Cognitive impact of chronic low-level carbon monoxide exposure in older adults

Beth Cheshire, Prof Trevor Crawford & Prof Carol Holland

CO Poisoning

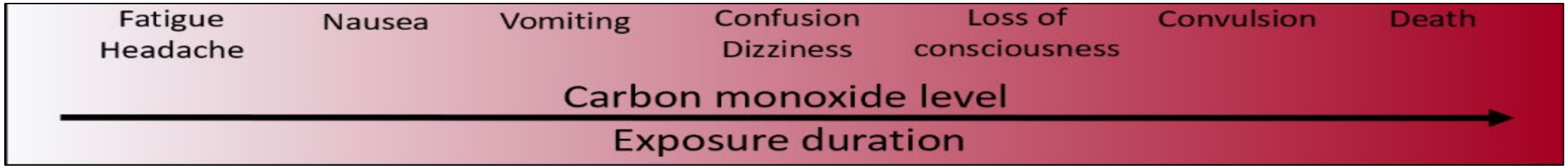
CO poisoning is one of the most common causes of accidental and intentional poisoning worldwide

CO enters the bloodstream where it binds to haemoglobin (Hb) forming carboxyhaemoglobin (COHb):

- Reduces the oxygen carrying capacity of the blood
- Availability of oxygen to the tissues and organs is decreased
- Leading to hypoxia

Severe acute poisoning:

- Initial symptoms include headache, fatigue, nausea, vomiting, confusion, dizziness, loss of consciousness, death.



- Neuropsychological impairments can also present and can include a wide range of neurological deficits, cognitive impairments, and affective changes.

Low-level CO Exposure

Evidence on the effects associated with low-level exposure is limited and inconsistent

Acute low-level CO exposure (duration ≤24 hours)

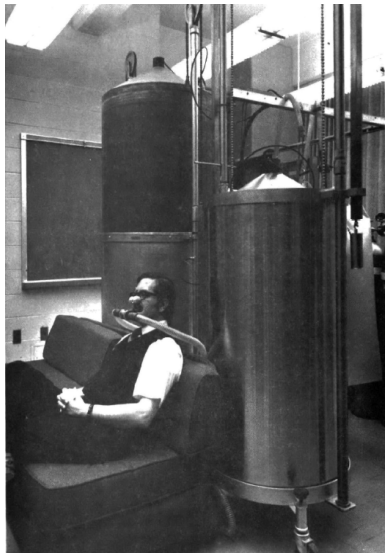
Experimental studies:

- COHb levels of around 5% associated with impaired cognitive function

Chronic low-level CO exposure (duration >24 hours)

Case reports:

- Headache and nausea
- Affective disorders
- Memory impairments and motor slowing (Myers et al., 1998).



McFarland et al., 1972

Epidemiological studies:

- Associations between air pollution and increased risk of stroke, MI and heart failure
- CO exposure and increased dementia development risk (Chang et al., 2014).

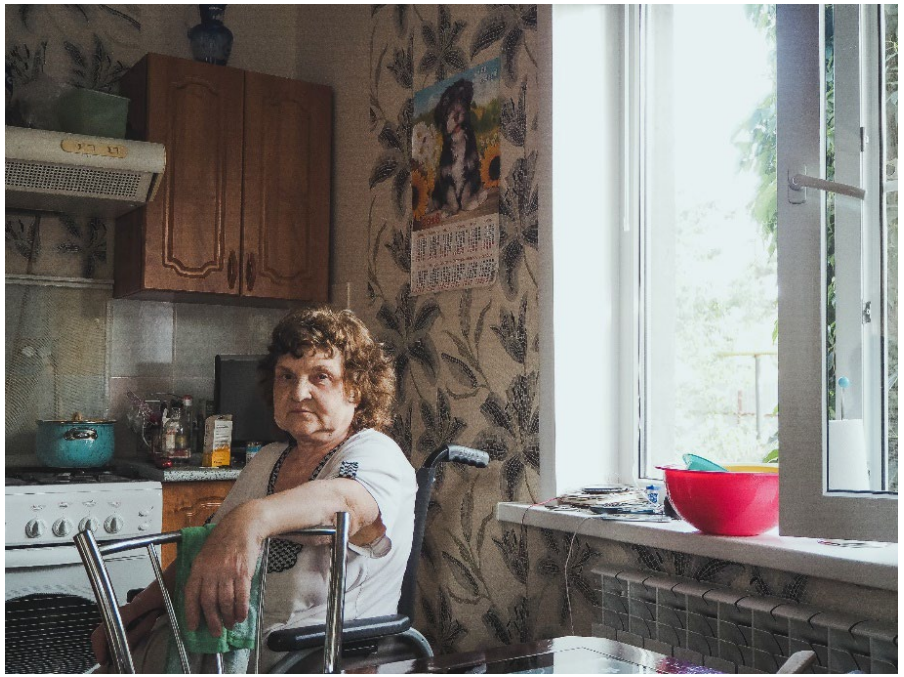
Neuropsychological deficits may present following less severe exposures

- May be persistent in nature.

High Risk groups

Poisoning severity depends on human and environmental factors:

- Duration of exposure
- Concentration of CO in the air
- Pre-existing disease



Older adults may be:

- More susceptible to the effects of CO
  - ➢ Reduced physiological reserve
  - ➢ Pre-existing disease
- At higher risk of accidental CO exposure within the home
  - ➢ Likely to spend more time within the home

CO levels within UK homes

Within UK homes CO levels have been reported to exceed the WHO (1999;2010) guidelines:

- 326 homes monitored
- 19% had CO levels exceeding the 8-hour guideline of 9ppm (Croxford et al., 2005a; Croxford et al., 2005b)

- Frequently associated with gas appliances
- Particular concern in the UK as gas appliances are widely used for heating and cooking

A percentage of the population may be at risk from low-level CO exposure

- At levels above those considered safe
- May be having a detrimental impact on health

Individuals unaware leading to chronic exposure

Aims and Method

Fire officers report high levels of confusion in older residents

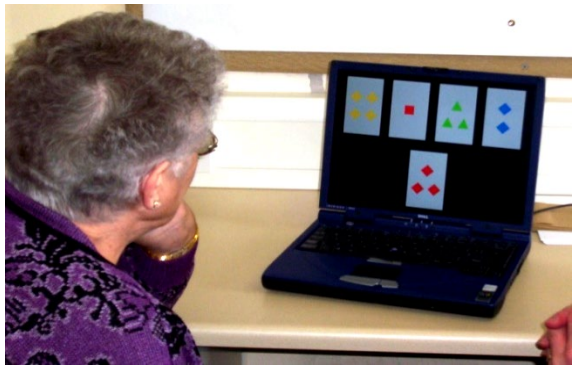
- Low-level exposures may be an unidentified cause of cognitive impairment

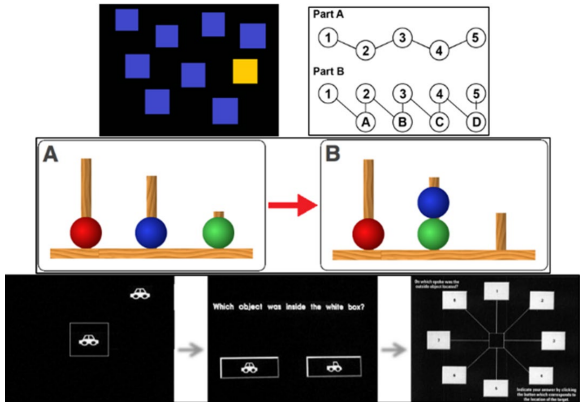
Aims:

- Examine the proportion of older adult homes in Coventry with low-level CO
- Examine the effects of chronic low-level CO exposure on cognitive function

A sample of 106 older adults (*M*=75.60 yrs) residing in Coventry were recruited

- Home CO monitoring 1 month
- Neuropsychological assessment
- Follow-up CO monitoring and assessments at 7 months
- Examine longer term impact





CO Levels within the Home

First data collection: 70/106 (66%) homes had some CO readings over the month

Exposure patterns observed in the data:

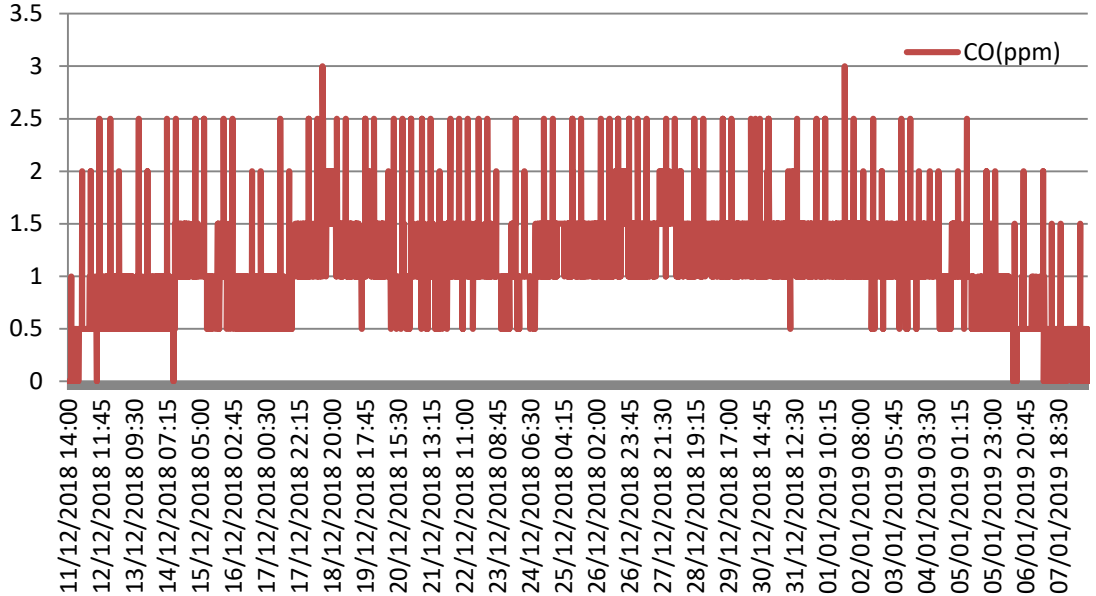


Figure 1. CO levels over 1-month showing continuous extremely low CO levels. Gas fire and boiler

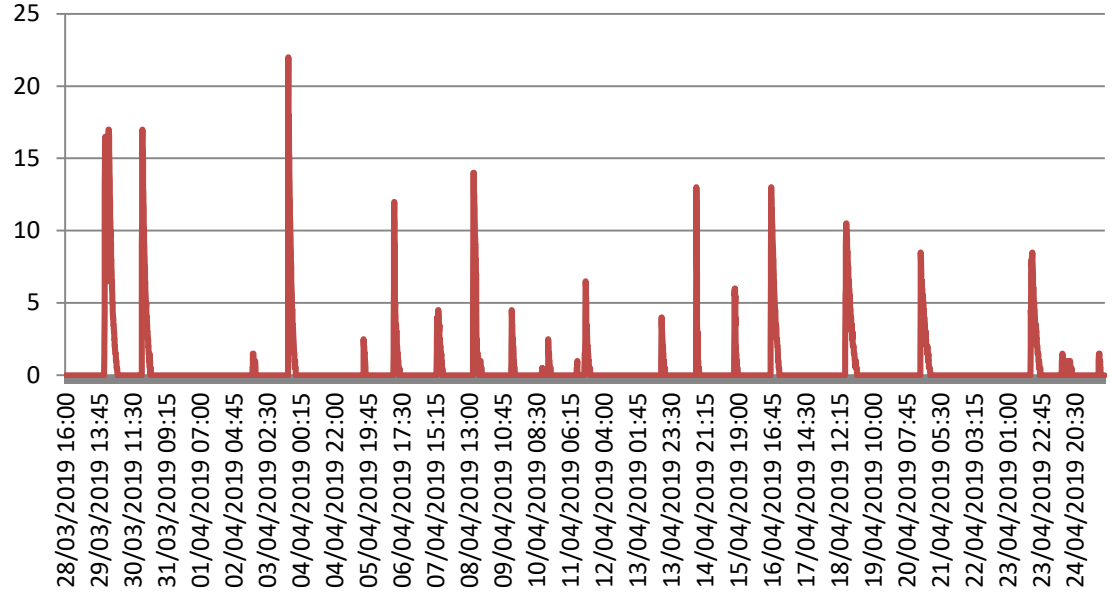


Figure 2. CO levels over 1-month showing higher short lasting CO peaks. Gas fire, boiler and cooker

- Continuous extremely low-level CO exposure with the majority of readings between 0.5-2.5ppm (Figure 1)
- A majority of zero CO readings with higher short lasting CO peaks up to around 22ppm (Figure 2)

Cross-sectional Results: Short-term effects

Chronic exposure ≥4 weeks to low-level CO was associated with **positive cognitive effects**

Cognitive performance **increased** with greater CO exposure:

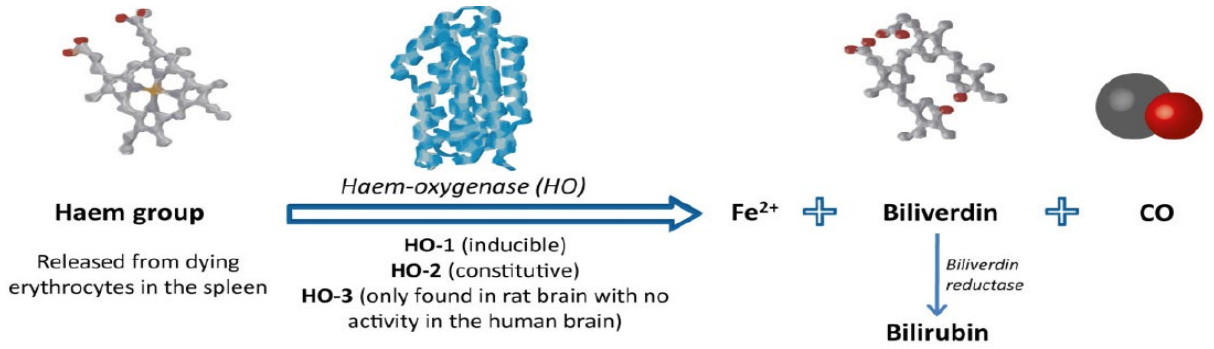
- Auditory working memory
- Memory recognition
- Visual working memory
- Visuospatial ability, planning and problem solving
- Selective attention and resistance to distractor interference

CO levels were **extremely low** (ambient: ≤29ppm; *M*= .09ppm, COHb *M*= 0.7%)

Discussion: Cross-sectional

Endogenous CO production:

- Results from the degradation of haem catalysed by haem oxygenase
- Biliverdin, free iron and CO



(Queiroga, Vercelli, & Vieira, 2015)

- Involved in various cellular functions including vasodilation and proliferation
- Plays a crucial role in cellular maintenance, protection, regeneration and survival

These physiological processes may also result from low-levels of inhaled CO:

- Potentially **minimise risk** to the **central nervous system**
- Playing a **protective** or even **beneficial role** up to a certain dose and duration

Discussion: Cross-sectional

For example:

- Endogenous CO plays a role in the regulation of vascular tone acting as a vasodilator
- Vasodilation increases blood flow through widening of the blood vessels
- Increases blood flow to the brain
- Optimal blood flow is vital for normal brain function.

Vasoactive properties may also result from low-level inhaled CO

- Play a **protective role to cognitive functioning** by temporarily **increasing and maintaining cerebral blood flow (CBF)**

Ageing is associated with structural and functional vascular changes that can influence cognitive function:

- Vasodilation and CBF decline in healthy ageing
- Age-related changes to blood vessels, such as stiffening and narrowing, can lead to impaired vessel function
- Leading to decreased blood flow to the brain

Discussion: Cross-sectional

Cardiovascular risk factors:

Heart failure, coronary artery disease and atrial fibrillation are more common in older adults

- Lead to greater decreases in CBF and chronic hypo-perfusion
- **Further compromising** the already **reduced CBF** that is present in ageing

The effects of these age and disease-related vascular changes on CBF have been associated with:

- **Increased risk of cognitive decline, MCI** and **dementia development**

The potential protective effects of low-level exogenous CO may be of particular benefit to older adults

However any protective effects are likely to be:

- Transient with COHb accumulation over time placing stress on the body's physiological resources
- Reaches a point where the body can no longer compensate for the continuous uptake of CO
- Insufficient CBF and ischaemia may follow
- Resulting in a shift from positive to negative cognitive impacts.

Longitudinal Results: Longer-term Effects

Examined the longer-term impact of exposure on cognitive function

- Determine whether the observed beneficial effects are short lasting and result in damage given sufficient exposure time/ time post-exposure
- 78 participants completed the follow-up at 7 months

Similar proportion of homes with some CO readings: 47/78 (60%)

Longer-term impact from T1 exposure on performance at 7 months

Cognitive performance **decreased** with greater CO exposure

- Processing speed
- Intra-individual variability in responding
- Selective attention, resistance to distractor interference

Longitudinal Results: Total Exposure

Cognitive performance **decreased** with greater CO exposure:

- Memory recognition
- Auditory working memory
- Cognitive flexibility, resistance to proactive interference
- Intra-individual variability in responding
- Selective attention, resistance to distractor interference

With the exception of visual working memory where:

- Positive effects continued to be observed
- Performance **increased** with greater CO exposure

Overall Results

Relatively consistent pattern of results:

- **Positive CO-related effects** observed across a range of functions in the **short-term** following exposure

However, the majority of these effects were short-lasting and **lead to longer-term negative impacts** either:

- Given sufficient time post-exposure (negative impacts from T1 exposure present at 7 months)
- Accumulation of two one-month exposure periods (total exposure)

This shift of effects was observed across a range of functions:

- Selective attention and resistance to distractor interference
- Memory recognition
- Auditory working memory
- Processing speed

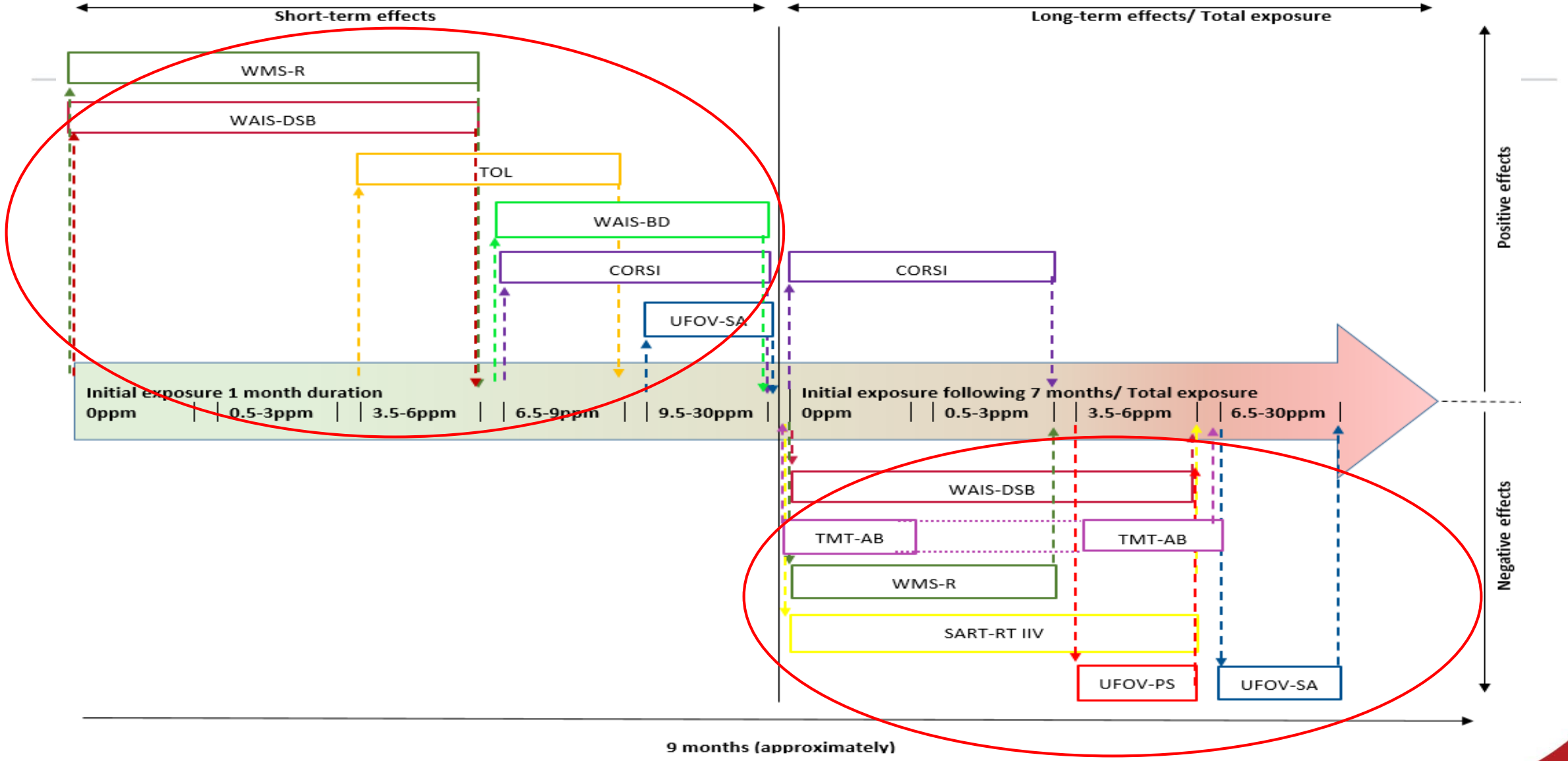
Overall Results

Particular cognitive areas appear to be **more resilient to CO** exposure associated with **positive effects only**:

- Visual working memory
- Currently unclear whether these positive effects are followed by negative impacts
- Likely that negative impacts do follow at levels above those reported

The results indicate that the effects of chronic low-level CO exposure may be **viewed on a continuum:**

- One end representing **extremely low-level exposure** and potential **beneficial effects**
- **Negative impacts** at the opposite end of the spectrum
- with **increasing exposure duration** and **concentration**


Short-term effects
Long-term effects/ Total exposure
WMS-R
WAIS-DSB
TOL
WAIS-BD
CORSI
UFOV-SA
Initial exposure 1 month duration
0ppm
0.5-3ppm
3.5-6ppm
6.5-9ppm
9.5-30ppm
CORSI
Initial exposure following 7 months/ Total exposure
0ppm
0.5-3ppm
3.5-6ppm
6.5-30ppm
WAIS-DSB
TMT-AB
TMT-AB
WMS-R
SART-RT IIV
UFOV-PS
UFOV-SA
Positive effects
Negative effects
9 months (approximately)

Overall Discussion

Results indicate that **chronic exposure to low-level CO** may result in **longer-term cognitive impairments**

The vascular alterations observed in ageing and cardiovascular disease and their effects on CBF along with:

- Age-related cerebral changes such as atrophy of the hippocampus and white matter hyperintensities
- Associated with **greater risk of early cognitive decline and dementia development**

The possibility that **chronic exposure to low-level CO adds to this burden** presents significant concern

- May place an already susceptible group at an **even greater risk of early cognitive decline and dementia**

Future Research

The association between CO exposure and dementia development risk has gained attention over the last decade:

Retrospective studies

- CO poisoned patients are at a higher risk of dementia development

Case reports

- Associations between less severe exposures and cognitive impairments

Epidemiological studies

- Chronic exposure to air pollution including low-level CO may increase risk of dementia
- **Air pollution** recently identified as a **dementia development risk factor** in later life (>65)

Future research

Longitudinal study of the cognitive impacts of chronic low-level exposure within the home

- Examine the risk for early cognitive decline, MCI and dementia development
- Preventative measures and reduced risk

Thank you for listening

Acknowledgements

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