

Aircraft cabin air contamination and oil seals

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Disclaimer

- I am an independent PhD researcher in the area of bleed air contamination.
- I undertake some research on behalf of the Global Cabin Air Quality Executive (GCAQE).
- I declare no conflicts of interest.



Who am I?



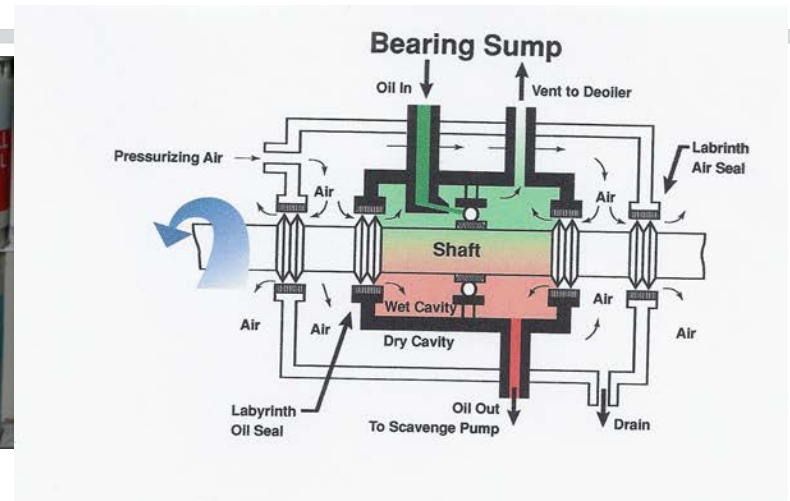
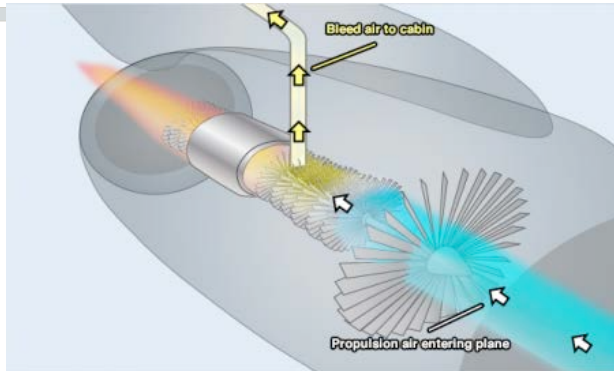
Health and Flight Safety
Implications from Exposure
to Contaminated Air in Aircraft

PhD
S. Michaelis
2010

PhD - <http://handle.unsw.edu.au/1959.4/50342>



Bleed air = Cabin air



UNFILTERED

Move to bleed air to supply cabin air

Non Bleed air



Bleed air



- Bleed air – SUD- E Caravelle, 1955



B727: 737: DC9...

The problem

- ✈ Synthetic engine oils –

 - ✈ Leakage past seals into super heated compressor/ bleed air

- ✈ Compromising flight safety

- ✈ Adverse health effects

- ✈ Other substances can leak into bleed air – hydraulic/ deicing fluids...



Pressurised air/seals

✈ Compressor pressurised air used to:

- Supply cabin ventilation air supply &
- Seal oil bearing chamber

✈ Seals leak oil at low levels in normal operations and will enter air supply (*not just during failure condition*)

✈ Toxicity of super heated oils recognised in 1954-
USAF

✈ Reports of adverse effects commenced after
introduction of bleed air

Substances - Oils

- ✈ Synthetic ester base stock ~95%
- ✈ Antiwear additive - Triaryl phosphate (OP) ~3%
 - TCP - includes orthos isomers/TOCP... & TXP...
- ✈ Amine antioxidant – (1%)
- ✈ Proprietary substances
- ✈ Wide variety of pyrolysis substances
- ✈ Endocrine disruptors (TCP; TBP; TPP)

EU/UN Hazard Classifications (CLP /REACH)

Oil, hydraulic, deicing fluids: **HAZARDS**



✈ Harmful if swallowed/dermal:	✈ Eye/skin irritant & ? Respiratory irritant
✈ May (suspected) cause damage fertility or harm the unborn child	✈ Skin sensitizer
✈ Single exposure & repeated target organ toxicity - nervous system	✈ Very toxic by inhalation
✈ May cause genetic defects	✈ May cause allergy/asthma or breathing difficulties if inhaled
✈ May (Suspected) of causing cancer	✈ May cause drowsiness or dizziness

TXP – Substance of Very High Concern (SVHC) – REACH

✈ **May cause harm to the unborn/Impair fertility**



ICSC/HSDB- adverse effects



- Oils, Hydraulic & de-icing fluids associated with a wide range of acute and long-term effects: e.g:

Irritant of skin, eyes, mucous membranes, respiratory tract	Gastrointestinal upset	Decrease in strength of arms/ legs	Tingling of hands, feet (limbs)
Vertigo	Headache	Numbness	Cramps
Abdominal Pain, diarrhea.	Formation of Methemoglobin in blood	Low blood pressure	Attack on Peripheral nerves/ pyramidal tract
Irritability	Nausea/vomiting	Dizziness	Visual disturbances
Muscular weakness	Blue lips/ fingernails/skin	Confusion	Skin redness
Excessive sweating	Convulsions/ Unconsciousness	Cough/sore throat	Pain/redness in eyes

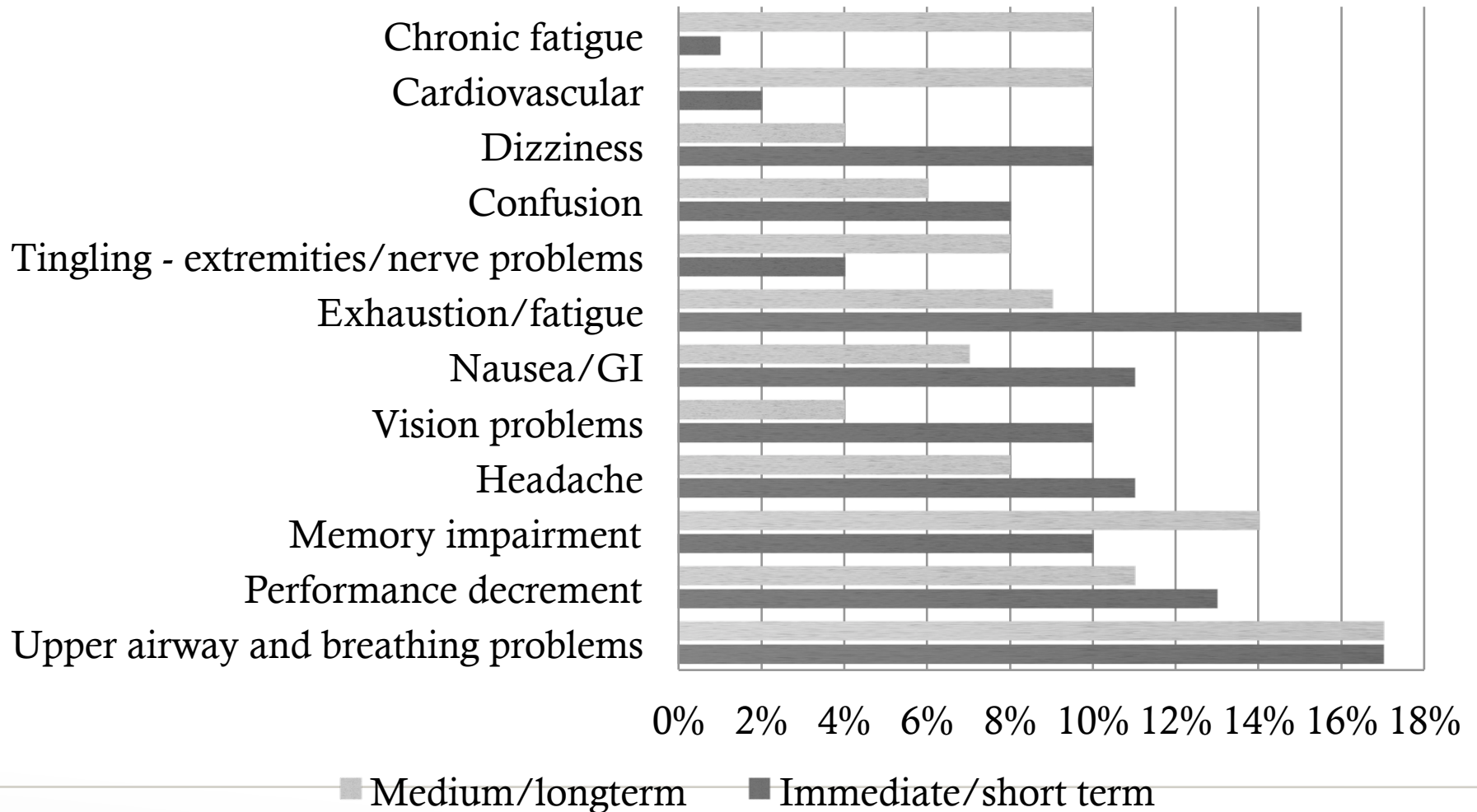
PhD research objective 1

- ✈ Review health problems reported by aircrew when exposed to contaminated bleed air whilst flying;
- ✈ Undertake a health survey of BAe 146 pilots exposed to contaminated air in aircraft.



BAe 146 pilot health survey

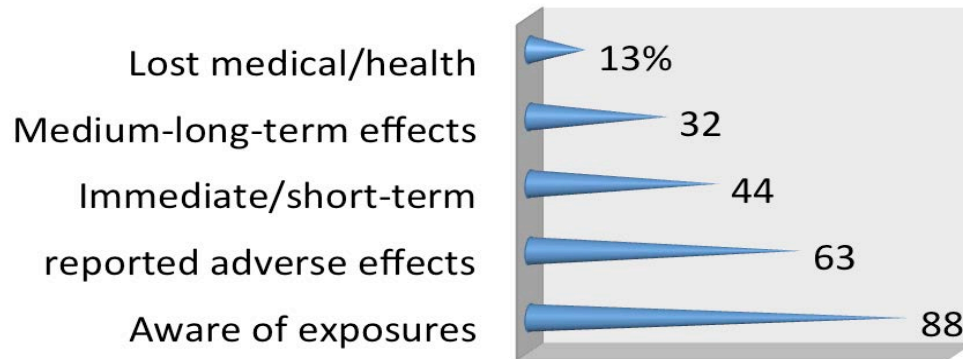
BAe 146/RJ - Health effects n=219



Adverse effects

Chronic ill health
37- 433%
above controls

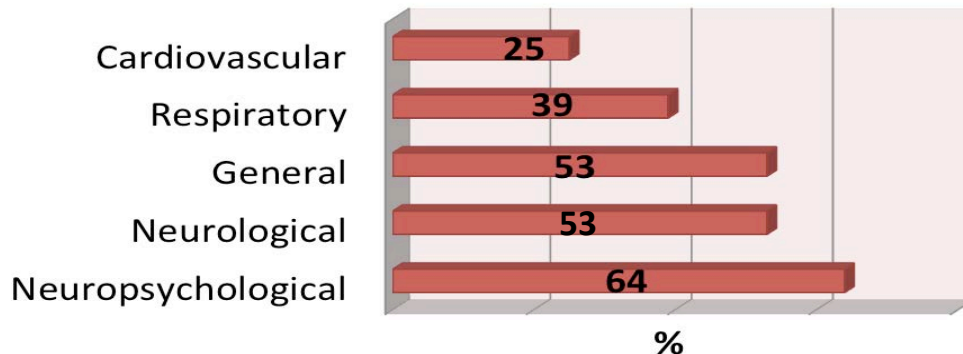
BAe 146 adverse health effects n=274



Aircrew/passengers are reporting:
Chronic neurological, respiratory
disease consistent with exposure
to jet engine oils including OPs

Cancers: Higher than population
averages

Chronic ill health effects



Aerotoxic Syndrome is a valid
term

- Causative relationship exists
- Published literature - ✓

Michaelis S (2010) PhD – 'Health and Flight Safety
Implications from Exposure to Contaminated
Air in Aircraft'.

Short & long-term symptoms

Table 2 Aerotoxic syndrome: short- and long-term symptoms

Short term exposure	Long term exposure
<p><i>Neurotoxic symptoms:</i> blurred or tunnel vision, nystagmus, disorientation, shaking and tremors, loss of balance and vertigo, seizures, loss of consciousness, parathesias;</p> <p><i>Neuropsychological or Psychotoxic symptoms:</i> memory impairment, headache, light-headedness, dizziness, confusion and feeling intoxicated;</p> <p><i>Gastro-intestinal symptoms:</i> nausea, vomiting;</p> <p><i>Respiratory symptoms:</i> cough, breathing difficulties (shortness of breath), tightness in chest, respiratory failure requiring oxygen;</p> <p><i>Cardiovascular symptoms:</i> increased heart rate and palpitations;</p> <p><i>Irritation of eyes, nose and upper airways.</i></p>	<p><i>Neurotoxic symptoms:</i> numbness (fingers, lips, limbs), parathesias;</p> <p><i>Neuropsychological or Psychotoxic symptoms:</i> memory impairment forgetfulness, lack of coordination, severe headaches, dizziness balance, sleep disorders;</p> <p><i>Gastro-intestinal symptoms:</i> salivation, nausea, vomiting, diarrhoea;</p> <p><i>Respiratory symptoms:</i> breathing difficulties (shortness of breath), tightness in chest, respiratory failure, susceptibility to upper respiratory tract infections;</p> <p><i>Cardiovascular symptoms:</i> chest pain, increased heart rate and palpitations;</p> <p><i>Skin symptoms:</i> skin itching and rashes, skin blisters (on uncovered body parts), hair loss;</p> <p><i>Irritation of eyes, nose and upper airways;</i></p> <p><i>Sensitivity:</i> signs of immunosuppression, chemical sensitivity leading to acquired or multiple chemical sensitivity</p> <p><i>General:</i> weakness and fatigue (leading to chronic fatigue), exhaustion, hot flashes, joint pain, muscle weakness and pain.</p>

Winder, C., Michaelis. S. (2005) .'Aircraft Air Quality Malfunction Incidents - Crew Effects from Toxic Exposures on Aircraft'. Air Quality in Airplane Cabins and Similar Enclosed Spaces – The Handbook of Environmental Chemistry – Publisher: Springer-Verlag GmbH. August 2005.



Bradford Hill

- Strength – ✓ Extensive history & recognition of exposure
- Consistency – ✓ effects repeatedly observed globally
- Specificity – ✓ Onset of symptoms specific to flight
- Temporality – ✓ Close relationship : exposure & effects
- Dose response ✗ Many reports after repeat low-level exposure
- Plausibility – ✓ Both biologically & in terms of engineering
- Coherence – ✓ Cause & effect between flying & illness
- Experiment – ✓ Each crew member – onset, recovery, recurrence
- Analogy – ✓ F111 workers; veterans; agricultural workers...



Various published studies

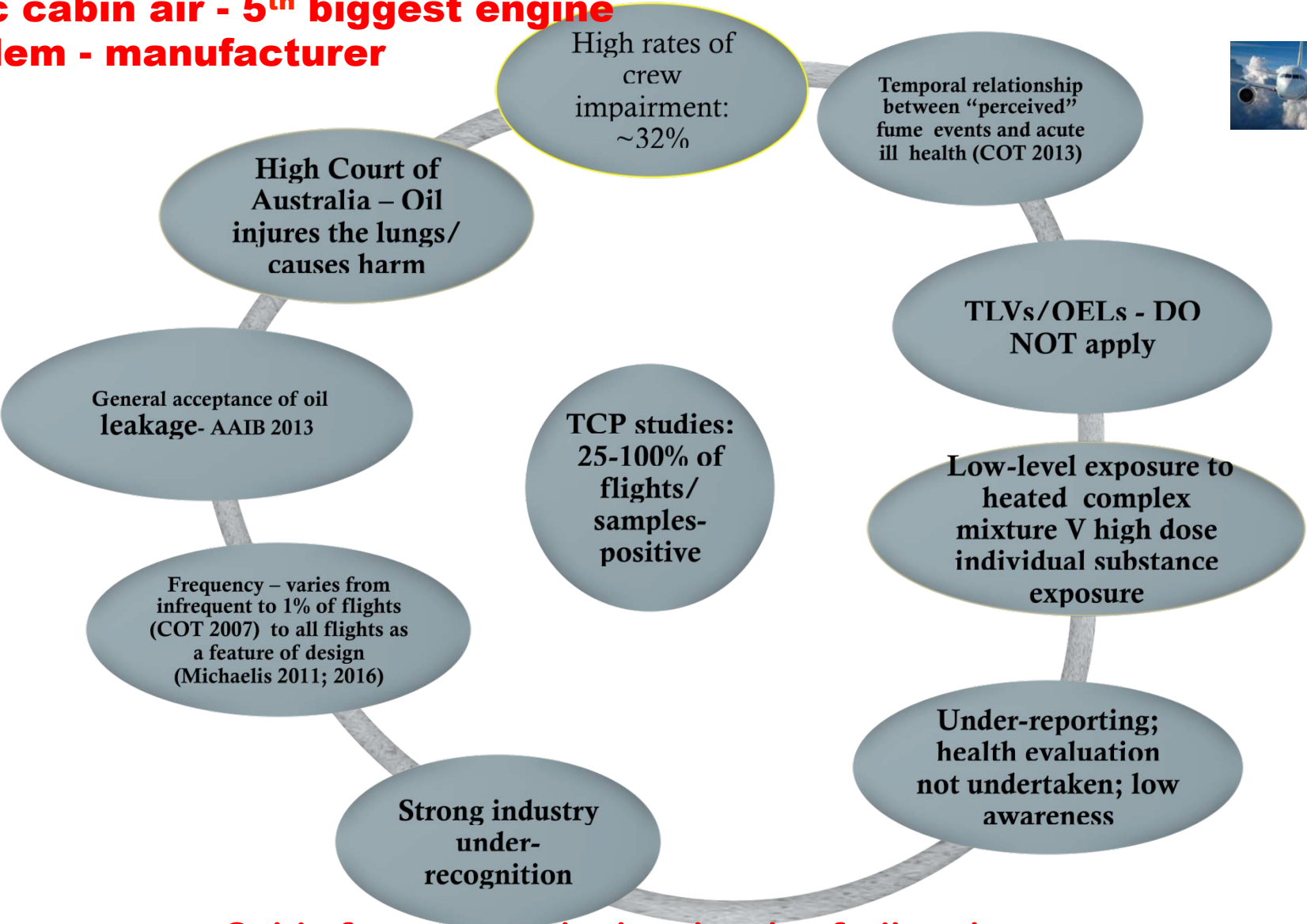


Treon: (USAF) 1954 – Oil pyrolysis
Aldridge: 1954 – TCP neurotoxicity
Montgomer: 1977 – Case study
Winder: 2002 – Aerotoxic Syndrome
Coxon: 2002, 2014 – Cognitive
Michaelis: 2002; 2003; 2005 – Crew health
Harper: 2005 – Occupational
Mackenzie Ross: 2008; 2016 – Cognitive
Abou-Donia: 2005; 2013, 2014 – Chronic neurotoxicity
OHRCA: 2009 – Medical protocol
Michaelis: 2010 - PhD
Burdon: 2011; 2012/2014 – Respiratory
Baker: 2012 – TAP biomarkers
Furlong: 2011– TAP biomarkers
Hausherr: 2014 – Glutamate Signaling
Kojima: 2014 – EDs TCP, TBP....
Reneman: 2015 – TOCP P450s
Reinen: 2015 – P450s & TCP
Megson: 2016 – Oil pyrolysis

& Many more...



Toxic cabin air - 5th biggest engine problem - manufacturer



Cabin fumes - can be low-levels of oil and difficult to investigate & eliminate - manufacturer



Industry/Government positions

- ✈ No evidence X
- ✈ No epidemiological studies with monitoring ✓
 - ✈ Case studies & no detection systems despite requirement by regulation
 - ✈ Symptoms due hyperventilation/ nocebo X
- ✈ Symptoms not consistent with TOCP toxicity X
- ✈ 10% of population get such symptoms daily ?
- ✈ Too few effected X
 - ✈ data not collated/ low awareness/ passengers not advised
- ✈ Substances cause irritation only/not toxicity X
- ✈ Aviation medical community show corporate conflict of interest ✓
- ✈ Aviation regulators do not have OHS/hazardous substances expertise & OHS regulators not given access with OHS directives.... Ignored

Airbus COO (Farnborough 2014) contaminated air is absurd/does not happen



Solutions

- ✈ Bleed free aircraft
- ✈ Filter/clean bleed air
- ✈ Detection systems
- ✈ Better engine design & sealing systems
- ✈ Health studies – independent – *We need your help!!*

Director General for DG employment, Mr Koos Richelle:
“Cabin air quality can be a genuine workplace health issue & there may be a need to start looking at such areas.”





Thank you

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