



Understanding and minimising the consequences of environmental carbon monoxide exposure during pregnancy

Funded by: CO Research Trust

Prepared by: Beth Cheshire and Hilary Wareing

Executive summary

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Background

Improving Performance in Practice (iPiP) are undertaking a project, funded by the CO Research Trust (CORT), to support the development of protocols and pathways for the identification of those who are in danger of harm along with appropriate treatment pathways.

The **published literature** has been reviewed to gain an understanding of:

- **What we know about the harm** of moderate or severe CO exposure to the unborn child.
- Current knowledge about **how best to identify** those women who are being exposed.
- The evidence regarding **how pregnant women should be treated** to minimise harm to her and the unborn child.
- The **gaps in knowledge** regarding identification and treatment.

Secondly, experts in a variety of areas met to consider:

- What the available information tells us about **how best to identify and treat pregnant women and unborn babies impacted by** environmental exposure to carbon monoxide.
- The gaps in knowledge and understanding.
- How and by whom the gaps can be filled.

Executive summary

- **Carbon monoxide (CO) is a colourless, odourless, tasteless, and non-irritable gas** that is formed by the partial combustion of fuel such as wood, coal, and gas. Carbon monoxide poisoning is one of the most common causes of accidental and intentional poisoning worldwide.
- Acute exposure includes durations up to 24 hours; chronic describes longer exposures lasting more than 24 hours (including intermittent exposure); and acute-on-chronic includes a combination of both. Chronic exposures to CO can range from several weeks to years in duration, with intermittent exposure commonly occurring.
- **Evidence is accumulating of raised CO levels with UK homes at levels above those recommended as safe.** Indoor sources of CO such as gas appliances and smoking habits contribute significantly to CO exposure within the home.
- **CO poisoning is variable in its clinical presentation**, symptoms are non-specific and include headache, fatigue, nausea and vomiting, which are progressively followed by confusion, dizziness loss of consciousness, seizures and ultimately death. Neuropsychological sequelae (NS) following acute CO poisoning can also present, including a wide range of neurological deficits, cognitive impairments, and affective changes. **COHb levels below 10% may present with headache but are usually asymptomatic. During pregnancy symptoms may be mistaken for the signs and symptoms of pregnancy.**
- COHb has an average elimination half-life of around 320 minutes in young healthy adults breathing room air, so levels of blood COHb fall quickly once an individual is removed from the CO source. However, in pregnancy, **once fetal COHb concentrations began to rise, they reach maternal levels and continue to increase**, surpassing that of the mother's). In acute exposure, maternal COHb levels rise rapidly and slowly diminish, whereas fetal COHb levels slowly

increase and continue to rise to levels twice that of the mothers. In chronic exposure conditions, maternal COHb levels rise rapidly in the first few hours, plateauing in 7-8 hours. Fetal COHb levels rise slowly, reaching that of maternal levels in 14-24 hours and continue to rise for 36-48 hours, therefore **maternal COHb concentrations may not accurately reflect fetal concentration**. Elimination half-life post exposure is approximately 2 hours for the mother and 7 hours for the fetus.

- **Evidence indicates that maternal smoking and chronic exposure to low-level indoor and outdoor air pollution, including carbon monoxide (CO), may contribute to adverse fetal and infant outcomes.**
- **The fetus in utero is extremely vulnerable to CO exposure.** Acute severe poisoning is harmful to both mother and fetus however, **chronic exposure can cause disproportionate harm to the fetus** during development placing the fetus at greater risk of damage than the mother due to progressive tissue hypoxia. Lower level exposures to CO and the potential public health impacts such exposures may represent, has largely been underappreciated.
- Predicting fetal outcomes in CO poisoning is difficult, severity of maternal exposure, as defined by COHb levels, does not correlate with fetal COHb concentrations.
- **Of great concern are findings that low maternal COHb concentrations have been related to poor fetal outcomes** particularly to increased risk of low birth weight.
- **These findings represent significant public health concern** particularly when considered with studies that have identified birth weight as a significant predictor of infant health. Low birth weight is associated with health problems and poor developmental and cognitive outcomes.
- As part of identifying those who smoke, raising concern and referring to specialist support, pregnant women are now routinely tested using carbon monoxide breathalysers at antenatal appointments.
- Referrals to 'opt out' stop smoking support is recommended, by NICE, for all women who indicate active smoking or cessation in the past two weeks, breath CO levels revealing concentrations of 4 parts per million (ppm) or above or in cases where previous referrals have not been engaged.
- **NICE guidance provides recommendations about environmental CO exposure for women who identify as non-smokers** and whose exhaled breath levels are 3ppm and above or 10ppm and above. It is unclear as to how those levels were set. **There is no mention of actions for smokers regarding environmental exposure.**
- Between 3-12% of pregnant women who report to be non-smokers have raised CO concentrations breath CO concentrations. It is possible that the raised CO levels in a proportion of these women may be due to outdoor or home exposure.
- **If exposure has occurred in the home, CO levels are likely to have dropped upon arrival at the antenatal appointment**, so levels identified with the exhaled breath test are unlikely to accurately reflect the severity of any exposure. **The half-life of exhaled CO is 4.6 hours.** Exhaled breath tests are not a measure of cigarette smoking or environmental exposure per-se but instead detect the presence and concentration of CO.
- There are no published guidelines specifically on the identification and treatment of CO poisoning in pregnancy. It is advised that the management of CO poisoning in the pregnant patient should follow the same guidance as for non-pregnant patients. However, longer treatment may be required in order to remove CO from the fetus due to the reduced capacity of the fetus to remove CO.

- There is a lack of guidance and training available for midwives on identifying environmental sources of CO exposure and a lack of referral pathways when exposure from other sources is suspected.
- Further understanding of the potential effects associated with chronic low-level CO exposure during pregnancy is needed. In their 2017 report, the **All-Party Parliamentary Carbon Monoxide Group (APPCOG) emphasised the urgent need for research into the prevalence of environmental CO exposure in pregnancy, improved identification and better protection for pregnant women** through actions by healthcare professionals and other agencies, and a better understanding within communities and particularly the most vulnerable groups.

A roundtable was held to discuss the findings of the literature review and consider the actions required. The attendees included representatives from OHID, NHSE, maternity trusts, fire and rescue (FRS), gas distribution networks, Maternity Voices Partnership, SANDS, RCM and the CO Research Trust. The expertise in the room included air quality, toxicology maternity, insights, gas safety and home safety. For those unable to attend, separate discussions will be offered to ensure the widest possible consultation regarding the way forward. Those organisations include NHSE, RCOG, UKHSA and alarm manufacturers.

Below are some of the concerns raised and potential actions considered at the roundtable.

Key Concerns

- Midwifery staff do not have the expertise or resources to identify environmental CO exposure and poisoning. They are **not routinely offered training** that enables them to have **honest conversations** about the potential sources of CO or how to help women protect themselves and their unborn baby.
- Pregnant women are **not routinely provided with information** that helps them protect themselves and their family.
- There is **not clarity about the ppm/symptoms** that should instigate actions to protect and treat the pregnant woman and her unborn child.
- There are **no pathways/ protocols/ algorithms** to support identification of those at risk or potentially at risk, treatment and removal of harm.
- CO testing may not be the most accurate way of identifying risk and the level of risk, **the half-life of exhaled CO being 4.6 hours.**
- **Environmental CO exposure may only be being considered in those identifying as non-smokers.**
- Those exposed may be wrongly **labelled as non-disclosing smokers.**
- **Non-smokers may be referred to stop smoking services** when the risk is from environmental factors not smoking. Also, stop smoking practitioners do not generally have expertise in environmental poisoning.
- The group that discusses this issue is the Smoking in Pregnancy Challenge Group, this may not be helpful when trying to address environmental exposure and poisoning.
- **Many pregnant women will go through their pregnancy without a health professional visiting them at home.**

- **Pregnancy is not included as a factor which would allow registration on the on the Priority Services Register**, this needs to change.
- **CO alarms do not help identify chronic low level CO poisoning** but may not even be present and working in the pregnant woman's home environment.
- If a baby is exposed in utero, it is **likely they will continue to be exposed after birth**.
- CO exposure may impact the ability to breastfeed.

Key Actions

- There is a need to **change the narrative**, so CO testing and the conversations are about CO rather than just smoking.
- We need to listen to women, with solutions being **women centred and co designed** with women and professionals.
- **Training** needs to be developed and delivered to midwifery teams and other key professionals.
- Ethnicity and other difference including **vulnerability and type of home environment** needed to be considered when developing solutions.
- Easily accessible **Information** needs to be available to all pregnant women and those planning a pregnancy. These resources need to be available to midwifery staff to use within their conversations with women.
- **Protocols/pathways/ algorithms** are needed to ensure those impacted are identified, treated and the harm removed. These need to include the actions required at different levels of exposure and how best to identify those at risk.
- **Further research** and data gathering is required to understand the impact of CO on the unborn child (especially at low levels), how to identify harm (bio markers) and the best treatment for those exposed.
- Pregnancy needs to be a category on the **Priority Services Register**.
- Pregnant women, especially the most vulnerable, should be a priority for **safe and well visits** undertaken by FRS.
- The **levels at which alarms alert** householders to raised CO levels needs to be reviewed.
- The potential **valuable role that FRS can play** needs further investigation.
- **These concerns should be raised with all the relevant agencies and the appropriate APPGs.**

For further information or to discuss the contents of this document please contact Hilary Wareing, Director, Improving Performance in Practice.

Email: hwareing@pip.co.uk