UK Health Security Agency

Carbon monoxide (CO)

Antenatal checks algorithm

An algorithm to help midwives and maternity staff diagnose environmental carbon monoxide (CO) poisoning in both smoking and non-smoking pregnant women and offer advice in the event of suspected exposure.

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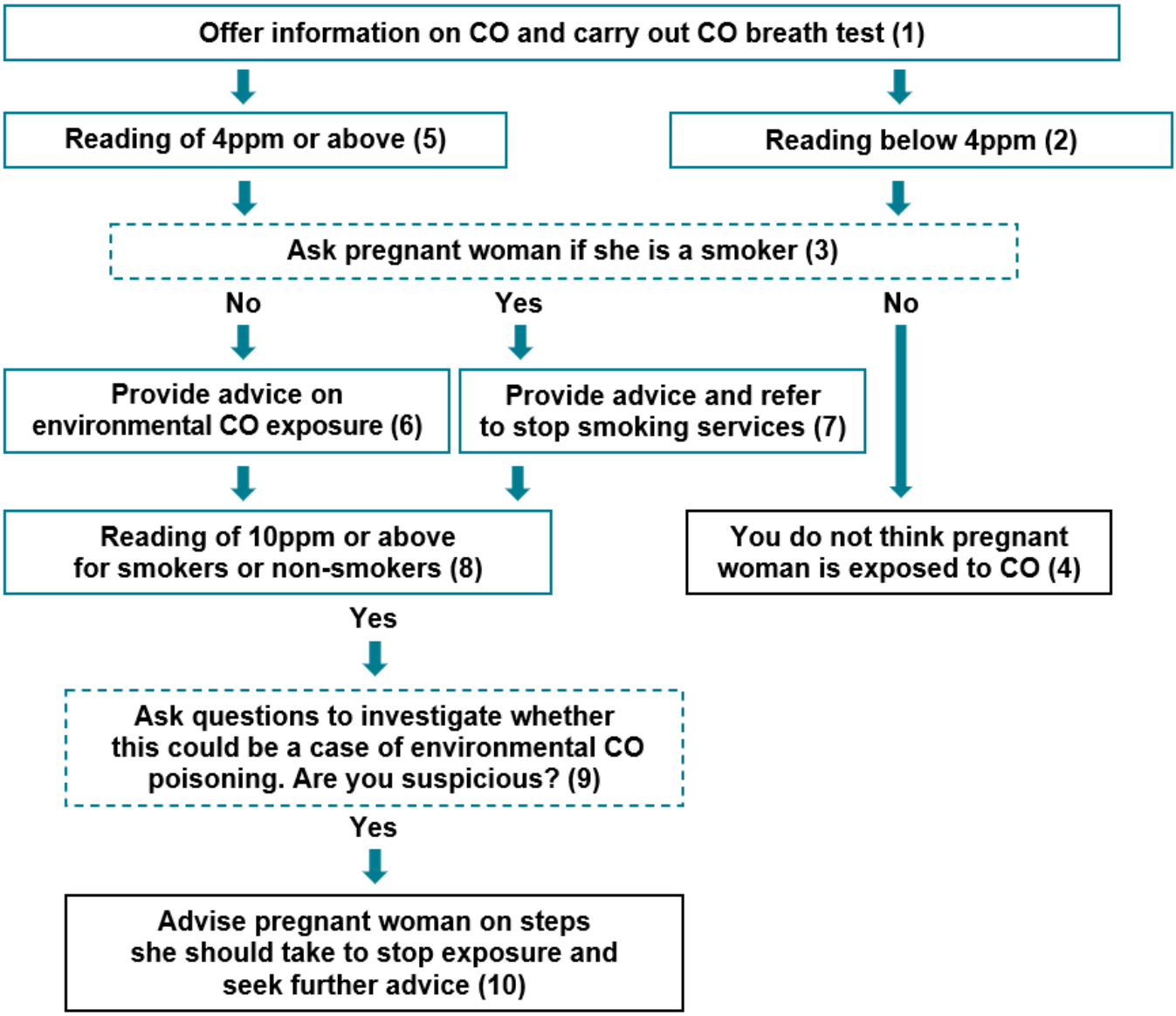
The algorithm

This algorithm is designed to help midwives and maternity staff diagnose environmental carbon monoxide (CO) poisoning in both smoking and non-smoking pregnant women and offer advice in the event of suspected exposure. The term ‘pregnant woman’ is used throughout the algorithm. This term should be taken to include people who do not identify as women but who are pregnant or have given birth.

The numbers in brackets refer to sections of this document which explain each step in more detail. ppm stands for parts per million.



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Algorithm steps and actions

1. Offer information on CO and carry-out CO breath test

Provide information on:

- what carbon monoxide (CO) is
- what the risks are and possible sources of exposure
- the procedure for the test, explaining that this is routine practice at antenatal appointments

Carry out the CO breath test and compare levels to previous readings if available.

Additional information

Carbon monoxide is produced as a product of incomplete combustion. CO is produced when tobacco products are burnt, such as hand-rolled or store-bought cigarettes, cigarillos or cigars, shisha or waterpipe and cannabis. Active smokers and passive smokers exposed to side stream and exhaled smoke will inhale the CO contained in the smoke of burning tobacco products. This makes the levels of CO found in the exhaled breath of smokers and passive smokers higher than levels among non-smokers.

CO can also come from other environmental sources such as malfunctioning, inappropriately used or poorly ventilated, flued and unflued domestic or portable fuel burning appliances (boilers, heaters, fires, stoves and ovens), vehicle exhausts, industrial processes, and incense burners or ceremonial coals. These sources can be found in the home, workplace, places of education, places of worship, public buildings, other indoor spaces, and in and around vehicles or industrial processes (UKHSA 2022a). Since CO is colourless, odourless and tasteless, CO alarms are important in alerting people to its presence before levels lead to severe harm or death. Most CO alarms only sound at high levels (consult the CO alarm user manual for the sensitivity level), however some CO alarms also monitor and detect low-level CO.

Analysis of exhaled breath is an indicator of exposure to CO and to tobacco smoke. It is important that a CO breath test is undertaken to confirm exposure and start a discussion to help identify the source of exposure. This could save both the baby and the pregnant woman from harm. Regardless of where the CO comes from (smoking, second-hand smoke or other environmental sources), the health risks are the same.

Several adverse outcomes have been reported following acute exposure to high levels of carbon monoxide during pregnancy. These include fetal and neonatal death, congenital malformations, neurological effects, and moderate to severe maternal toxicity (UKHSA 2022b).

Some studies have reported adverse effects following chronic low-level exposure to carbon monoxide during pregnancy, without maternal toxicity (UKHSA 2022b).

2. Reading below 4ppm

Advise the pregnant woman that her reading is less than 4ppm and she is unlikely to be exposed to CO.

3. Ask the pregnant woman if she is a smoker

Ask the pregnant woman if she is a smoker or has ever smoked (for example, hand-rolled or store-bought cigarettes, cigarillos or cigars, shisha or waterpipe and cannabis), however infrequently.

4. You do not think the pregnant woman is exposed to CO

You do not think the pregnant woman is exposed to CO, particularly if her CO readings at previous appointments (if this is not the first appointment) have also been below 4ppm.

5. Reading of 4ppm or above

Advise the pregnant woman that her reading is raised. Explain that this is a concern and that the main source of exposure is usually smoking (NICE 2021). However, it is important to have a conversation about second-hand smoke exposure if the pregnant woman has been around others who smoke or members of the household are active smokers, and discuss ways to reduce her exposure and offer support for the household to quit. It is also important to have a conversation about other potential environmental sources of CO, signs and symptoms to be aware of and ways to reduce levels.

Additional information

For all pregnant women with exhaled breath tests between 4 and 9ppm of CO, it is important to have a conversation about:

- other potential environmental sources of exposure (for example, domestic or portable fuel burning appliances, vehicle exhausts and incense burners)
- signs of CO (soot or stains around fuel burning appliances, yellow or orange flames except for fuel-effect fires, pilot lights that frequently blow out, and blocked or obstructed fixed ventilation or flues)

- symptoms to be aware of (for example, headache, dizziness, flu-like symptoms, weakness, drowsiness, confusion and/or nausea)
- ways to reduce levels (for example, regular maintenance of fuel burning appliances by a registered engineer, ventilate indoor spaces, have chimneys swept at least once a year by a qualified sweep, and minimise exposure to potential environmental sources of exposure, for example, vehicle exhausts and incense burners)

Regardless of the potential source of CO exposure, if you feel concerned about raised levels of CO and/or signs and symptoms of CO poisoning, please use your clinical judgement and follow the local trust's policies.

6. Provide advice on environmental CO exposure

It is important to have a conversation about second-hand smoke exposure if the pregnant woman has been around others who smoke or members of the household are active smokers, and discuss ways to reduce her exposure and offer advice on quitting for them. It is also important to have a conversation about other potential environmental sources of CO, signs and symptoms to be aware of and ways to reduce levels.

7. Provide advice and refer to stop smoking services

If the pregnant woman is a current smoker, regardless of her level of CO, express your concern for both her and her baby. Advise that because of the risk to the baby you will make an immediate referral to a specialist service who can support her to quit smoking. Use local referral systems to complete the referral and advise the pregnant woman when and how she will be contacted for further discussion (NICE 2021).

If recently quit, congratulate the pregnant woman, acknowledging that this will have not have been easy. Let her know you will be making a referral to a specialist service which will be able to offer her support to stay quit.

If a previous referral has been made and the pregnant woman did not engage, raise your concern, provide advice, and make another referral.

It is important to have a conversation about second-hand smoke exposure if the pregnant woman has been around others who smoke or members of the household are active smokers, and discuss ways to reduce her exposure and offer advice on quitting for them. It is also important to have a conversation about other potential environmental sources of CO, signs and symptoms to be aware of and ways to reduce levels.

8. Reading of 10ppm or above for smokers or non-smokers

For smokers, inform the pregnant woman that her reading is high, and to protect her and her baby, you want to check if the level recorded is due to smoking, second-hand smoke exposure and/or other potential environmental sources of CO.
For non-smokers, inform the pregnant woman that her reading is high, and that to protect her and her baby, you want to check what might be causing this.

Additional information

If the level is 10ppm or above (NICE 2021), it is important to ask questions (see step 10) which will help identify the potential source of CO, ways to stop exposure and protect the pregnant woman and her baby. If the pregnant woman is a smoker it should not be presumed that the raised level is completely due to smoking.

9. Ask questions to investigate whether this could be a case of environmental CO poisoning. Are you suspicious?

Contextual questions:

- ask smokers and non-smokers: ‘Did you come here from your home, at what time did you leave and how did you travel here (for example, walking, cycling, car, bus or train)?’
- ask smokers: ‘Did you have your last smoke within the 4 hours preceding this test?’

Positive responses to any of the following questions raise suspicion of environmental exposure for both smokers and non-smokers:

- ‘Do you or cohabitees suffer from headache, dizziness, flu-like symptoms, weakness, drowsiness, confusion and/or nausea? If so, do symptoms improve when you are outside?’
- ‘Does your work involve exposure to smoke, fumes, or motor vehicle exhaust?’
- ‘Do you have gas, oil or solid fuel appliances (for example, boilers, cookers or fires) in your home, has it been a while since they were last serviced, and/or has one been newly installed or have you started using an old appliance you have not used for a while?’
- ‘Do you ever use your gas oven or stove for heating purposes as well as for cooking?’
- ‘Do you ever burn incense or ceremonial coals at home?’

- ‘Has there been any change in ventilation in your home recently (for example, fitting double glazing or insulation)?’

It is also important to ask:

- ‘Do you have a working CO alarm in your home?’

If ‘no’ recommend the installation of an audible CO alarm (BS EN 50291-1 compliant) in the home and see ‘Additional information’, below.

If ‘yes’, ask:

- ‘Has it sounded recently?’

Based on the responses to these questions, if you are suspicious that this could be a case of environmental CO poisoning, progress to step 10.

Additional information

Exhaled CO declines exponentially with a half life of about 4.5 hours. It takes even longer for the baby to eliminate CO from its system, causing a disproportionate potential for harm. Asking the pregnant woman where she travelled from, what time she left and what mode of travel she used (for example, walking, cycling, car, bus or train along busy routes), might provide an indication as to whether environmental exposure to CO is likely to be identified.

If the pregnant woman is a smoker, ask her at what time she last smoked. If it was within 4 hours of the CO test, it is likely that the high CO reading is from recent smoking (Ke-Ting Pan and others 2021). Having recently consumed milk or being lactose-intolerant may produce a slightly higher reading (Miyoshi and others 2022; McNeill and others 1990). Pregnant women with gestational diabetes may also naturally produce higher levels of exhaled CO (Paredi and others 1999).

CO poisoning can mimic many symptoms of early pregnancy. Headache is the most common symptom, though other symptoms may include dizziness, flu-like symptoms, feeling weak, confusion, drowsiness, nausea chest and muscle pain and shortness of breath (NHS 2022, UKHSA 2022b). Furthermore, chronic low-level CO poisoning may show little in the way of symptoms. CO poisoning may also affect pets causing them to act strangely.

Gas, oil, coal and wood heating appliances are the most common sources of CO in the home, other than tobacco smoke. More than one appliance may be causing the problem. Inappropriate appliance use and the inappropriate use of generators and BBQs indoors, including burning charcoal, can quickly lead to a build-up of potentially fatal levels of CO. If an appliance has been newly installed or serviced, it is worth asking whether this was done by a registered engineer. If not, this may raise suspicion about potentially faulty appliances.

Recently fitted double glazing, insulation or blocking vents will reduce ventilation and if there is a problem appliance, CO will build up in the property.

CO alarms should be tested regularly to ensure proper functioning.

10. Advise the pregnant woman on steps she should take to stop exposure and seek further advice

If you are suspicious that this could be a case of environmental CO poisoning:

- refer the pregnant woman and any cohabitees to emergency services if they are **symptomatic** (emergency services staff should be told that symptoms may be related to CO poisoning), unless there is a specific local pathway
- the pregnant woman or cohabitees should contact the National Gas Emergency Service Line (freephone 0800 111 999) for advice on all types of fuel burning appliances
- the pregnant woman or cohabitees should turn off fuel-burning appliances, open windows to ventilate the building, and not go back into the suspected building (or vehicle) until they have got advice
- the pregnant woman or cohabitees should install a CO alarm (BS EN 50291-1 compliant) or ask the landlord to install a CO alarm in the case of rented properties for each fixed combustion appliance, such as boilers; some CO alarms (BS EN 50291-1 compliant) can also monitor and detect low-level CO

Always record the exhaled CO level and any feedback given in antenatal records.

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Additional information

Preventing further exposure is critical and you can assist the pregnant woman with contacting the National Gas Emergency Service Line if concerned. Whomever makes the call, it is important to state that there is a pregnant woman in the household. Any occupant experiencing any of the symptoms listed in step 9 should seek medical attention immediately (NHS 2022). A

pregnant woman exposed to lower levels of CO may not experience symptoms, but this does not mean that there is no harm to the unborn child.

Recommend the purchase of an audible CO alarm for installation in the home, but stress that the level at which alarms sound is meant to prevent severe harm and death from CO, and that health impacts can occur even at lower levels. In addition, a CO alarm is not a substitute for regular maintenance of fuel burning appliances by an appropriately registered engineer. For rented homes (private and social housing), landlords are required by law to install CO alarms (BS EN 50291-1 compliant) in any room which is used wholly or partly as living accommodation and contains a fixed combustion appliance (excluding gas cookers in England) (DLUHC 2022). Some CO alarms (BS EN 50291-1 compliant) can also monitor and identify low-level CO indoors (for example, home, workplace, places of worship, public buildings and so on).

The National Poisons Information Service provides information on clinical management for health professionals through the TOXBASE® website or phone 0344 892 0111.

Emergency contacts

- Ambulance (severe symptoms): 999
- National Gas Emergency Helpline (concerns about fuel burning appliances): 0800 111 999

Useful contacts

- NHS (non-emergency line) (mild symptoms): 111
- Gas Safe Register (registered gas engineers): 0800 408 5500
- HETAS (registered solid fuel engineers): 01684 278170
- OFTEC (registered oil or biofuel engineers): 01473 626298

Priority Services Register

Use this registration link to register.

Note: pregnant women may be eligible to register.

Annexe A. How the algorithm was revised

The revision of the algorithm was led by the Air Quality and Public Health team at the UK Health Security Agency (Sophia Garkov, Professor Sani Dimitroulopoulou and Dr Sierra Clark). The revised algorithm was piloted in maternity services across the country prior to its publication, funded by the Carbon Monoxide Research Trust (CORT).

We would like to thank the following individuals who contributed to the revision of the algorithm and/or its review by providing expertise in midwifery, tobacco control and CO:

- Hilary Wareing - Improving Performance in Practice (iPiP)
- Rachel Harrison - Improving Performance in Practice (iPiP)
- Isabella Myers - Independent Consultant, IQHealth Strategies Ltd
- Jo Locker - Office for Health Improvements and Disparities (OHID) in the Department for Health and Social Care (DHSC)

Furthermore, the algorithm was reviewed by scientists working in environmental emergency and incident response in UKHSA and the Gas Distribution Networks were engaged to ensure alignment on recommendations given if environmental CO exposure was suspected.

About the UK Health Security Agency

UK Health Security Agency (UKHSA) prevents, prepares for and responds to infectious diseases, and environmental hazards, to keep all our communities safe, save lives and protect livelihoods. We provide scientific and operational leadership, working with local, national and international partners to protect the public's health and build the nation's health security capability.

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