**TOX/2022/30**

# Committee on the Toxicity of Chemicals in Food, Consumer Products and the Environment.

# Introductory paper to an update of the COT position on aircraft cabin air

## Introduction

1. In 2007, the Committee on Toxicity (COT) published a statement on aircraft cabin air, having been asked by the Department for Transport (DfT) to undertake an independent scientific review of data submitted by the British Airline Pilots Association (BALPA) relating to organophosphate (OP) compounds, the cabin air environment, ill-health in aircraft crews and the possible relationship to smoke/fume events in aircraft, due to concerns about the possible effects on aircrew health of oil/hydraulic fluid smoke/fume contamination incidents in commercial aircraft (COT, 2007).

2. In 2013, DfT asked the COT to undertake an independent scientific review of the results of DfT-funded aircraft cabin environment research commissioned in response to recommendations made by COT in 2007, after which the COT issued a position statement on cabin air (COT, 2013).

3. The COT has now been asked by DfT to investigate any new data have been published and to re-evaluate their previous view in the original statement from 2007 (COT, 2007) and position statement from 2013 (COT, 2013).

4. The scope of this follow-up work is to re-assess the overarching question on the potential health effects due to fume/contamination events, expanding the focus to include volatile organic compounds (VOCs) and semi-volatile organic compounds (sVOCs), on which there has been more focus in recent years.

**Background**

5. Between July 2006 and July 2007, the COT considered a referral from DfT to review data submitted by the BALPA due to concerns about possible effects on aircrew health following oil/hydraulic fluid smoke/fume contamination incidents in commercial aircraft. The objectives for COT were to evaluate the data sourced by BALPA to provide an independent scientific review of data due to concerns about the possible effects on aircrew health of oil/hydraulic fluid smoke/fume contamination incidents in commercial aircraft. The data submitted by BALPA related to OPs, the cabin air environment, ill-health in aircraft crews and the possible relationship to fume events in aircraft. A summary of the data considered by the Committee is provided in the 2007 COT statement (COT, 2007). The second objective was to provide DfT with appropriate advice on any further research required.

6. In the COT 2007/06 statement, the Committee concluded: "It was not possible on the basis of the available evidence in the BALPA submission or that sourced by the Secretariat and DH Toxicology Unit to conclude that there is a causal association between cabin air exposures (either general or following incidents) and ill-health in commercial aircraft crews. However, we noted a number of oil/hydraulic fluid smoke/fume contamination incidents where the temporal relationship between reports of exposure and acute health symptoms provided evidence that an association was plausible" (COT, 2007).

7. Regarding health, it was noted that there was insufficient evidence available to the Committee to recommend additional epidemiological research on acute health effects or specifically on OPs. However, the need to obtain objective measures of exposure in epidemiology studies was acknowledged, and this could be achieved using exposure monitoring via proxy measures of exposure. There was also insufficient evidence to recommend additional research relating to acute or chronic health effects with regard to oil/hydraulic fluid contamination incidents on commercial aircraft, although the limited evidence and information on pilots supported further investigation into potential neuropsychological impairment in commercial pilots. This could be achieved by carrying out a cross-sectional study, comparing results of neuropsychological testing between pilots flying different airframes/engine combinations and between pilots who report, or do not report, air quality incidents.

Use of a validated proxy exposure for oil/hydraulic fluid contamination exposure would be necessary in order to determine whether there is an association between oil/hydraulic fluid smoke/fume contamination and neuropsychological effects (COT, 2007).

8. To address recommendations made by COT, DfT commissioned four studies, namely: the identification of air monitoring equipment capable of sampling air during fume events in real time; a statistical analysis of data relating to fume events and operational parameters in aircraft to investigate a potential link between cabin air fume events and aircraft full power take-offs; real time in-flight cabin air sampling and data analysis; and an investigation of aircraft cabin surface residues. These projects aimed to assess airborne concentrations and surface deposition of chemical pollutants in the cabins of commercial aircraft, and to investigate operational parameters associated with fume events.

9. In 2013, COT reviewed a discussion paper on exposure monitoring of the aircraft cabin environment, covering the four projects commissioned by DfT. The Committee also considered papers that had been published in the peer-reviewed scientific literature since 2007, concerning exposures to chemical pollutants in aircraft cabins (TOX/2013/32).

10. In 2013, COT also produced a position paper on cabin air that summarised the Committees evaluation of the four study reports, the conclusions drawn from the evidence considered to date, the scientific uncertainties that remained, and options for further research to address the continuing uncertainties (COT, 2013). The Committee agreed several conclusions relating to health:

- “The acute illness which has occurred in relation to perceived episodes of contamination might reflect a toxic effect of one or more chemicals, but it could also have occurred through nocebo effects”.

- “While there is strong scientific evidence that nocebo effects can lead to (sometimes severely disabling) illness from environmental exposures that are perceived as hazardous, there is no simple and reliable way of establishing that nocebo responses are responsible for individual cases of illness. However, they are a plausible alternative explanation if toxicity seems

unlikely. Distinguishing whether acute illness from fume events is likely to arise from toxicity or nocebo responses depends on: assessment of the patterns of symptoms and clinical abnormalities in affected individuals; the levels of relevant chemicals to which they might have been exposed; and what is known about the toxic effects of those chemicals and the levels of exposure at which such toxic effects occur (including the possibility that some individuals might be unusually sensitive)".

- "The patterns of illness that have been reported following fume events do not conform with that which would be expected from exposure to triaryl phosphates such as ortho-tricresyl phosphate (o-TCP) (which differs from the pattern of illness that occurs with over-exposure to organophosphate insecticides and nerve agents). Over-exposure to tricresyl phosphates would be expected to cause delayed peripheral neuropathy. Given the short duration of reported fume incidents, in order to cause such toxicity, peak exposures would have to be much higher than those which have been indicated by monitoring to date".

- "More generally, the Committee considers that a toxic mechanism for the illness that has been reported in temporal relation to fume incidents is unlikely. Many different chemicals have been identified in the bleed air from aircraft engines, but to cause serious acute toxicity, they would have to occur at very much higher concentrations than have been found to date (although lower concentrations of some might cause an odour or minor irritation of the eyes or airways). Furthermore, the symptoms that have been reported following fume incidents have been wide-ranging (including headache, hot flushes, nausea, vomiting, chest pain, respiratory problems, dizziness and light-headedness), whereas toxic effects of chemicals tend to be more specific. However, uncertainties remain, and a toxic mechanism for symptoms cannot confidently be ruled out".

11. Overall, the Committee stated: "Finally, it should be emphasised that illness can be disabling whether it occurs through toxicity or through nocebo effects, and therefore there is a continuing imperative to minimise the risk of fume incidents that give rise to symptoms" (COT, 2013).

**Current paper**

12. The current paper is a scoping paper to outline literature searches carried out to update the evidence base and to outline potential future work.

13. An update of the literature searches previously undertaken between 2007 and 2013 regarding health effects in flight crew following exposure to aircraft cabin environments and the potential relationship to smoke/fume events in aircraft is presented. Literature searches were carried out using the original search terms, focussing on literature published during 2007-2021. The searches were limited to the chemicals included in the original searches, which largely focussed on OP-type chemicals. Five additional papers were identified from the title and abstract as possibly being of relevance. A short narrative of each paper is presented below (paragraph 15 - 21.

14. A literature search was also carried out to identify exposure data for VOCs and sVOCs in modes of transport, including aircraft, and indoor work environments such as offices, to allow comparison between different environments. Results of such searches are presented below (paragraph 22 - 27).

**Updated literature search on OPs (2007-2021)**

15. Search terms used previously were replicated; inclusion and exclusion criteria and the search results are presented in Annex 1 to this paper.

16. Five new papers were identified that assessed the health effects in flight crew following exposure to OPs from fume events.

17. de Boer et al. (2015) noted that airline pilots reported loss of memory, headaches, dizziness, tunnel vision and other neurotoxic effects, despite levels of TCP in flight deck air not exceeding provisional toxicity thresholds. It was suggested that TCP on its own is not likely to be responsible for the reported health effects.

18. de Ree et al. (2014) reported that TCP has been suggested to be associated with the alleged ‘aerotoxic syndrome’, the symptoms of which include headaches, loss of balance, numbness and neurobehavioral abnormalities such as emotional

instability, depression and cognitive dysfunction. Measurements of non-ortho and ortho-isomers were monitored in aircraft and showed the presence of non-toxic non-ortho isomers at low concentrations. However, tri-ortho-cresyl phosphate (ToCP) and other ortho-isomers were not detected. The authors concluded that it is unlikely that health effects and aerotoxic syndrome are due to exposure to ToCP.

19. Heutelbeck et al. (2016) investigated individual acetylcholinesterase (AChE) and neuropathy target esterase (NTE) activities in flight crew members exhibiting headache, cognitive difficulties, and neurological disorder after fume events. Using biochemical effect monitoring, the measured AChE activities indicated a minor contribution of OP or related compounds to the observed activities. The authors concluded that it was not possible to infer a direct correlation between manifestations and AChE-inhibiting compounds.

20. Wolkoff, Crump and Harrison (2016) carried out a review of sensory effects in the eyes and airways and neurological symptoms such as headache reported in aircraft crew and office workers and their possible association with VOC and ToCP exposure. Despite using a conservative approach to assess any correlation, the authors concluded that the health risk of exposure to ToCP in aircraft is negligible.

21. Reneman et al. (2016) recorded more self-reported cognitive complaints and depressive symptoms in two flight crew subjects compared with two controls. Subjects also showed small clusters in the brain where white matter microstructure was affected, higher cerebral perfusion values in the left occipital cortex, and reduced brain activation on a functional magnetic resonance imaging (MRI) executive function task. It was concluded that the extent of cognitive impairment was strongly associated with white matter integrity, but the extent of estimated number of flight hours was not associated with cognitive impairment nor with reductions in white matter microstructure.

**Literature search on exposure to VOCs in modes of transport**

22. A literature search was carried out to collate exposure data on VOCs in aircraft in comparison with other modes of transport such as cars, buses, trains, taxis

and metros. The search terms used for the literature search are presented in Annex 2.

23. Forty-one papers were identified. Two papers related to vehicles in general, six papers related to exposure to VOCs in buses, two papers each in metros and taxis, three paper in trains and thirteen papers each in cars and aircraft. A list of all publications is given in Annex 2.

**Literature search on exposure to VOCs in other work environments**

24. A literature search was carried out to investigate how exposure to VOCs in aircraft compared with that in other public spaces such as offices, schools and hospitals. The search terms used for the literature search are presented in Annex 3.

25. Thirty-two papers were identified. All 32 related to exposure in offices, while six papers also addressed exposure in schools and one reported exposure in hospitals. A list of all publications is given in Annex 3.

**Future work planned**

26. A number of papers are planned for the future, including:

- Definition of a fume/contamination event and identification and levels of chemicals measured in such events
- Narrative of papers identified in searches carried out for this scoping paper regarding exposure data on VOC/sVOCs in aircraft cabins, and comparison with exposure in other modes of transport and indoor work environments such as offices
- Comparison of adverse health effects reported in aircraft cabin workers and office workers
- Identification of VOC/sVOCs of particular interest
- Toxicological review of VOC/sVOCs of interest, including collation or derivation of health-based guidance values

- Health effects of mixture of VOC/sVOCs, using COT papers on mixtures, EFSA review of combinations of chemicals, and Working Group on Pesticides (WGP) papers as information sources

- Narrative of papers identified in the original and updated searches on OPs in cabin air.

**Questions on which the views of the Committee are sought**

27. Members are invited to consider this paper and in particular the following questions:

i. Do Members have any comments on the searches undertaken to date?

ii. Do Members have any suggestions for other aspects to consider to support the Committee consideration of this topic in the coming meetings?

**IEH Consulting under contract supporting the PHE COT Secretariat**
**May 2022**

**References**

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COT, 2013a. Discussion paper on exposure monitoring of the aircraft cabin environment. TOX/2013/32. https://cot.food.gov.uk/sites/default/files/cot/tox201332.pdf

COT, 2013b. Annex 6. Discussion paper on exposure monitoring of the aircraft cabin environment. TOX/2013/32. Annex 6. https://cot.food.gov.uk/sites/default/files/cot/tox32anex6.pdf

COT, 2013. Position paper on cabin air. https://webarchive.nationalarchives.gov.uk/ukgwa/20200803134320/https:/cot.food.gov.uk/cotstatements/cotstatementsyrs/cotstatements2013/cotpospacabair

de Boer, J., A. Antelo, I. van der Veen, S. Brandsma & N. Lammertse (2015) Tricresyl phosphate and the aerotoxic syndrome of flight crew members - Current gaps in knowledge. *Chemosphere,* 119**,** S58.

de Ree, H., M. van den Berg, T. Brand, G. J. Mulder, R. Simons, B. Veldhuijzen van Zanten & R. H. S. Westerink (2014) Health risk assessment of exposure to TriCresyl Phosphates (TCPs) in aircraft: A commentary. *NeuroToxicology,* 45**,** 209-215.

Heutelbeck, A. R. R., C. Bornemann, M. Lange, A. Seeckts & M. M. Mueller (2016) Acetylcholinesterase and neuropathy target esterase activities in 11 cases of symptomatic flight crew members after fume events. *J. Toxicol. Environ. Health, Part A,* 79**,** 1050-1056.

Reneman, L., S. B. Schagen, M. Mulder, H. J. Mutsaerts, G. Hageman & M. B. de Ruiter (2016) Cognitive impairment and associated loss in brain white microstructure in aircrew members exposed to engine oil fumes. *Brain Imaging Behav,* 10**,** 437-444.

Wolkoff, P., D. R. Crump & P. T. C. Harrison (2016) Pollutant exposures and health symptoms in aircrew and office workers: Is there a link? *Environ. Int.,* 87**,** 74-84.

**List of Abbreviations and Technical terms**

| | |
|---|---|
| AChE | Acetylcholinesterase |
| BALPA | British Airline Pilots Association |
| COT | Committee on Toxicity |
| DfT | Department for Transport |
| DH | Department of Health |
| MRI | Magnetic resonance imaging |
| NTE | Neuropathy target esterase |
| OP | Organophosphate |
| o-TCP | Ortho-tricresyl phosphate |
| sVOC | Semi-volatile organic compounds |
| ToCP | Tri-ortho-cresyl phosphate |
| VOC | Volatile organic compounds |
| WGP | Working Group on Pesticides |

# Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment

## Introductory paper to an update of the COT position on aircraft cabin air

### Introduction

1. The COT was asked to update the literature searches previously carried out between 2007 and 2013 regarding air quality in aircraft cabin environments and the potential relationship to smoke/fume events in aircraft and health effects in cabin crew focussing on organophosphates (OPs).

2. Search terms presented in TOX/2013/32 Annex 6 were replicated for the searches. Inclusion and exclusion criteria used in TOX/2013/32 Annex 6 were amended and included the following:

3. Inclusion criteria

- Peer reviewed publications
- Relevant reviews
- In PubMed, search terms in title and abstract
- In SciFinder, search terms in all fields
- Papers from 2013 to present

4. Exclusion criteria

- Studies not reporting original results, including comments, letters or editorials
- Papers without an abstract

- Papers concerned only with methodology
- Studies reporting animal or *in vitro* data
- Studies dealing only with health outcomes or biomonitoring
- Studies dealing with exposures other than those relating to chemical exposure from oil/hydraulic fluid and flame retardants, for example tobacco smoke, solar radiation, infectious disease particles, ozone, pesticides
- Papers dealing with organophosphates previously reviewed by COT
- Conflicting abbreviations such as BDPP (bioactive dietary polyphenol preparation), DBPP (diastolic blood pressure percentile), TCP (transscleral cyclophotocoagulation) and TBP (treated beyond progression or TATA box-binding protein or tuberculous pleuritis)

5. The number of publications considered to be relevant, based on the title and abstract, from current and previous searches are presented in Table 1. The current searches were carried out using PubMed and SciFinder whereas the previous searches were carried out using PubMed and Web of Science.

**Table 1 Literature searches in PubMed (2007-2013 and 2013-present), Web of Science (2007-2013) and SciFinder (2013-present)**

| | | PubMed | Web of Science | PubMed | PubMed | SciFinder | SciFinder | PubMed + SciFinder |
|---|---|---|---|---|---|---|---|---|
| | **Search Terms/ Details** | **Relevant references 2007-2013** | **Relevant references 2007-2013** | **No. of references retrieved 2013-present** | **Relevant references 2013-present** | **No. of references retrieved 2013-present** | **Relevant references 2013-present** | **Total no. of relevant references 2013-present**** |
| 1 | Cabin air | *4* | *4* | 44 | 6 | 99 | 5 | 8 |
| 2 | Cabin air quality | *1* | *1* | 10 | 0 | 23 | 0 | 0 |
| 3 | Aircraft air contamination | *2* | *2* | 0 | 0 | 0 | 0 | 0 |
| 4 | Butyl diphenyl phosphate | *0* | *0* | 0 | 0 | 9 | 0 | 0 |
| 5 | Dibutylphenyl phosphate | *1* | *2* | 0 | 0 | 1 | 0 | 0 |
| 6 | Tri-ortho-cresyl phosphate | *2* | *0* | 27 | 1 | 30 | 4 | 4 |
| 7 | Tri-cresyl phosphate | *0* | *0* | 6 | 0 | 9 | 0 | 0 |
| 8 | Tricresyl phosphate | *4* | *4* | 60 | 1 | 518 | 5 | 5 |
| 9 | Tributyl phosphate | *0* | *2* | 124 | 0 | 1845 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10 | Tri-ortho-cresyl phosphate AND aircraft | *2* | *0* | 3 | 0 | 8* | 0 | 0 |
| 11 | Toluene AND aircraft | *0* | *2* | 2 | 0 | 297 | 0 | 0 |
| 12 | Xylene AND aircraft | *0* | *2* | 0 | 0 | 130 | 0 | 0 |
| 13 | Limonene AND aircraft | *0* | *0* | 0 | 0 | 15 | 0 | 0 |
| 14 | Undecane AND aircraft | *0* | *0* | 1 | 0 | 31 | 1 | 1 |
| 15 | Tributyl phosphate AND aircraft | *0* | *0* | 3 | 0 | 8 | 0 | 0 |
| 16 | Tricresyl phosphate AND aircraft | *0* | *4* | 14 | 2 | 21 | 4 | 4 |
| 17 | Butyl diphenyl phosphate AND aircraft | *0* | *0* | 0 | 0 | 0 | 0 | 0 |
| 18 | Dibutylphenyl phosphate AND aircraft | *1* | *2* | 0 | 0 | 0 | 0 | 0 |
| 19 | Aircraft AND fume(s) | *1* | *0* | 8 | 2 | 16 | 3 | 4 |
| 20 | Aircraft AND oil | *3* | *4* | 59 | 3 | 708 | 1 | 4 |
| 21 | Air quality AND (airline OR airplane OR aircraft OR cockpit OR “passenger cabin” OR flight deck) | *1* | *4* | 78 | 0 | 317 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 22 | Aircrew OR "airline crew" OR "cabin attendants" OR "cabin crew" OR "cockpit crew" OR "crew members" OR "flying crew" OR "flight engineers" OR "flight attendants" OR flight deck OR "airline pilots" OR "aircraft pilots" OR "airplane pilots" OR stewardesses OR "flight deck crew" NOT "aircraft carrier" | *1* | *3* | 764 | 1 | 812 | 0 | 1 |
| 23 | (aircrew OR "airline crew" OR "cabin attendants" OR "cabin crew" OR "cockpit crew" OR "crew members" OR "flying crew" OR "flight engineers" OR "flight attendants" OR flight deck OR "airline pilots" OR "aircraft pilots" OR "airplane pilots" OR stewardesses OR "flight deck crew" NOT "aircraft | *1* | *3* | 45 | 0 | 65 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | carrier") AND (fume OR fumes OR smoke OR haze OR mist OR smell OR smells OR odor* OR odour* OR vapor* OR dust OR aerosol* OR gas OR gases) | | | | | | | |
| 24 | Air quality AND airport | *0* | *13* | 44 | 0 | 87 | 0 | 0 |
| 25 | Air quality AND “airport building” OR “airport buildings” | *0* | *0* | 0 | 0 | 0 | 0 | 0 |
| 25 | Air quality AND “airport offices” | *0* | *0* | 0 | 0 | 0 | 0 | 0 |
| 26 | Cabin air AND flame retardant | *0* | *2* | 2 | 1 | 3 | 1 | 1 |
| 27 | Aircraft and flame retardant | *3* | *3* | 12 | 0 | 35 | 0 | 0 |
| 28 | Toluene AND indoor air | *1* | *0* | 139 | 0 | 591 | 0 | 0 |
| 29 | Xylene AND indoor air | *1* | *0* | 71 | 0 | 12 | 0 | 0 |
| 30 | Tributyl phosphate AND indoor air | *0* | *0* | 5 | 0 | 75 | 0 | 0 |
| 31 | Tricresyl phosphate AND indoor air | *0* | *0* | 0 | 0 | 38 | 0 | 0 |

*2013-2016

**With duplicates removed

**Results**

6. Of the 26 papers identified, five are considered to be of relevance:

- de Boer, J., A. Antelo, I. van der Veen, S. Brandsma & N. Lammertse (2015) Tricresyl phosphate and the aerotoxic syndrome of flight crew members - Current gaps in knowledge. *Chemosphere,* 119**,** S58.

- de Ree, H., M. van den Berg, T. Brand, G. J. Mulder, R. Simons, B. Veldhuijzen van Zanten & R. H. S. Westerink (2014) Health risk assessment of exposure to TriCresyl Phosphates (TCPs) in aircraft: A commentary. *NeuroToxicology,* 45**,** 209-215.

- Heutelbeck, A. R. R., C. Bornemann, M. Lange, A. Seeckts & M. M. Mueller (2016) Acetylcholinesterase and neuropathy target esterase activities in 11 cases of symptomatic flight crew members after fume events. *J. Toxicol. Environ. Health, Part A,* 79**,** 1050-1056.

- Reneman, L., S. B. Schagen, M. Mulder, H. J. Mutsaerts, G. Hageman & M. B. de Ruiter (2016) Cognitive impairment and associated loss in brain white microstructure in aircrew members exposed to engine oil fumes. *Brain Imaging Behav,* 10**,** 437-444.

- Wolkoff, P., D. R. Crump & P. T. C. Harrison (2016) Pollutant exposures and health symptoms in aircrew and office workers: Is there a link? *Environ. Int.,* 87**,** 74-84.

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# Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment

## Introductory paper to an update of the COT position on aircraft cabin air

### Literature searches for exposure to VOCs in other modes of transport

### Search terms

1. Search terms for Scopus and PubMed are presented below.

Scopus

(TITLE-ABS-KEY ( "volatile organic compound*" OR "semivolatile organic compound*" OR vocs OR svocs ) AND TITLE-ABS-KEY ( "public transport*" OR taxi* OR car OR cars OR bus OR buses OR train OR trains OR aeroplane* OR aircraft* OR submarine* OR boat* OR ship OR ships ) ) AND PUBYEAR > 2012 AND PUBYEAR < 2022 AND ( LIMIT-TO ( LANGUAGE , "English" ) OR EXCLUDE ( LANGUAGE , "French" ) ): 954

PubMed

(("volatile organic compound*"[Title/Abstract] OR VOCs[Title/Abstract] OR sVOCs[Title/Abstract] OR "semivolatile organic compound*"[Title/Abstract]) OR (compounds, volatile organic OR organic compounds, volatile[MeSH Terms])) AND ("public transport*" [Title/Abstract] OR taxi* [Title/Abstract] OR car [Title/Abstract] OR cars [Title/Abstract] OR bus [Title/Abstract] OR buses [Title/Abstract] OR train [Title/Abstract] OR trains [Title/Abstract] OR aeroplane* [Title/Abstract] OR aircraft* [Title/Abstract] OR submarine* [Title/Abstract] OR boat* [Title/Abstract] OR ship [Title/Abstract] OR ships[Title/Abstract] AND ((2013/1/1:2021/12/31[pdat]) AND (english[Filter]))): 273

2. Inclusion criteria

- Peer reviewed publications
- Relevant reviews
- In PubMed, search terms in title and abstract
- In Scopus, search terms in all fields
- Papers from 2013 to present

3. Exclusion criteria

- Studies not reporting original results, including comments, letters or editorials
- Papers without an abstract
- Papers concerned only with methodology
- Studies dealing only with health outcomes or biomonitoring
- Conflicting abbreviations such as BDPP (bioactive dietary polyphenol preparation), DBPP (diastolic blood pressure percentile), TCP (transscleral cyclophotocoagulation) and TBP (treated beyond progression or TATA box-binding protein or tuberculous pleuritis)

**Results**

4. Forty-one papers were identified.

5. Two papers related to vehicles in general (Do et al. 2014, Xu, Chen and Xiong 2018).

6. Six papers related to exposure to VOCs in buses (Cheng, Yen and Li , Gastelum-Arellanez et al. 2021, Kim 2020, Lin et al. 2020, Moolla, Curtis and Knight 2015a, Moolla, Curtis and Knight 2015b).

7. Two papers related to metros (Passi, Nagendra and Maiya 2021, Xu and Hao 2017).

8. Two papers related to taxis (Bakhtiari et al. 2018, Moreno et al. 2019),

9. Three papers related to trains (Awang, Isah and Hamid 2015, Awang et al. 2014, Maggos et al. 2016).

10. Thirteen papers related to cars (Ali et al. 2021, Brodzik et al. 2014, Faber and Brodzik 2017, Gong et al. 2017, Gong et al. 2019, Kim, Park and Lee 2019, Kim et al. 2016, Lexén et al. 2021, Ren et al. 2017, Siripongpokin et al. 2014, Yassin, Ramadan and Alshammari , Yue et al. 2017, Zulauf et al. 2019)

11. Thirteen papers related to aircraft (Chen et al. 2021, Cross et al. 2013, Guan et al. 2014a, Guan, Li and Yang 2015, Guan et al. 2014b, Guan, Yang and Li , Mokalled et al. 2019, Schuchardt, Koch and Rosenberger 2019, Wang et al. 2014a, Wang et al. 2014b, Wolkoff, Crump and Harrison 2016, Yang et al. 2018, Zubair, Ahmad and Riazuddin 2014).

**Papers**


- Ali, N., M. W. Kadi, H. M. S. Ali Albar, M. I. Rashid, S. Chandrasekaran, A. S. Summan, C. A. de Wit & G. Malarvannan (2021) Semi-volatile organic compounds in car dust: A pilot study in jeddah, saudi arabia. *International Journal of Environmental Research and Public Health,* 18.

- Awang, N., S. A. Isah & A. Hamid (2015) Cytogenetic analysis among train depot workers exposed to total volatile organic compounds. *OnLine Journal of Biological Sciences,* 15**,** 53-58.

- Awang, N., N. F. Mohd. Alwi, S. Hajar Yaacob & I. Ishak (2014) A study on exposure to air pollutants and their effects to the respiratory level

among employees of Sentul Railway Electric Multiple Unit (EMU) depot. *World Applied Sciences Journal,* 29**,** 402-407.

- Bakhtiari, R., M. Hadei, P. K. Hopke, A. Shahsavani, N. Rastkari, M. Kermani, M. Yarahmadi & A. Ghaderpoori (2018) Investigation of in-cabin volatile organic compounds (VOCs) in taxis; influence of vehicle's age, model, fuel, and refueling. *Environmental Pollution,* 237**,** 348-355.

- Brodzik, K., J. Faber, D. Łomankiewicz & A. Gołda-Kopek (2014) In-vehicle VOCs composition of unconditioned, newly produced cars. *Journal of Environmental Sciences (China),* 26**,** 1052-1061.

- Chen, R., L. Fang, J. Liu, B. Herbig, V. Norrefeldt, F. Mayer, R. Fox & P. Wargocki (2021) Cabin air quality on non-smoking commercial flights: A review of published data on airborne pollutants. *Indoor air,* 31**,** 926-957.

- Cheng, Y. H., G. W. Yen & A. C. Li. Short-term exposure to volatile organic compounds for passengers at two intercity bus terminals.

- Cross, E. S., J. F. Hunter, A. J. Carrasquillo, J. P. Franklin, S. C. Herndon, J. T. Jayne, D. R. Worsnop, R. C. Miake-Lye & J. H. Kroll (2013) Online measurements of the emissions of intermediate-volatility and semi-volatile organic compounds from aircraft. *Atmospheric Chemistry and Physics,* 13**,** 7845-7858.

- Do, D. H., H. Van Langenhove, S. I. Chigbo, A. N. Amare, K. Demeestere & C. Walgraeve (2014) Exposure to volatile organic compounds: Comparison among different transportation modes. *Atmospheric Environment,* 94**,** 53-62.

- Faber, J. & K. Brodzik (2017) Air quality inside passenger cars. *AIMS Environmental Science,* 4**,** 112-133.

- Gastelum-Arellanez, A., J. Esquivel-Días, R. Lopez-Padilla, V. H. Robledo, R. Paulina, M. F. Beltrán & J. O. Saucedo-Lucero (2021) Assessment of persistent indoor VOCs inside public transport during winter season. *Chemosphere,* 263.

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# Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment

## Introductory paper to an update of the COT position on aircraft cabin air

## Literature searches for exposure to VOCs in indoor work environments such as offices

### Search terms

1. Search terms for Scopus and PubMed are presented below.

   Scopus
   ( TITLE-ABS-KEY ( "volatile organic compound*" OR "semivolatile organic compound*" OR vocs OR svocs ) AND TITLE-ABS-KEY ( "office OR work place ) ) AND PUBYEAR > 2012 AND PUBYEAR < 2022 AND ( LIMIT-TO ( LANGUAGE , "English" ) OR EXCLUDE ( LANGUAGE , "French" ) )

   PubMed
   (("volatile organic compound*"[Title/Abstract] OR VOCs[Title/Abstract] OR sVOCs[Title/Abstract] OR "semivolatile organic compound*"[Title/Abstract]) OR (compounds, volatile organic OR organic compounds, volatile[MeSH Terms])) AND ("office" [Title/Abstract] OR work place [Title/Abstract] AND ((2013/1/1:2021/12/31[pdat]) AND (english[Filter])))

2. Inclusion criteria

   - Peer reviewed publications
   - Relevant reviews

- In PubMed, search terms in title and abstract
- In Scopus, search terms in all fields
- Papers from 2013 to present

3. Exclusion criteria

- Studies not reporting original results, including comments, letters or editorials
- Papers without an abstract
- Papers concerned only with methodology
- Studies dealing only with health outcomes or biomonitoring
- Conflicting abbreviations such as BDPP (bioactive dietary polyphenol preparation), DBPP (diastolic blood pressure percentile), TCP (transscleral cyclophotocoagulation) and TBP (treated beyond progression or TATA box-binding protein or tuberculous pleuritis)

**Results**

4. Thirty-two papers were identified.

5. All 32 papers related to office environments.

6. Six papers related to exposure in schools (Cometto-Muñiz and Abraham 2015, Faria et al. 2016, Goodman et al. , Lucattini et al. 2018, Paciência et al. , Paciência et al. 2016).

7. One paper reported exposure in hospitals (Fan et al. 2021).

8. Some papers such as Campagnolo et al. (2017) specifically focussed on VOCs, whereas others such as Datta et al. (2017) included VOCs in a review of indoor air quality hence may be of less relevance.

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