeA (for men)

Poor glycemic control at U.S. adults aged ≥ 65 years with known T2DM

Perspectives

- Assessing the effect of mixtures

- Evaluating PFAS and its influence on the oral glucose test in adults of various ages

- Repeat analyses with longitudinal data

- Work with more PFAS for a more global scheme (including alternative PFAS)

- Enable prevention campaigns by formation healthcare professionals to alert people at risk

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