



Solid fuel and carbon monoxide review

Final report

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Solid fuel and carbon monoxide review

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Executive Summary

This report discusses work performed by the Institute of Occupational Medicine (IOM) for the CO Research Trust on the current state of play for the regulatory and policy landscape and incident data for Carbon Monoxide (CO) in domestic settings in the UK. A literature review, stakeholder engagement and Freedom of Information (FOI) requests to health authorities and emergency services have been performed during the project duration.

The current regulatory and policy landscape for solid fuels has been divided into four sub-sections:

- the manufacture of appliances (dominantly CE (soon to be CA)) markings and Ecodesign requirements
- the safety of appliances (covered under the General Product Safety Regulations, 2005)
- installation (predominantly the Building Regulations)
- legislation relating to solid fuels (air quality regulations)

For the gas sector, the regulatory and policy landscape is more developed than that for solid fuel. Key differences between the solid fuel and gas regulations are the requirements to report gas incidents under RIDDOR; there is no equivalent reporting requirements for solid fuel incidents and for enforcement of solid fuel regulations.

Incident data for solid fuel CO incidents is limited. Data is available from the literature, health care providers, National Poisons Information Service (FOI) and from some Fire and Rescue Services (FRS) and ambulance services for the total numbers of CO incidents attended. However, for the number of CO incidents from solid fuels, there are only a limited number of publicly available sources available (such as the CO Research Trust's Downstream Incident Data Report (DIDR) and the CO and Gas Safety Society). FOI requests for solid fuel CO incidents only resulted in incident data from a small number of FRSs; not all groups were able to supply this data and where available, the quality of the data varied. The lack of mandatory reporting, different requirements/methods between services and data collection for solid fuel incidents means that it is not possible to state the numbers of incidents and fatalities relating to the use of solid fuel. Gas CO incident numbers are slightly better understood thanks to the RIDDOR reporting requirements, although it is accepted that there are gas related incidents that do not get captured, and there are the same issues for reporting for the emergency services as for solid fuel.

From this project, a number of action points for future work have been developed for the regulatory and policy landscape, incident data and research opportunities. These are as follows:

- Regulatory and policy landscape:
 - Improving awareness of relevant regulations, through guidance documents and training/education of parties in the solid fuel sector.

- Regulations need to consider social housing and changes in leisure such as glamping. There is also potential for improving regulations for CO alarm positioning.
 - Possibility of RIDDOR Regulations bringing solid fuel incidents into scope.
- Collation and reporting of incident data:
 - Development of a standardised data collection digital template for recording solid fuel CO incidents for use by relevant parties (such as emergency services). This would also involve trialling the template with a range of stakeholders who are involved in inputting data in the template and those involved in the data analysis to ensure ease of use and collation of all relevant data. The development of a standardised database would allow data to be collected consistently throughout the UK and allow an accurate number of incidents to be collated/reported.
 - Development of a centralised database for recording solid fuel CO incidences with an authority/organisation being responsible for the database. This would also allow data to be visible and accessible to relevant stakeholders.
 - Requiring the mandatory reporting of solid fuel incidences, such as in the gas sector (RIDDOR).
- Future Research Opportunities:
 - Provide awareness to relevant stakeholders for the monitoring of appliances and for burning solid fuels safely to consumers and users.
 - Conducting research on solid fuel appliances to see if they are working correctly and investigating if appliances remain safe over time.
 - Providing awareness to consumers and users on potential CO exposure, appliance usage, monitoring and maintenance.

1. Introduction and Aims

1.1 Background to the study

The Institute of Occupational Medicine (IOM) was commissioned by the CO Research Trust (formerly the Gas Safety Trust) to carry out a review of solid fuel and Carbon Monoxide (CO) to establish whether there is an elevated CO risk from solid fuels in UK homes, what the barriers are to obtaining accurate data on CO incidents and how these can be overcome. The study was carried out between January 2021 and July 2021. This report summarises the findings of the study.

1.2 Properties of CO

Carbon monoxide is a poisonous gas, which is colourless, odourless and tasteless. CO is produced by the incomplete combustion of carbon based fuels.¹ Examples of carbon based fuels include coal, gas, oil and wood; **this report only focusses on solid fuels**. Selected chemical and physical properties of CO are presented in Table 1. CO has also been shown in the literature to be able to diffuse through porous walls at a diffusion range that may be dangerous to occupants and CO can also diffuse through walls through experiments performed in realistic conditions.²

Table 1: Selected chemical and physical properties of CO³

Property	Details
CAS number	630-0800
EC number	211-12803
Chemical formula	CO
Appearance	Colourless, compressed gas
Molecular weight	28.01 g/mol
Vapour density	0.97 – (Air =1.0)
Melting point/freezing point	-205 °C
Initial boiling point and range	-191.5 °C
Hazard Statements	
H220	Extremely flammable gas

¹ HSE (2021). Gas safety – Carbon monoxide awareness frequently asked questions. <https://www.hse.gov.uk/gas/domestic/co.htm>

² Vermesi I et al (2018). Carbon Monoxide Diffusion Through Porous Walls: Evidence Found in Incidents and Experimental Studies. *Front. Built Environ.*, 4, 44, doi: <https://doi.org/10.3389/fbuil.2018.00044>

³ Merck (2021): Carbon monoxide Safety Data Sheet. <https://www.sigmaaldrich.com/GB/en/sds/aldrich/295116>

Property	Details
H331	Toxic if inhaled
H372	Causes damage to organs through prolonged or repeated exposure if inhaled
H360D	May damage the unborn child
H372	Causes damage to organs through prolonged or repeated exposure if inhaled

CO is absorbed through the lungs and then preferentially combines with haemoglobin producing carboxyhaemoglobin (COHb). This, in turn reduces the delivery of oxygen to vital tissues. CO also impairs the cellular utilisation of oxygen by binding to myoglobin in cardiac and skeletal muscle and also cytochrome oxidases.⁴

The diagnosis of CO exposure can be difficult. Diagnosing CO poisoning can be dependent on a number of factors, including the elevation of COHb, identifying symptoms that are consistent with CO exposure and exposure history. For measuring elevated COHb levels, a number of methods can be used such as fingertip pulse CO-oximetry, spectrophotometrical blood sampling measurement and exhaled breath testing. However, even then diagnosis can be difficult as symptoms can be varied, can be poor correlation with the percentage of COHb and the half-life of COHb% is also affected following treatment of 100% oxygen (reduced from approximately 5 hours to 80 minutes when breathing air)⁴.

Symptoms of CO exposure can include a tension-type headache, dizziness, feeling and being sick, difficulty with breathing, confusion, tiredness, stomach pain and a shortness of breath. Standard oxygen therapy (administrated 100% oxygen through a mask) is normally the recommended treatment for CO poisoning, however hyperbaric oxygen therapy (flooding the body with pure oxygen) may be used in some situations.⁵ When there is a suspicion of CO exposure, the guidance is to open doors and windows, leave the house and immediately get fresh air.⁶

Office of National Statistics (ONS) data indicates that there were approximately 20 deaths in 2019 in England and Wales. However, due to the difficulty in diagnosing CO poisoning these numbers are an underestimate⁷.

1.3 Aims and Objectives

The overarching aim of this project has been to carry out a review to establish whether there is an elevated CO risk from solid fuels in UK homes, what the barriers are to obtaining accurate data on CO incidents and how these can be overcome.

⁴ Gentile D et al. (2021). Carbon monoxide exposures related to the UK National Poisons Information Service: a 4-year study. *Journal of Public Health*, fdab132, <https://doi.org/10.1093/pubmed/fdab132>

⁵ NHS (2019). Carbon monoxide poisoning. <https://www.nhs.uk/conditions/carbon-monoxide-poisoning/>

⁶ CO Research Trust (2021). Consumer Information. <https://www.coresearchtrust.org/consumer-information>

⁷ Newcastle University (2016). Identification of Protein Markers in Peripheral Blood Lymphocytes Following CO Exposure. <https://www.coresearchtrust.org/our-research/newcastle-university-2>

To achieve the overall project aim, the study had the following principal objectives:

- To gain an appreciation of the number of solid fuel related CO poisoning incidents in the UK and any potential level of under-reporting;
- To understand what the barriers are to obtaining accurate CO incident data;
- To begin to quantify the level of risk of CO exposure from the use of solid fuel in the home;
- To identify issues or risks associated with the installation, maintenance, and use of solid fuel appliances;
- To feed into future CO Research Trust grant calls and research, which will inform CO Research Trust policy and awareness activities.

2 Methods

2.1 Introduction

To achieve the project aim and objectives outlined in section 1.3, we identified five key work tasks aligned with the objectives:

- Review of current available incident data relating to solid fuel
- Review of current regulatory and policy landscape for solid fuel
- Review of key stakeholders and interested parties
- Performing a gap analysis for solid fuel
- Identification of future research

Each of these tasks are described in more detail below.

2.2 Review of current available incident data relating to solid fuel

Searches were performed in Web of Science, PubMed and Google Scholar to identify potential and currently available incident data relating to solid fuels. This was supplemented by reviewing incident data held by the CO Research Trust for their CO incident database, incident data published by the Carbon Monoxide and Gas Safety Society and reviewing data from ONS.

The CO Research Trust provided to IOM a list of questions that had previously been used for requesting solid fuel incident data, through Freedom of Information (FOI) requests to the Fire and Rescue Services (FRS). These questions were modified as appropriate for the objectives of this project with information requested for solid fuel CO incident data and gas CO incident data. A copy of the questions is included in Appendix 1 of this report. FOI requests were submitted to the three emergency services (Police Services, Ambulance Services and FRS). In total, FOI requests were submitted to 14 police services, 12 ambulance services and 12 fire and rescue services across the UK ensuring a geographical spread. Available incident data was also available from five fire and rescue services supplied by the Gas Safety Trust from previous FOI requests.

A similar methodology was employed for current available incident data relating to piped natural gas. In addition to the sources of incident data identified for solid fuels, HSE RIDDOR data for CO incidents relating to piped natural gas has been reviewed. As part of the FOI requests, questions were included for incident data for CO and piped natural gas.

2.3 Review of current regulatory and policy landscape for solid fuel

Relevant regulations and policies for solid fuel and piped natural gas were identified for the UK as a whole and per country (England, Wales, Scotland and Northern Ireland). These were identified by searching the following sources:

- Cross Government Group on Gas Safety and Carbon Monoxide Annual Reports;
- Gas Safety Trust CO Portal;
- Health and Safety Executive;
- HETAS website;
- Legislation.gov.uk;
- Northern Ireland Housing Executive and Health and Safety Executive;
- Welsh Parliament.

This was supplemented by relevant references identified through Web of Science, PubMed and Google Scholar.

A similar methodology was also employed for reviewing the current regulatory and policy landscapes for the gas sector.

2.4 Review of key stakeholders' and interested parties' view

Semi-structured one-to-one telephone interviews were carried out with key stakeholders in the solid fuel industry. These stakeholders were identified in discussion with CO Research Trust. Relevant stakeholders were first contacted by CO Research Trust with details about the project and were asked to contact IOM directly if they were willing to take part in the study. IOM then contacted the respondents to arrange mutually convenient dates and times for the interviews. Topics included in the interview for discussion were incident data in the solid fuel sector, current regulations for installation and manufacturing, comparisons between regulations in the solid fuel and gas industry, and risks of CO exposure. Interviewees were also asked about knowledge gaps and research opportunities associated with CO exposure in the solid fuel sector. A copy of the interview pro-forma is included in Appendix 2.

2.5 Performing a gap analysis for solid fuel

A gap analysis has been performed for the regulatory and policy landscape and current available incident data for solid fuels using the outcomes of sections 2.2-2.4. This gap analysis involved reviewing the current state, the desired state, the gaps between the current state and desired state and possible remedies.

2.6 Identification of future research

Ideas for future research topics that could feed into future CO Research Trust grant calls and research, (to inform CO Research Trust policy and awareness activities) were determined from identified knowledge gaps from the review of the regulatory and policy landscape, number of current incident data available and from the one-to-one telephone interviews with stakeholders.

3 Results

3.1 Overview of the solid fuel sector with regards to the risk of CO exposure

3.1.1 Regulatory and policy landscape

Searches were performed using the sources listed in section 2.3 to identify relevant regulations for solid fuel. This was supplemented by an interview with experts in the sector involved in the safe installation and use of solid fuel, wood and biomass combustion appliances and fuels; to ensure the relevant regulations were included and to discuss the current regulatory and policy landscape for solid fuels.

The regulatory and policy landscape for the solid fuel sector with regards to the risk of CO exposure can be divided as follows for clarity:

- Manufacture of appliances;
- Safety of appliances;
- Installation;
- Fuel legislation.

These areas are discussed further in the following sections. It is also worth noting, that there are no RIDDOR requirements for the gas sector (see section 3.2) for reporting solid fuel CO incidents.

Manufacture of appliances

For the manufacture of solid fuel appliances, there is the requirement for CE marking. Solid fuel appliances are regulated under system 3 for the European system of attestation. This requires appliances to be tested by a certificated laboratory, with the manufacturer also self-declaring the appliance with a copy of the laboratory report.⁸ In England, Scotland and Wales it is planned to replace the CE mark by 1 January 2022, which will be replaced with CA marking with UK laboratories required to perform the testing.⁹ For the manufacture of stoves, there are additional Ecodesign requirements (limits the emissions of particulate matter, organic gaseous compounds and CO) for stoves from January 2022. This was also introduced for boilers in January 2021. The required reduction in the CO limit for Ecodesign is 88%.¹⁰

⁸ HETAS (2020). The changing face of solid fuel. <https://www.hetas.co.uk/the-changing-face-of-solid-fuel/>

⁹ Gov.UK (2021). Using the UKCA marking. <https://www.gov.uk/guidance/using-the-ukca-marking>

¹⁰ Stove Industry Alliance. Ecodesign Legislation & Implications. <https://stoveindustryalliance.com/sia-ecodesign-ready-appliances/ecodesign-legislation->

Finally, there is also the need for manufacturers to comply with the General Product Safety Regulations 2005, which deals with the safety of manufactured good.¹¹

Safety of appliances

There is currently no relevant landlord safety regulation for solid fuel appliances. Product safety requirements for appliances are included in the General Product Safety Regulations 2005.

Installation

The main regulations for solid fuel for domestic installation are the Building Regulations in England and Wales, Scotland and Northern Ireland (summarised in Table 2). These currently require the installation of a CO alarm (in accordance with the BS EN standard) where a new or replacement solid fuel combustion appliance is installed. The Building Regulations also set out the requirements for the location of the CO alarm.

There is presently a proposal on extending the scope of the Smoke and Carbon Monoxide (Regulations) 2015 in England. This would involve amending the Approved Document J of the Building Regulations, which would require CO alarms to be fitted when installing fixed compliance appliances of any fuel type (gas cookers excluded).¹²

An impact assessment has been performed for carbon monoxide alarms in private rental properties in England and Wales.¹³ This estimates an average annual cost of £0.8 million to business (landlords) for buying alarms (present value of £7.7 million) and an average annual cost of £0.1 million to install alarms (present value of £1.3 million). The average annual cost to tenants is £0.6 million for purchasing batteries (total present value of £4.3 million). The benefits for installing CO alarms is 6-9 fewer fatalities and 306-450 fewer injuries over 10 years.¹³

The Building Regulations additionally set out the requirements for the installation of solid fuel appliances with a rated heat output up to 50 kW (however, the regulations extend to any buildings covered by the Building Regulations). For England and Wales, this includes the requirements of flues (size, height and outlets) and the requirements of chimneys. The Building standards technical handbook 2020 for Scotland sets out the equivalent requirements for solid fuel appliance installation as set out in the Building (Scotland) Regulations 2004. In Northern Ireland, the requirements are set out in Technical Booklet L

implications/#:~:text=Ecodesign%20is%20due%20to%20be,burning%20and%20multi%20fuel%20stoves.&text=Most%20manufacturers%20will%20declare%20and,Particulate%20Matter%20(PM10%20%26%20PM2.

¹¹ The General Product Safety Regulations 2005.

<https://www.legislation.gov.uk/uksi/2005/1803/contents/made>

¹² Gov.UK (2020). Domestic smoke and carbon monoxide alarms: proposals to extend regulations.

<https://www.gov.uk/government/consultations/domestic-smoke-and-carbon-monoxide-alarms/domestic-smoke-and-carbon-monoxide-alarms-proposals-to-extend-regulations>

¹³ Gas Safety Trust. Impact Assessment: Carbon monoxide alarms in Private Rented Properties.

<https://www.coportal.org/standard/272/impact-assessment:-carbon-monoxide-alarms-in-private-rented-properties/>

(Combustion appliances and fuel storage systems) sets out the equivalent requirements in Northern Ireland.

Table 2: Regulations for CO alarms

Country	Regulation	Details
England	The Building Regulations 2010: Part J- Combustion appliances and fuel storage systems	Requirements of CO alarms for fixed combustion appliances in dwellings including for solid fuel appliance. The CO alarm needs to be fitted in the same room as that of the solid fuel appliance
England	Smoke and Carbon Monoxide Alarm (Regulations) 2015 ¹⁴	Requirement that private sector landlords must have a CO alarm in any room, which contains a solid fuel burning appliance. Enforcement is performed by local authorities (maximum fine of up to £5,000)
Scotland	The Building (Scotland) Act 2003	All dwellings are required to be fitted with CO detection by February 2021. CO detectors (in accordance with BS EN 50291:2010) should be installed where a combustion appliance (new or replaced) is used. Requirements for CO alarms are covered under Tolerable Standard.
Wales	The Building Regulations 2010: Part K- Combustion appliances and fuel storage systems	Requirement of CO alarms (in accordance with BS EN 50291:2010) in the room where the solid fuel appliance is located
Northern Ireland	The Building Regulations (Northern Ireland) 2012	A CO alarm is required to be installed when a combustion appliance is installed or replaced

The recommended positioning of CO alarms within the Building Regulations (Approved Document J) and BS8303 standard (Installation of domestic heating and cooking appliances burning wood and solid mineral fuels. Specification) is for alarms to be positioned on the ceiling (at a distance of at least 300mm from any wall), or if installed on a wall to be as high as possible (not within 150mm of the ceiling and above windows and doors) and to also be at a distance of 1 metre-3 metre horizontally away from the appliance.¹⁵ A graphical representation on the recommended location for CO alarm is presented in Figure 1.

¹⁴ Covers private sector landlords only, a consultation process has been undertaken to also include social landlords (<https://www.gov.uk/government/consultations/domestic-smoke-and-carbon-monoxide-alarms>)

¹⁵ HETAS (2021). Be Alarmed. <https://www.hetas.co.uk/be-alarmed/>

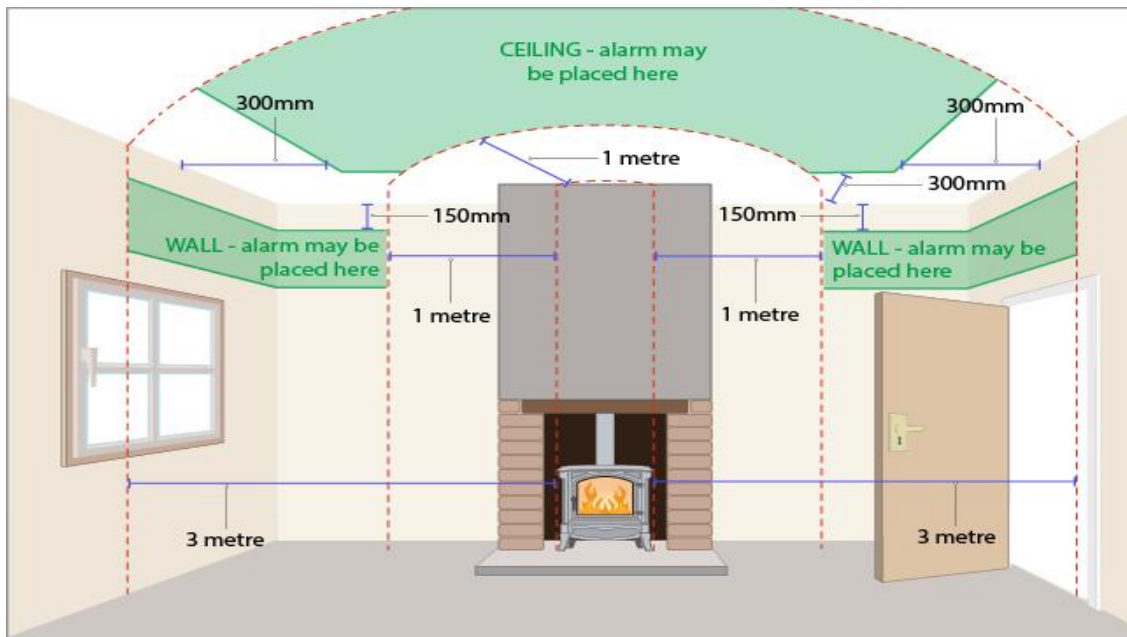


Figure 1: Recommended CO alarm positioning¹⁶

Fuel legislation

The Air Quality (Domestic Solid Fuels Standards) (England) Regulations 2020, bans the sale of both wet wood and house coal.¹⁷ Manufacturers of solid fuels must ensure their product is certified for use for it to be legally sold. The 'Ready to Burn' logo, manufacturer details and the unique certification number must be attached to the packaging.¹⁸ For wood, suppliers are required to provide customers with a notice which explains drying, storage and moisture checking of the wood before use for volumes of two cubic metres or more. It is also required that wood which is sold in volumes below two cubic metres need to be certified as 'Ready to Burn' (scheme administered by HETAS) as per manufactured solid fuels. Enforcement options include a fixed penalty notice of £300 from the local authority or a greater fine issued by the courts. In Scotland, there has recently been a consultation process on prohibiting the sale of wet wood and restricting the sulphur content to below 2% for smokeless fuels.¹⁹ In Wales, a consultation process recently finished which includes prohibiting the sale of wet wood and introducing a standard for a sulphur content of below

¹⁶ HETAS (2021). Be Alarmed. <https://www.hetas.co.uk/be-alarmed/>

¹⁷ HETAS (2021). New legislation for wood and manufactured solid fuels. <https://www.hetas.co.uk/new-legislation-for-wood-and-manufactured-solid-fuels/>

¹⁸ Gov.UK (2021). Domestic solid fuels: rules for local authorities in England.

<https://www.gov.uk/guidance/domestic-solid-fuels-rules-for-local-authorities-in-england>

¹⁹ Scottish Government (2020). Cleaner Air for Scotland 2: consultation.

<https://www.gov.scot/publications/cleaner-air-scotland-2-draft-air-quality-strategy-consultation/pages/12/>

2% for manufactured mineral solid fuels.²⁰ There is also a similar consultation in Northern Ireland with responses invited until 20 June 2021.²¹

Additional to the 'Ready to Burn' scheme, is the Woodsure scheme.²² This scheme assesses the quality of wood fuel (woodchip, pellets, briquettes, hog fuel, and firewood).

3.1.1.1 Enforcement of regulations

Enforcement of regulations is performed by local authorities, Health and Safety Executive (HSE), environmental health and trading standards.

3.1.2 Standards

Along with the regulations, there are British Standards (BS) and European Standards (EN) for CO:²³

- BS EN 50292: 2013. Electrical apparatus for the detection of carbon monoxide in domestic premises. Guide on the selection, installation, use and maintenance
- BS EN 50291-1: 2018. Gas detectors. Electrical apparatus for the detection of carbon monoxide in domestic premises. Test methods and performance requirements.

There are also standards associated with air quality and emissions from solid fuels:²³

- BS 3841-1: 1994. Determination of smoke emissions from manufactured solid fuels. General method for determination of smoke of smoke emissions rate
- BS 3841-2: 1994- Determination of smoke from manufactured solid fuels for domestic use. Methods for measuring the smoke emission rate.
- DD CEN/TW 15883: 2009. Residential solid fuel burning appliances. Emission test methods
- PD 6434: 1969. Recommendations for the design and testing of smoke reducing solid fuel burning appliances.

There are also a number of standards for fuels, appliances and chimneys for solid fuel appliances.²³

3.1.3 Incident data

Current available incident data has been reviewed. Firstly, for CO incident data and is then broken down to the number of incidents attributed to solid fuel appliances to illustrate the available data. Incident data has been collected from publicly available information sources and FOI requests to the emergency services.

²⁰ Welsh Government (2021). Reducing emissions from domestic burning of solid fuels.

<https://gov.wales/sites/default/files/consultations/2021-01/reducing-emissions-from-domestic-burning-of-solid-fuels.pdf>

²¹ Energy Strategy for Northern Ireland: Consultation on Policy Options.

<https://consultations.nidirect.gov.uk/dfe/energy-strategy-for-northern-ireland-consultation-1/consultation/subpage.2021-03-09.6989951507/>

²² See: <https://woodsuresure.co.uk/>

²³ HETAS (2021). Standards. <https://www.hetas.co.uk/professionals/standards/>

3.1.3.1 CO incident data

Firstly, a number of publicly available information sources on the numbers of CO associated incidents with solid fuel source are available. These sources include data from health care providers, ONS, the National Poisons Information Service (NPIS) and the Cross Government Group on Gas Safety and Carbon Monoxide (CO) Awareness (latest available data is for 2019).

Data for hospital admissions has been obtained by NPIS and shared with the project team. For hospital admissions between 2002 and 2016, 6643 admissions for CO poisonings were identified, with 52.5% of these admissions (1782) from unintentional CO exposure.²⁴ In England (for 2009-2018), there has been a total of 3489 admissions that have been recorded with a primary diagnosis of toxic effect of carbon monoxide (ICD-10 code of T58). A breakdown of these numbers is given in Figure 2, in which between 2013 and 2018 there has been a downward trend. For 2019, there have been 217 admissions using the ICD-10 code of T58, however this number is provisional. In Scotland, for 2015-2018, there have been a total of 96 admissions attributed to the ICD-10 code 58 (33 in 2015; 25 in 2016; 26 in 2017; and 12 in 2018). In Wales, data is split between accidental CO, intentional CO and undetermined CO. Between 2009-2019, there has been a total of 222 accidental CO poisonings, 77 intentional CO poisonings and 1 undetermined CO poisoning. In Northern Ireland, there has been 182 hospital admissions attributed to ICD-10 code T58 between 2008/2009 and 2018/19. Due to the differences between recording, for example data for Wales is not for ICD-10 code T58 and data for Northern Ireland is not per calendar year, it is only possible to compare data across Great Britain.

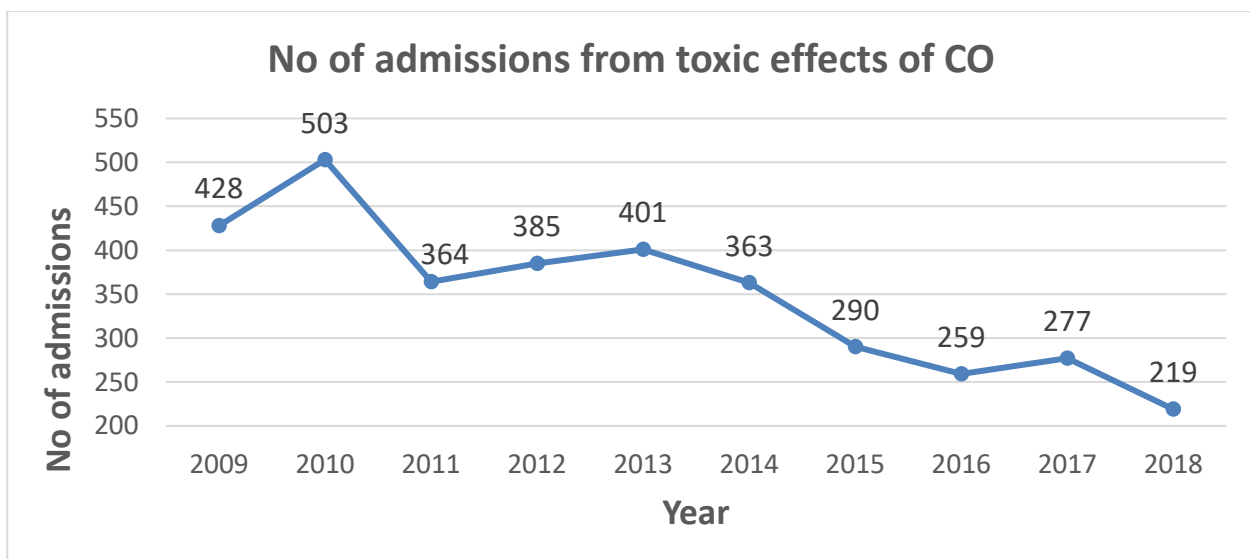


Figure 2: Hospital admissions in England with primary diagnosis of toxic effect of CO (ICD code: T58). Data provided by NPIS.

²⁴ Barceló AR et al (2020). Temporal trends and demographic risk factors for hospital admissions due to carbon monoxide poisoning in England. *Preventive Medicine*, 136, 106104.

The NPIS reports that for 2019, there was available data for 757 unintentional non-fire CO exposures between 1 January 2019 and 31 December 2019 from NPIS enquiries.²⁵ In terms of the case of exposure, faulty domestic boilers were responsible for 222 cases (29.2% of all cases). Furthermore, between 1st July 2015 and 30th June 2019 there were 2970 unintentional non-fire related CO exposures reported to NPIS.²⁶ Of these numbers, 60% of exposure occurred in a domestic setting with faulty boilers the most common source of exposure identified (27.4%) (35.7% unknown appliance/source) as illustrated in Figure 3.

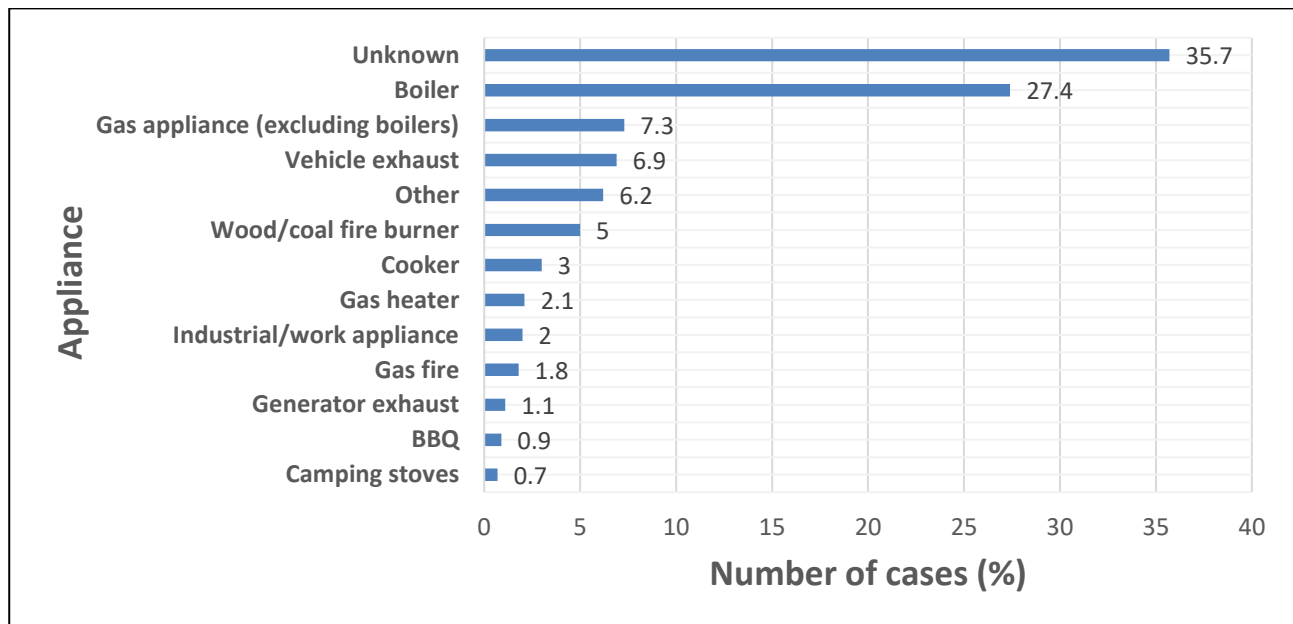


Figure 3: Sources of exposure for non-fire related CO exposures. Data reported in Gentile et al.⁴

ONS data for the number of deaths from accidental poisoning by CO is available for England and Wales, with the latest figures being that for 2019. Overall, there are 53 incidents for accidental CO poisonings which is illustrated in Figure 4. Twenty-three of these incidents (44% of all accidental CO monoxide poisonings) were from accidental poisoning by other gases and vapours with 17 of those (74%) occurring in a domestic setting. For the twenty-nine incidents reported for accidental exposure to smoke, fire and flames, no information is supplied in the report for the location of these incidents.

²⁵ National Poisons Information Service Report 2019/20.

<https://www.npis.org/Download/NPIS%20Report%202019-20.pdf>

²⁶ Gentile D et al (2021). Carbon monoxide exposures reported to the UK National Poisons Information Service: a 4-year study. *Journal of Public Health*, <https://doi.org/10.1093/pubmed/fdab132>

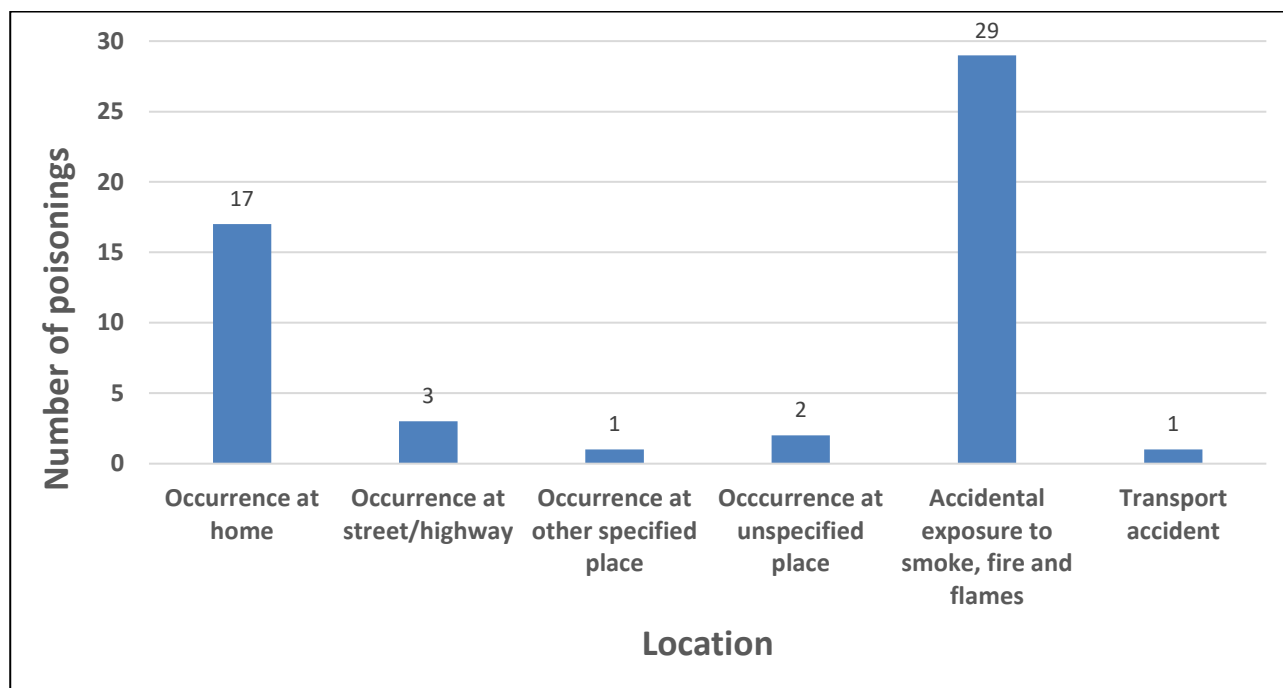


Figure 4: CO poisoning occurrences for England and Wales in 2019.

Annual reports from the Cross Government Group on Gas Safety and Carbon Monoxide (CO) Awareness provide data collected from ONS (on behalf of the Department of Health and Social Care) for England and Wales (Table) with data also from Health Protection Scotland and Health and Safety Executive for Northern Ireland (Table). The most recent incident numbers are from 2019 which is illustrated in Figure 4.²⁷ The data provided for England and Wales includes numbers of where the occurrence occurred, whilst the figures for Northern Ireland report the type of incident. However, there is no breakdown available for the figures from the National Records of Scotland for the relevant code (X47) associated to CO poisoning. The numbers for Scotland are as follows:

- 4 deaths in 2015.
- 3 deaths in 2019.
- 1 death in 2012, 2014 and 2017.
- No deaths in 2013 and 2018.

Table 3: CO mortality figures for England and Wales

Year	Total number of deaths (VO1-X59)	Accidental poisoning by other gases and vapours (Code X47)	Occurrence at home	
			No of deaths	% of total no of deaths
2011	79	34	29	37
2012	65	25	18	28

²⁷ The Cross-Government Group on Gas Safety and Carbon Monoxide Awareness Annual Report Autumn 2019 to Autumn 2020. <https://www.hse.gov.uk/gas/domestic/cross-government-group-1920.pdf>

Year	Total number of deaths (VO1-X59)	Accidental poisoning by other gases and vapours (Code X47)	Occurrence at home	
			No of deaths	% of total no of deaths
2013	60	24	16	27
2014	55	26	18	33
2015	53	25	24	45
2016	49	15	13	27
2017	59	17	11	19
2018	42	16	10	24
2019	53	23	17	32

Table 4: CO mortality figures for Northern Ireland

Year	Total number of deaths	Accidental poisoning by other gases and vapours (Code X47)	
		Number of deaths	% of total deaths
2012	8	1	13%
2013	12	0	0%
2014	10	6	60%
2015	7	3	43%
2016	5	1	20%
2017	6	3	50%
2018	7	1	14%
2019	3	1	33%

3.1.3.2 FOI requests

As part of the FOI requests to the emergency services (Healthcare Providers, Police, FRS and Ambulance services), information was requested on the number of attended CO incidents UK wide. The following section discusses the results for CO incident data with further discussion on the breakdown by fuel type discussed in section 3.1.3.5 for solid fuels and section 3.2.2.2 for gas.

Healthcare Providers

No CO accident data was available for the FOI requests made to healthcare providers, however data has been received from NPIS which is discussed in the previous section.

Police

In total, eleven responses were received from the FOI requests made to a number of police forces. Of these, nine (82%) were unable to supply data due to the costs involved. Reasons for this included that the information was not held in an accessible format, it was not possible to search by keywords for the requested information and that each individual incident record would need to be reviewed. A single police force provided data (North Wales) with four incidents in 2018 and one incident in 2019 which mentioned CO. West Mercia Police were able to provide a partial response, where the total number of incidents for CO attended over a three year period were as follows: 2018- 10 incidents (4 injuries and 1 death), 2019- 16 incidents (3 injuries and 1 death) and 2020 - 15 incidents (4 injuries and 1 death).

FRS

Responses were received from all FRSs (twelve requests) in which FOIs were submitted. Additionally, the CO Research Trust provided FOI responses from four FRSs for solid fuel CO incidents which had previously been requested (latest data from 2020). Norfolk FRS could not supply incident numbers as a free text field is used, with this information being optional and also solid fuel appliances are not identified in a coded manner in the Home Office system. The responses for CO incident data are summarised in Table .

Table 5: FRS CO incident data

FRS	Number of CO incidents	Number of injuries and fatalities	Comments
Scottish FRS	2017-18: 57 2018-19: 34 2019-20: 41	2017-18: 24 injuries 2018-19: 3 injuries, 1 death 2019-20: 3 injuries, 2 deaths	Data supplied by CO Research Trust
Devon and Somerset FRS	2017-2019: 225	2017-19: 78 injuries, 5 deaths	No breakdown for years. Data supplied by CO Research Trust
South Wales FRS	2017/18: 286 2018/19: 266 2019/20: 281	2017/18: 16 treated 2018/19: 16 treated 2019/20: 11 treated	Data supplied by CO Research Trust
London Fire Brigade	2017/18: 609 2018/19: 673 2019/20: 749	2017/18: 63 injuries, 5 deaths 2018/19: 99 injuries, 2 deaths 2019/20: 91 injuries, 1 death	Data supplied by CO Research Trust
Kent FRS	2018/19: 29 2019/20: 25 2020/21: 58	2018/19: 7 injuries, 2 deaths 2019/20: 7 injuries, 0 deaths 2020/21: 14 injuries, 1 death	
North Yorkshire FRS	-	-	Do not attend CO alarm related incidents

FRS	Number of CO incidents	Number of injuries and fatalities	Comments
Nottinghamshire FRS	2018/19: 17 2018/19: 14 2020/21: 16	2018/19: 0 2019/20: 1 injury 2020/21: 0	
Cumbria FRS	2018/19: 36 2019/20: 34 2020/21: 46	2018/19: 2 injuries, 2 deaths 2019/20: 2 injuries, 1 death 2020/21: 8	Data from 1 April 2018- 31 March 2021. No CO flag in the incident system- used keyword search
Mid and West Wales FRS	2018/19: 74 2019/20: 50 2020/21: 42	2018/19: 15 injuries, 1 death 2019/20: 8 injuries 2020/21: 4 injuries	
North Wales FRS	2018: 5 2019: 8 2020: 5	2018: 0 2019: 0 2020: 0	The IRS does not contain a sub-category for CO only; question Q8.4 (What was the source of ignition? With response = fuel/chemical related. False arms also included.
Northern Ireland FRS	2018/19: 997 2019/20: 898 2020/21: 820	2018/19: 84 casualties, 2 deaths 2019/20: 99 casualties 2020/21: 63 casualties	Free text is used for detailing incidents. Includes false alarms.
Shropshire FRS	No incidents related to CO	N/A	Incident Reporting System (IRS) does not report in CO specifically other than if it was involved as hazardous material.
Cornwall FRS	Over last three years: 116	Over last three years: 14 injuries, 5 deaths	
Norfolk FRS	-	-	CO is not a Home Office systems coded data item. Unable to supply data in FOI appropriate limit
Greater Manchester FRS	Over last three years: 109	Over last three years: 3 injuries, 2 deaths	
Northumbria FRS	N/A	Over last three years: 13 injuries from "Overcome by gas, smoke or toxic fumes: asphyxiation	No specific field to record a CO incident
West Midlands FRS	2017/18: 175 2018/19: 182 2019/20: 211	85 injuries, 2 deaths	Data supplied by CO Research Trust
Total (shown for illustrative purposes)	4162	822 injuries 32 deaths	For information only

Ambulance Services

Responses were received from all ambulance services (eleven requests) in which FOIs were submitted. For these, no breakdown has been possible from the ambulance services for the fuel type involved in the incidents involving CO apart from one service which could provide numbers for gas. Where data is available, this has been typically for CO incidents only, as summarised in Table .

One ambulance service (South Western Ambulance Service) have no means to extract information related to CO incidents as there are no specific fields in the reporting form or diagnosis codes which specifically relate to CO. West Midlands Ambulance Service do not record CO information.

Table 6: FOI responses from ambulance services

Ambulance Service	Number of CO incidents	Number of injuries and deaths	Comments
North East Ambulance Service	Five incidents up to Oct 20 for calendar year and 9 up to 31 st March 2021	N/A	A wildcard search was used, so this data is only as a guide. The Trust do not hold information on deaths.
Yorkshire Ambulance Service	2018/19: 689 2019/20: 719 2020/21: 577	2018/19: 6 deaths 2019/20: 8 deaths 2020/21: 9 deaths	Unable to provide data on injuries. Incidents for chief complaint of CO/Inhalation/HazMat) for incident numbers
North West Ambulance Service	Data for 2018-2021: Emergency Incidents: 1,029 Hear and Treat: 3 See and Treat: 547 See and Convey: 479	N/A	Triage system is used (hear and treat, see and treat and see and convey)
East Midlands Ambulance Service	2018/19: 529 2019/20: 543 2020/21: 505	N/A	No information held for CO deaths
Scottish Ambulance Service	2018/19: 135 2019/20: 118 2020/21: 110	2018/19: 0 deaths 2019/20: <5 deaths 2020/21: <5 deaths	CO/Gas/Fumes incidents attended. Optional field for recording CO- data is from records where paramedics recorded this information
Welsh Ambulance Service	2018/19: 194 2019/20: 228 2020/21: 201	2018/19: 194 injuries 2019/20: 228 injuries 2020/21: 201 injuries, 1 death	Only total CO figures available. Wildcard search was used.
East of England Ambulance Service	For CO 2019/20: 58; for all AMPDS codes referencing CO: 436 2020/21: 66; for all AMPDS codes referencing CO: 387	Unable to distinguish between incidents and injuries.	Do not record source apart from CO poisoning apart from in general sense. CO is grouped by AMPDS code in Carbon Monoxide / Inhalation / HAZCHEM / CBRN category. Deaths not recorded in Computer Aided Dispatch System.

Ambulance Service	Number of CO incidents	Number of injuries and deaths	Comments
South Western Ambulance Service	N/A	N/A	Unable to extract information for CO incidents
West Midlands Ambulance Service	N/A	N/A	Not recorded
London Ambulance Service	573 incident attended for 2018-2020	Deaths: 0	Death figure is related to hospital code '9808 – Deceased, not removed'
Northern Ireland Ambulance Service	2018/19: 221 2019/20: 226 2020/21: 181	2018/19: 2 deaths 2019/20: 4 deaths 2020/21: 2 deaths	Number of injures same as the number of incidents, this data may be underreported as the overall number of patients data is erroneous which is not reliable.
<i>Total</i>	7243	-	<i>For indicative purposes only; many caveats to the supplied data</i>

3.1.3.3 Conclusion for CO incident data

Publicly available figures are available for the number of CO incidents including ONS data which is also reported in the annual reports of the Cross Government Group on Gas Safety and Carbon Monoxide (CO) Awareness. Hospital data has also been supplied by NPIS. It is also worth noting that for hospital admission figures there are also other ICD10 codes apart from T58 that could be used, namely X47 (Accidental poisoning by and exposure to other gases and vapours), X67 (Intentional self-poisoning by and exposure to other gases and vapours) and Y17 (Poisoning by and exposure to other gases and vapours, undetermined intent) which could lead to underreporting. The reported CO incident data shows that domestic settings are a major source of CO exposure, with NPIS data illustrating that 60% of CO exposure is in a domestic setting.

No update to hospital CO admission data from section 3.1.3.1 was possible from FOI requests. The majority of the police services who FOI requests were submitted to were unable to provide data on CO incident numbers. This was due to this information not being able to be easily retrieved. CO incident figures were available for FRSs in which FOI requests were submitted except for Norfolk FRS, in which the data could not be easily retrieved. For FRSs, a total of 4162 incidents were reported with 32 deaths and 822 injuries, although there are caveats to this data which were supplied in the FOI responses. This includes free text fields being used for reporting, the Incident Reporting System not including a field specifically for CO and also CO is not a Home Office systems coded data item. For ambulance services, eight ambulance services were able to supply CO incident data. However, as is the case for the FRSs, different services report incidents differently. For example, East Midlands uses a triage system, the Scottish Ambulance Service has an optional field for recording CO and East of England only records CO poisoning in a general sense. In addition, as in the case of FRS for some services, a wildcard search or similar has been used for retrieving data by some of the services.

From the FOI responses, it can be seen that reporting of CO incident data differs between emergency services and also within emergency services. For example, some emergency services use free text to detail incidents and have also identified shortcomings for recording CO for IRS and Home Office systems. Due to the differences between services and the caveats for the supplied data, it is not possible to identify any trends in incident numbers. It may also be the case that due to the differing processes, the reported numbers may be underestimated (total of 11,451 CO incidents reported).

3.1.3.4 Current available incident data for solid fuel CO incidents

The literature review performed in this project only identified three sources of incident data for a breakdown of incident CO exposure data from solid fuel. In the review, 195 sources were initially identified, with 39 sources identified as being potentially relevant from screening of the title of abstract. These 39 sources were then subject to full text screening, with 11 articles taking forward for data extraction. Of these 11 sources, only three contained data on solid fuel CO incidents.

The GST CO Incident database includes details on the region, casualty type, gender, age, fuel type, property type and appliances.²⁸ In total, 33 incidents have been reported from 1996 to 2014. An abstract available by Close et al. for the 14th UK & Ireland Occupational and Environmental Epidemiology Society annual meeting, presents an analysis of coroners' findings. Solid/multifuel fuel accounted for 13% of deaths for unintentional carbon monoxide deaths (total of 751 deaths).²⁹ The CO and Gas Safety Society collates information on unintentional deaths and injuries resulting from exposure to CO including for solid fuel. A total of 218 unintentional deaths have been reported from solid fuel and CO exposure between 1995/1996 and 2019/2020. The number of deaths has generally decreased from 1995/1996 to 2019/2020.³⁰ The breakdown of these figures per year is provided in Figure 5.

²⁸ See <https://www.coportal.org/downstream-incident-data-search-result/>

²⁹ Close R et al (2021). Which groups of individuals are more likely to die from unintentional carbon monoxide poisoning? An overview of coroners' findings. <https://epidemiologysociety.files.wordpress.com/2021/04/oes-meeting-2021-abstract-book.pdf>

³⁰ See <https://www.co-gassafety.co.uk/wp-content/uploads/2021/02/Summary-stats-sheet-2019-2020.pdf>

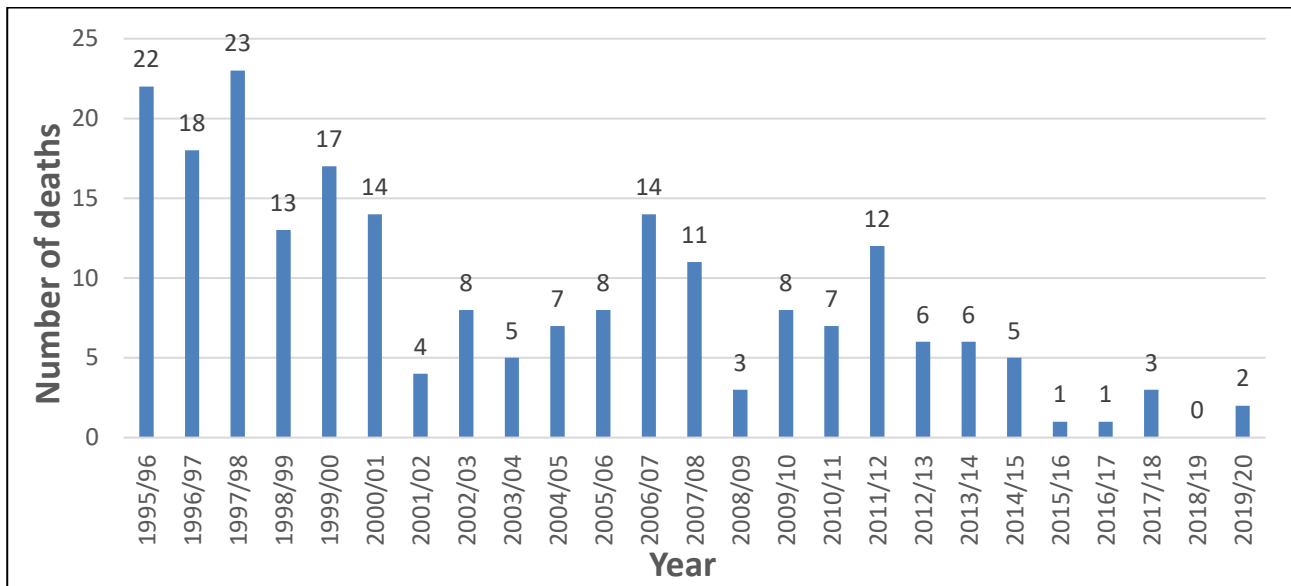


Figure 5: Unintentional CO deaths for solid fuel. Data from CO and Gas Safety Society³⁰

No data is reported for solid fuels and CO exposure in the annual reports of the Cross Government Group on Gas Safety and Carbon Monoxide (CO) Awareness. The data from ONS for accidental poisoning is not broken down by fuel type, so no solid fuel incident data is presented in the ONS data. Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) does not include data from solid fuel.

3.1.3.5 FOI requests

No CO incident data for solid fuel could be provided by the various UK Police and Ambulance services. Specifically for the ambulance services, the Northern Ireland Ambulance Service indicate in their FOI response, that no incidents were identified from solid fuel appliances. Solid fuel CO incident data has been available for a number of FRSs. For the twelve FRS, three services (25%) could not supply any incident data. Cornwall FRS and Greater Manchester FRS do not record the numbers for solid fuel and Norfolk FRS could not supply incident numbers as a free text field is used (information being optional and also solid fuel appliances are not identified in a coded manner in the Home Office system). Northumbria FRS identified one incident in the free text field which identified the source of the injury as from a faulty fire and blocked flue resulting from a coal fire. For fire and rescue services who provided incident numbers, these are summarised in Table .

Table 7: FOI responses from FRS for solid fuel incidents

FRS	Number of solid fuel incidents	Number of injuries and deaths	Comments
Scottish FRS	2017/18: 57 2018/19: 34 2019/20: 41 2020/21: 18	N/A	Total number of appliances suspected as source of CO- manually entered. The 2021 data is year to date, so is not complete for the whole reporting period. Data supplied by CO Research Trust.

FRS	Number of solid fuel CO incidents	Number of injuries and deaths	Comments
South Wales FRS	2017/18: 5 2018/19: 5 2019/20: 1	N/A	Where solid fuel appliance as suspected as the source. Data supplied by CO Research Trust.
London Fire Brigade	Number of incidents: 1	For 2017-2020: Number of all injuries: 9	Unsafe use of equipment or appliance-solids; coal, coke, wood, card. Data supplied by CO Research Trust.
Kent FRS	2018/19: 2 2019/20: 3 2020/21: 6	2018/19: 1 death 2019/20: 2 injuries 2020/21: 6 injuries	
North Yorkshire FRS	Over three year period: 40 incidents	N/A	Ignition source was 'solid fuel'
Nottinghamshire FRS	2018/19: 50 2019/20: 33 2020/21: 61	2020/21: 1 injury	
Cumbria FRS	2018/19: 0 2019/20: 2 2020/21: 2	2020/21: 4 injuries	Data from 1 April 2018- 31 March 2021. No CO flag in the incident system- used keyword search
Mid and West Wales FRS	2018/2019: 15 2019/2020: 21 2020/2021: 20	2018/19: 1 injury, 1 death 2019/20: 3 injuries 2020/21: 3 injuries	
North Wales FRS	2018: 3 2019: 6 2020: 3 Total: 12	N/A	CO is not always a category in the IRS, groupings have been used for response
Northern Ireland FRS	2018/2019: 1 2019/2020: 1 2020/2021: 0	N/A	Free text is used for detailing incidents
Shropshire FRS	2018-2021: 2 accidents	N/A	Incident Reporting System (IRS) does not report in CO specifically other than if it was involved as hazardous material. Specific number cannot be provided.
<i>Total (for illustrative purposes)</i>	391	<i>Injuries: 29 Deaths: 2</i>	

As can be observed in Table 7, for those FRS who report on the number of CO incidents from solid fuel there are differences in how numbers are recorded and reported as previously discussed. In terms of the numbers reported, there are large differences in the reported numbers between the different FRSs. No trends can be observed from the

incident numbers, this could be due to the differences in reporting between FRSs and also the differences in years used for reporting (some FRSs report by financial year, whilst others report by calendar year). For illustrative purposes, a total of 391 incidents with 29 injuries and 2 deaths have been reported by FRSs in which FOIs have been requested. This number illustrates the reported figures (20 deaths per year) is likely to be underreported.

Figure 6 illustrates the differences in the reported number of incidents, for those who report numbers by financial years. This figure demonstrates potential issues with reporting requirements and also illustrates likely underreporting on incidents. As can be seen in Figure 6, there is a wide discrepancy in reporting between FRSs, for example Nottinghamshire FRS and Mid and West Wales FRS report larger number of incidents for all the three years shown (2018-19, 2019-2020 and 2020-2021) than South Wales FRS, Kent FRS and Cumbria FRS.

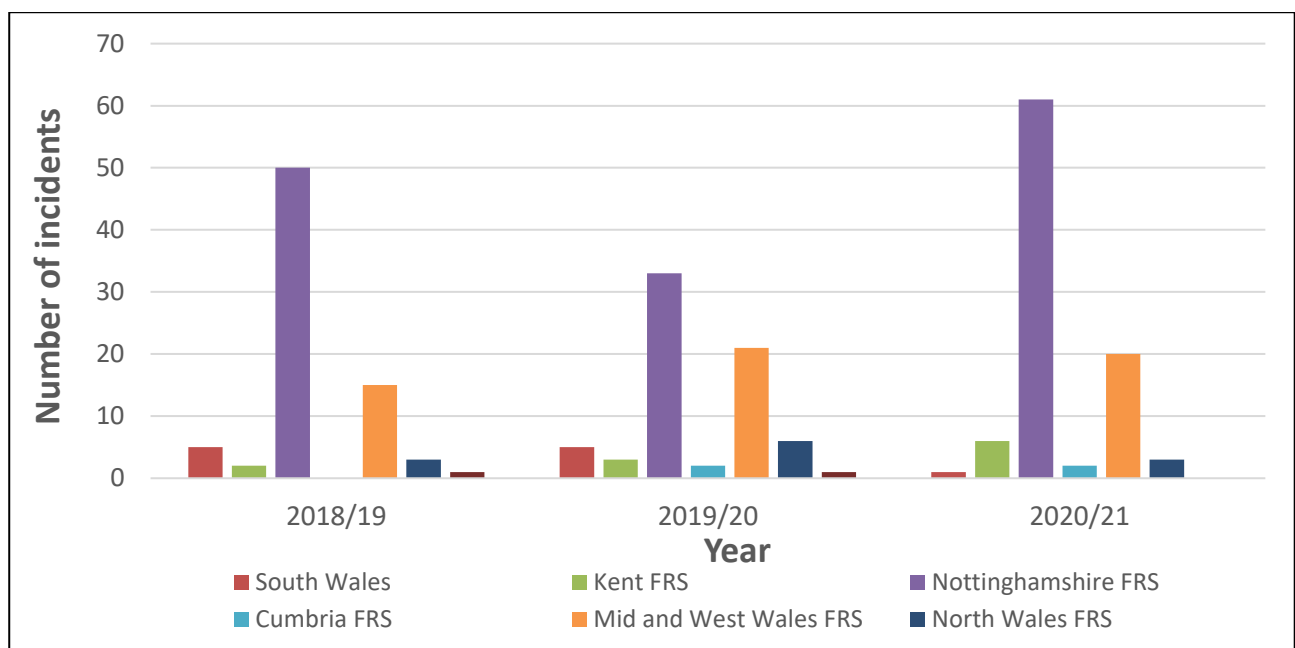


Figure 6: Solid fuel CO incidents for FRS from FOI requests

3.1.3.6 Conclusion for incident data for solid fuel CO incidents

Limited information is publically available for the number of solid fuels CO incidents. The GST CO Incident Database lists 33 incidents, although the last update was in 2014. The CO and Gas Safety Society lists 218 unintentional deaths from solid fuel CO exposure, with a decrease in deaths from 1995/96 to 2019/2020 (two deaths were reported). Unlike in the case of gas incidents, there is no equivalent RIDDOR requirements for solid fuel incidents.

In order to obtain up to date solid fuel CO incident data numbers, FOI requests were submitted. From the FOI responses, for the police, ambulance service and some FRSs it was not possible to provide data to satisfy the information request. Solid fuel CO incident numbers were only reported by FRSs, with 75% reporting incident numbers. The data reported by FRSs varies between each service. Some FRSs reported detailed numbers, for example Mid and West Wales FRS and Nottinghamshire FRS. Whereas, other FRSs required to use a keyword search to retrieve data, which could result in under/over reporting.

Differences in how incidents are reported between different services are highlighted, such as the use of free text fields for recording CO incidents and no CO categories in the Incident Reporting System.

From the data received from FOI for solid fuel CO incidents (391 incidents reported in total), it is not possible to conclude if this data is representative across the UK due to the differing reporting by services. This may result in the number of solid fuel CO incidents being underreported.

3.2 Overview of the gas industry with regards to the risk of CO exposure

3.2.1 Regulatory and policy landscape

Searches were undertaken using the sources listed in section 2.3 to identify relevant regulations for the gas industry. The regulatory and policy landscape for the gas sector with regards to the risk of CO exposure is divided in this section as follows for clarity:

- Manufacture of appliances.
- Installation.
- Safety of appliances.

These are discussed in the following sections.

Manufacture of appliances

In the manufacture of gas appliances, a similar situation exists as for solid fuel appliances (section 3.1). Specifically for gas appliances, the following also applies:

- Requirement for CE marking (to be replaced by the CA marking in England, Scotland and Wales) under the Gas Appliance Regulation (EU 2016/426).
- Gas appliances are covered under system 1 of the European system of attestation. This requires declaration of performance of the appliance by the manufacturer.³¹

Installation Regulations

The main regulations for gas for domestic installation are the Building Regulations in England and Wales, Scotland and Northern Ireland. This is the same situation as that of solid fuel which is discussed in section 3.1.1 which sets out the requirements.

Safety Regulations

The main safety regulations in the UK for gas appliances, namely the Gas Safety (Installation and Use) Regulations 1998, the Gas Safety Management Regulations 1998 and the RIDDOR

³¹ See <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R0305&from=EN>

2013 Regulation. The requirements of these regulations specifically for carbon monoxide (CO) are summarised in Table .

Table 8: Gas safety regulations and their requirements for carbon monoxide

Regulation	Details
Gas Safety (Installation and Use) Regulations 1998 ³²	Requirement for a responsible person to not use or allow the use of a gas appliance which could be a danger for carbon monoxide poisoning which arises from fixed ventilation/inadequate flue arrangements (Regulation 34 (1)-(2)) Requirement to report the emission or the suspected emission of carbon monoxide from a gas appliance under Regulation 37 for gas suppliers and the responsible person for the premises
Gas Safety Management Regulations 1998 ³³	Natural gas suppliers are required to perform investigations of carbon monoxide reported under RIDDOR (Regulation 7(14)). Under Regulation 7, British Gas are required to provide a Freephone number for gas escapes including carbon monoxide. The responsible person is required to take action for a gas fitting that includes an escape or emission of carbon monoxide from the incomplete combustion of gas in the fitting.
RIDDOR 2013 ³⁴	Carbon monoxide incidents are reportable under RIDDOR (regulation 11(1) including when there is no work related activity. No equivalent for solid fuel.

For gas appliances, under the Consumer Rights Act 2015, enforcement authorities in the UK are able to investigate claims for unsafe gas appliances, which entered the market from 21 April 2018.³⁵

3.2.1.1 Enforcement of regulations

Enforcement of gas regulations is performed by the Health and Safety Executive (HSE), GasSure and also trading standards. Under the Gas Safe Register, all gas engineers are required to be on their register.

3.2.2 Incident data

3.2.2.1 CO incident data

Sources of CO incident data are discussed in section 3.1.2.

³² HSE (2018). Safety on the installation and use of gas systems and appliances.

<https://www.hse.gov.uk/pubns/priced/l56.pdf>

³³ HSE (2007). A guide to the Gas Safety (Management) Regulations 1996.

<https://www.hse.gov.uk/pubns/priced/l80.pdf>

³⁴ HSE (2020). Downstream Gas events handling and investigation procedures.

<https://www.hse.gov.uk/foi/internalops/og/og-00118.pdf>

³⁵ The cross-government group on gas safety and carbon monoxide awareness. Annual Report Autumn 2018 to Autumn 2019. <https://www.hse.gov.uk/Gas/domestic/cross-government-group-1819.pdf>

3.2.2.2 Number of CO incidents from gas sources

Publicly accessible information is available on the number of incidents from CO exposure which is attributed to gas sources. RIDDOR provides data on the number of CO incidents reported under Regulation 11(1) of RIDDOR along with the number of injuries and deaths for flammable gas incidents in Great Britain (as reported). In summary, the number of incidents of CO poisoning with gas as the source is:

- 146 incidents in 2015/2016;
- 122 incidents in 2016/2017;
- 100 incidents in 2017/2018;
- 99 incidents in 2018/2019;
- 96 incidents in 2019/2020.

The GST CO database reports 189 CO incidents from LPG from 1997 to 2014. A breakdown of these figures reports 79 deaths and 110 injuries. An abstract available by Close et al. for the 14th UK & Ireland Occupational and Environmental Epidemiology Society annual meeting, presents an analysis of coroners' findings. Domestic gas accounted for 23% of deaths for unintentional carbon monoxide deaths (total of 751 deaths).³⁶

No other publicly available data sources were identified from the literature review.

3.2.2.3 Review of FOI requests

For the Police services no breakdown of CO incidents by fuel type has been provided in the FOI requests. For the ambulance services, only the Northern Ireland Ambulance Services could provide numbers for CO incidents due to gas when a crew is on the scene (recorded in the sub category gas cooker/gas fire/gas boiler). These numbers are 1 incident in 2018/2019, 2019/2020 and 2020/2021 (3 in total).

For the FRSs, Cornwall FRS and Greater Manchester FRS do not record the numbers for CO incidents from a gas source, whilst Norfolk FRS could not supply incident numbers as carbon monoxide is not identified in a coded manner in the Home Office system and information on the number of incidents is only available for primary fires. North Yorkshire FRS do not hold information on injuries and deaths from CO exposure, however recorded 244 incidents where the ignition source of the primary fire has been recorded as 'cooker incl. oven, barbecue, camping stove, other cooking appliance'.

For FRSs who provided incident numbers, these are summarised in Table .

³⁶ Close R et al (2021). Which groups of individuals are more likely to die from unintentional carbon monoxide poisoning? An overview of coroners' findings. <https://epidemiologysociety.files.wordpress.com/2021/04/oes-meeting-2021-abstract-book.pdf>

Table 9: FOI responses from fire and rescue services for gas and CO incidents

Fire and Rescue Service	Number of gas CO exposure incidents	Number of injuries and deaths	Comments
Kent FRS	2018/19: 8 2019/20: 9 2020/21: 17 Total: 34	2018/19: 7 injuries, 1 death 2019/20: 5 injuries 2020/21: 7 injuries, 1 death	
Northumbria FRS	Within last three year period: 35 fire-related incidents and 3 incidents for gas leaks/gas left on premises	N/A	No specific field in IRS for indicating a gas appliance
Nottinghamshire FRS	2018/2019: 77 2019/2020: 74 2020/2021: 69 Total: 220	2018/19: 6 injuries 2019/20: 6 injuries, 3 deaths 2020/21: 2 injuries, 1 death	
Cumbria FRS	2018-2019: 0 2019-2020: 1 2020-2021: 8 Total: 9	N/A	Data from 1 April 2018- 31 March 2021. No CO flag in the incident system- used keyword search
Mid and West Wales FRS	2018/2019: 42 2019/2020: 22 2020/2021: 20 Total: 82	2018/19: 11 injuries 2019/20: 4 injuries 2020/21: 1 injury	
North Wales FRS	2018: 40 2019: 51 2020: 35 Total: 126	2018: 5 injuries 2019: 8 injuries 2020: 36 injuries	CO is not always a category in the IRS, groupings have been used for response
Northern Ireland FRS	2018/2019: 2 2019/2020: 9 2020/2021: 6 Total: 17	2018/19: 2 injuries 2019/20: 9 injuries 2020/21: 5 injuries	Free text is used for detailing incidents
Shropshire FRS	2018-2021: 66 accidents due to gas appliances		Incident Reporting System (IRS) does not report in CO specifically other than if it was involved as hazardous material. Specific number cannot be provided.
<i>Total (for illustrative purposes)</i>	591	<i>Injuries: 113 Deaths: 6</i>	

3.2.2.4 Conclusion for incident data for gas CO incidents

Information is publically available for CO incidents for the gas sector, primarily through RIDDOR reporting which is not the case for solid fuel CO incidents. Reporting for gas incidents is also required under RIDDOR. For 2015-2020, there has been a total of 563 incidents reported.

FOI requests were also submitted for gas CO incident. A similar situation is observed for the reporting of gas CO incidents as that for solid fuel CO incidents. There are differences between fire services for reporting incidents. For example some FRs report numbers of incidents, whereas others have highlighted the absence of a CO flag in the IRS and also CO is not coded in the Home Office system. In total for those FRs and the one ambulance service who have reported numbers, 594 incidents are reported with 113 injuries and 6 deaths reported.

From the data received from FOI for gas CO incidents it is not possible to conclude if this data is representative across the UK due to the differing reporting by services. This may result in the number of gas CO incidents being underreported.

3.3 Outcomes from stakeholder interviews

In total nine stakeholders were interviewed as outlined in section 2.4, that represented a range of groups; safety and standards organisations, charities, manufacture associations, training providers, trade associations and building controls.

The responses from the stakeholders have been qualitatively analysed and synthesised in the following sections, the results presented in this section **represent the views of those stakeholders interviewed.**

3.2.3 Data in the solid fuel sector

The sources of CO incident data in the solid fuel sector identified by the stakeholders included; emergency respondents data, HETAS, Committee incident reports, HSE, Gas Safety Society, RIDDOR and clinical factors data.

A few different processes/stakeholders were identified from the stakeholder interviews in relation to the collection of data to CO incidents in the solid fuel sector, including:

- HETAS (procedures and various logs for incidents);
- Competent Persons Scheme (which includes installers, people who maintain appliances, chimney sweeps);
- Hospital records (e.g. from a clinical perspective in A & E identifying when a patient has been exposed to CO by asking what fuel they use, and referring them to a local protection unit (public health body));
- Electronic certificates (however these would depend on the certificate system and whether data is collected);
- RIDDOR;

- Local authorities;
- HSE;
- Members of the public/consumers;
- Operators;
- Managers of buildings;
- British Flue and Chimney Manufacturer Association (BFCMA);
- Chimney sweeps;
- All Party Parliamentary Carbon Monoxide Group (APPCOG).

3.2.4 Trust in the solid fuel incident data and figures

It was reported by some of the stakeholders that there is a lack of reliable figures for the solid fuel incident data and that where data is available it is under reported and possibly an under estimation. Whereas another stakeholder identified that the figures are generally correct for the incidence data relating to fatalities, however, figures for non-fatal incidents are not so clear.

These results demonstrate that there are mixed views on solid fuel incident data and figures. However, due to small number of respondents it is not possible to state if this is the case throughout the sector.

3.2.5 Barriers to obtaining and accessing CO incident data in the solid fuel sector

The main barrier identified by many of the stakeholders in relation to obtaining CO incident data in the solid fuel sector was that there is a the lack of a centralised record and there being a lack of consistency in approach across the various data repositories. In addition, due to this inconsistency, it was reported that there is a lack of sharing of data with relevant groups and a lack of understanding on how the data can be used effectively. It was identified that there needs to be greater visibility and clarity around the data, how it is obtained and the processes involved (e.g. how things are done, types of equipment). In reality, it was suggested that there are pockets of data that are available, however these are not brought together centrally. This highlights that there is currently no pathway for accessing all data with there being issues around data collection and data access/reporting/interpretation.

Electronic data gathering systems were suggested as a way to mitigate some of the barriers to obtaining and accessing a complete data set. However, it was reported that a barrier to developing this type of system is the cost involved; a suggestion was made that the impacts of a centralised data collection and storage system could outweigh this cost. Through the development and use of this type of system it could increase knowledge and ensure relevant and consistent data.

3.2.6 Improvement of CO incident data in the solid fuel sector

To improve the data and reporting on CO incidents in the solid fuel sector, as reported above, there was a suggestion by many of the stakeholders of having a centralised technology system that allows for the recording, storage and usage of data. It was reported that by having a central place it would allow for this collation from a central body that can then pass data to the relevant organisations and industries. In addition, it was suggested

that if the incidents data is centralised then it can be processed more efficiently which would allow trained individuals to investigate CO release/exposure incidents in a standardised manner.

As part of a technical centralised data set, it was suggested that there could be use of electronic certificates and apps (e.g. to measure levels). It was identified that for the best results any system developed should be simple to use then rolled out more widely to stakeholders identified in this review.

It was reported that a cross confidential system has been expanded to fire and perhaps could be expanded or modified to include CO incident data from heating appliances in the future.

3.2.7 Stakeholders that access and use (or would be interested in accessing an using) the CO incident data in the solid fuel sector

The interview respondents identified a range of stakeholders that could be interested in accessing and using the CO incident data if centrally available. This ranged from everyone and all actors in the sector, to examples of specific groups, including; HETAS, chimney safety groups (e.g. Federation of Chimney Sweeps), the All Party CO Group, Department of Health, stove and flue manufacturers and installers, scheme for all fuels, individual sweeps, trade associations, the Guild, Government, appliance officers, regulators and enforcers.

It was reported that there needs to be caution as data can be interpreted in different ways, so there is a need to ensure figures and outputs are easy to understand.

3.2.8 Comparison of the CO incident data in the solid fuel sector and the CO incident data in the gas industry (for example RIDDOR data from HSE)

Some of the stakeholders reported that there is a process and centralised records for gas industry reporting which is more effective than what is currently available for solid fuel incidents. An example was provided, where emergency response teams respond to solid fuel incidents as well, but if there is no gas appliance there will not be further recording. A proposed reason provided for a prioritisation in the gas industry is that there are more gas appliances in UK homes.

3.2.9 Current regulations - installation

Stakeholders identified the following CO safety related regulations that they are currently aware of which are relevant for appliance installation in the solid fuel industry:

- Document J of the Building Regulations;
- BS 13030 (Ventilation for buildings);
- BS 50291;
- Appliances installed by competent persons or signed off by building control;
- Appliances need to conform to United Kingdom Conformity Assessed (UKCA) (formerly CE);
- Eco design regulations;
- Health and safety regulations.

3.2.10 Views on current CO safety related regulations in the solid fuel industry for appliance installation

Overall, there were mixed opinions from stakeholders on whether they felt that the solid fuel industry is suitably regulated, specifically in the area of appliance installation and CO safety.

Those of the opinion that it is suitably regulated identified that Building Regulations, if followed, are acceptable for installation, yet others identified that there could be greater regulation in this area. Specifically, a stakeholder identified that improvement for these regulations could be driven through a requirement for the social housing sector to bring gas and oil 'in to scope', as any heating technology needs a CO alarm in that setting. It was reported that CO devices will become better and guidance and regulation will need to be sensitive to this and any future updates.

In addition a question was raised from the stakeholders perspective as to whether the solid fuel sector could be suitably regulated if it does not have an equivalent of the Gas Safe Register; current standard practice for the gas sector. Concerns were also raised around the rate of innovation, e.g. around positioning of CO alarms. In addition, it was identified that there are issues around there being a lack of regulation around self-certification (unless by complaint) for solid fuels, creating the potential for a lot of 'do it yourself' in solid fuels with home owners not always or clearly knowing the rules and regulations, which can result in installations and updates being conducted improperly or not by trained personnel.

Another response identified that the regulations for solid fuels are fairly rigorous, with installation being carried out with the required checks and recording procedures. However, it was also identified by stakeholders in the interviews that the home owners role is important, for example with CO alarm maintenance, replacing batteries, not blocking up ventilation, not tampering with CO alarms, burning the right fuel and having a chimney swept at appropriate intervals. So even when an appliance has been installed by a registered competent installer, issues can arise with maintenance and day to day operation.

In addition, it was identified that there are challenges in the leisure market, such as glamping, which is gaining traction, as there is a need to make sure that CO activation is covered.

3.2.11 Current regulations – control on manufacture

There were mixed responses around the CO safety related regulations for controls on manufacture. Some identified that at present all solid fuel appliances require testing under the Construction Products regulations, but this does not cover spillage of gases during refuelling.

Another respondent identified that UKCA means that manufacturers have to have their products tested and meet the approved standards, although this is the replacement for EU CE marking. In addition, it was also reported that the Eco-design Regulations have changed (recent changes are discussed in section 3.3.1) and are tighter (Eco-design appliances burn very differently from the older style appliances that had wider user control and enabled the users to shut appliances down to slightly smouldering, which produced

higher levels of CO within the permitted levels) and the new design results in much lower levels of CO generation and as such are much safer in terms of the CO profile.

In addition other regulations mentioned by the stakeholders were H&S regulations, EU standards and CE certification in regards to regulations associated to manufacture of solid fuel appliances.

3.2.12 Do you feel that the solid fuel industry is suitably regulated in the area of control on appliance manufacture/supply and CO safety, if indeed at all?

Some stakeholders felt that the solid fuel industry is suitably regulated, with an example of a reason for this being that there are regulations for appliances under System 3 and a HETAS approved scheme which provides necessary guidance for CO alarm installers and warning information in instructions, such as opening windows. In addition BFCMA helped develop a testing regime for manufacturers of appliances connected to flues and chimneys. There are up-to-date standards, and testing houses use this methodology.

3.2.13 Current CO safety related regulations in the solid fuel industry for control on appliance manufacture/supply

Of the few responses provided, on the one hand it was identified that control and standards are robust in the solid fuel sector for the control on appliance manufacture and supply, whereas on the other hand it was reported that more emphasis is needed on actual requirements and the positioning of CO alarms.

3.2.14 Comparison between solid fuel and gas industry regulations

The responses from stakeholders largely identified that the gas industry is currently more regulated and robust than the solid fuel industry. It was also reported that this robustness is also likely due to the gas industry being enforced by HSE and GasSafe. In comparison it was reported that there is still more work to be done in the solid fuel industry to have these lead regulators, with a stakeholder reporting that in their opinion there is no objection to this in the solid fuel sector.

3.2.15 Highest risks of CO exposure in the solid fuel sector

Most of the stakeholders identified the highest risk of CO exposure is mainly from chimneys, particularly the draw from a chimney in a domestic setting and in relation to chimney maintenance, cleaning and fuel combinations. If the chimney draw is not working correctly, then it was reported that there is a blow back in to the room of smoke, this fault can be more obvious than with gas as there is visual evidence of a problem. It was reported that there are building regulations related to draws on chimneys and the extraction of gases and that in most instances a good result is achieved with a good margin of error. It was identified that there is a requirement on the installer to produce documentation to test the solid fuel installation emissions at the point of installation and test that figures fall within the required level would be a useful separate document to tack on to the compliance document.

Additional risks for CO exposure identified, included; indoor appliances, poorly ventilated appliances, appliances having little heat energy from combustion to drive the flue pull, faulty flues, leaky chimneys, wood burners and other solid fuel central heating systems.

3.2.16 Mitigation of the highest risks in the solid fuel sector in future

There were a few suggestions from stakeholders for how the highest risks for CO exposure might be mitigated in the future for the solid fuel sector; these included education, research, and government.

In regards to education, it was identified that there is a gap related to consumer/user knowledge and awareness around CO exposure, ongoing monitoring of the use of appliances and how to burn fuel safely. Relating to this, it was suggested that it could be helpful to have an education programme for consumers on safe use and maintenance etc.

As part of the drive for education, it was identified that there is a need for data through conducting research that tests appliances and identifying how many are operating safely. In addition, it was identified that there could currently be inaccurate information on solid fuel appliances, as it could be based on inaccurate data, therefore further research and data is required. Finally, there is a need for CO alarms for all installations and a need for stronger regulations more broadly.

4 Discussion and conclusions

4.1 Overview of the solid fuel sector with regards to the risk of CO exposure

4.1.1 Regulatory and policy landscape

From the outcome of this literature review, the current regulatory landscape for solid fuel and CO is less developed than that of gas and the current requirements are not easy to follow or set out. In terms of the regulations for solid fuel, these are divided into four regulatory areas:

- Manufacture of appliances;
- Safety of appliances;
- Installation of appliances;
- Legislation relating to fuel.

Manufacture of appliances is included in relevant product regulations, which are not specific to solid fuel installations, for example the Constructions Products Regulations and the requirement for CE marking (soon to be CA marking). For safety of appliances, this is set out on the General Product Safety Regulations 2005. The installation of appliances is predominantly, set out in the Building Regulations (Approved Document J). The Regulation is a legal requirement whereas Approved Documents are guidance on how the regulation might be complied with. There are also alternative approaches e.g. EN ISO Standards. In terms of requirements for CO exposure and solid fuels, the current regulation is dominantly on the requirements for installing a CO alarm in the vicinity of a new or replacement solid fuel installations, where there is also a lack of requirements for existing private dwellings. Requirements for solid fuel appliances are set out in the Building Regulations for England and Wales. The approach in Scotland and Northern Ireland differs from England & Wales where competent person's self-certification schemes are used. Regulation is in place for England for solid fuel quality, with consultation either finished or ongoing in Wales, Scotland and Northern Ireland. There are also no specific requirements for reporting incidents associated to solid fuels CO incidents, such as for RIDDOR for the gas sector. From the literature reviewed, the current regulatory and policy landscape for solid fuels could be difficult to follow for the user and it is worth noting that various stakeholder require knowledge of the current regulatory landscape, for example policymakers, associations, installers and landlords.

The stakeholder engagement conducted as part of this project raised issues and concerns for solid fuel appliances and installations; also use including ongoing maintenance. Overall, there was a mixed response asking if the regulations were sufficient for solid fuels, with some

stakeholders identifying the regulations were suitable, whereas other stakeholders feel improvement is needed. The CO related regulations identified by stakeholders included the Building Regulations, conforming to UKCA, Eco -design regulations, and the requirements for fitting of CO alarms with any appliance installation. For solid fuel appliance regulations, the following improvements have been suggested:

- Improving regulations to include bringing gas and oil into scope for the social housing sector and the need for CO alarms;
- Enforcement through an equivalent of the Gas Safe Register for solid fuels;
- Needs to be the requirements around innovation such as CO alarm positioning;
- Homeowners require information on the regulations as their role is extremely important;
- The need to take into account the changing leisure market such as increase in glamping.

In terms of regulations for the manufacture of solid fuel appliances, this presented a mixed picture from respondents, with some aware of the associated regulations. One improvement in this area would be to ensure stakeholders are aware of these regulations, through education programs. It has been commented that the new requirements under the Eco-design regulations result in lower CO levels for solid fuel appliances. In terms of regulations for controls on appliance manufacture and supply, this showed a mixed picture amongst stakeholders in regards to solid fuel sector being sufficiently regulated. Improvements suggested include:

- An emphasis on the requirements of CO alarms;
- An emphasis on the positioning of CO alarms.

4.1.2 Incident data

There is no formal or regulated requirement for reporting CO incidents relating to the use of solid fuel, wood and biomass combustion installations such as RIDDOR for gas. Therefore there is no consistent approach to data collection or reporting between different authorities and many authorities do not routinely keep data or store data in an easily retrievable manner. Where data was available on solid fuel incidents, it was often incomplete with a number of caveats to the data, such as keywords used to search incident records.

The review identified several sources capturing the number of CO incidents. Sources of CO incidents include public health bodies, ONS data, the Cross Government Group on Gas Safety and Carbon Monoxide (CO) Awareness and NPIS. However, none of these identified sources for CO data, broken down further to incident type, such as fuel type (i.e. solid fuel). Two literature databases were identified for solid fuel and CO incidents. These were the GST CO Incident database and the Carbon Monoxide and Gas Safety Society. However, the last incident reported in the GST CO Incident database is for 2014 and the data for the Carbon Monoxide and Gas Safety Society does not also include the number of CO incidents that did not result in fatalities.

Freedom of Information (FOI) responses to the emergency services provided a mixed response to the incident data collected and the quality of data. It is worth noting, that no comparison of data is possible for the responses received from the emergency services

nationally across the UK. This is due to a variety of factors, including the reporting years (e.g. reporting by calendar year and/or financial year), caveats provided to the data (e.g. the use of wildcards for searching records), the use of field text for solid fuel incidents and the mixed data received. In terms of Police, no CO incident data and thus no solid fuel CO incident data were provided, as generally the information was not being held in an accessible format. For the Ambulance services, some data is available for CO incidents, but there is no breakdown available for solid fuel. Solid fuel CO incident numbers are available from the Fire and Rescue services (FRS), however the data available is of mixed quality. From the responses received from Fire and Rescue Services, three of these could not provide any solid fuel CO incident data as the data could not be easily retrieved or was not recorded for solid fuel. The responses received show the difference in data reporting for solid fuel CO incidents and are illustrated below:

- Norfolk FRS: Unable to supply information for CO incidents, as the cost would exceed the appropriate amount for an FOI. The response included that solid fuel appliances are not specifically identified in a coded manner within the Home Office system. Information can be recorded optionally in a 'free text' field:
- Mid and West Wales FRS:
 - 2018-2019: 15 solid fuel appliance incidents with 1 injury from CO exposure and 1 death from CO exposure;
 - 2019-2020: 21 solid fuel incidents with 3 injuries from CO exposure;
 - 2020-2021: 20 solid fuel incidents with 3 injuries from CO exposure;
- Shropshire FRS:
 - 2 accidents from solid fuel appliances over the past three years;
 - The service is unable to provide the specific number of cases for CO as the incident report does not report specifically on CO, other than if it was involved as a hazardous material as stated in the FOI response.

As can be seen from the FOI responses, there is no consistent reporting for solid fuel CO incidents between emergency services and also within emergency services. For example, some FRSs report accurate figures, whilst other FRSs have reported that free text fields are used for reporting CO incidents and also keywords were used for retrieving incidents. It is also worth noting, that some FRSs have highlighted issues with the current Incident Reporting System and Home Office systems which do not allow CO to be marked, this could in turn lead to underreporting of incident numbers. Due to the differences in reporting between FRSs, it has not been possible to perform extrapolation to the whole of UK based on the figures. The lack of mandatory reporting and data collection for solid fuel incidents means that it cannot be certainly stated the numbers of incidents and fatalities relating to the use of solid fuel, wood and biomass combustion in dwellings.

However, from the presented figures it can be observed that there is likely to be **underreporting of solid fuel CO incident numbers**. This can also be demonstrated by numbers not being available for the health services, ambulance services and police services. Underreporting is also demonstrated by there being no equivalent for RIDDOR reporting as for the gas sector.

Suggested barriers to incident data were identified by stakeholders during the interviews. Comments included the lack of consistency in data recording (as illustrated in the FOI responses, discussed above), the need to have a centralised record for incident data and the need for a pathway has been highlighted. One potential suggestion is the use of electronic data gathering systems, although setup costs could be a factor. The use of centralised data, would allow collation of data (also allowing quicker data processing) that could then be used by the relevant stakeholders with quicker and more consistent outcomes. Stakeholders also identified that data and the centralised entry system would need to allow for data to be input easily, simple to follow and straight forward to understand.

4.1.3 Risks of CO exposure

Stakeholders' views were gathered to determine where the highest risks of CO exposure occur in the solid fuel sector. The highest risk of CO exposure has been identified from chimneys, in particular from the draw of a chimney. Other potential areas of CO exposure identified includes wood burners, indoor appliances, poorly ventilated appliances, faulty flues and other solid fuel central heating systems. There is a fundamental difference in the design of most solid fuel appliances (stoves and open fires) to domestic gas appliances. Whereas gas appliances have evolved over time to become mainly room sealed, the vast majority of solid fuel appliances are open flue. This means that the combustion space is open to the room or via a duct to outside air, to enable air for combustion; and the flue terminates at high level. Additionally, gas and oil appliances can incorporate solenoid valves and sensors to immediately cut off the fuel supply in the event of danger. For most solid fuel appliances there is no similar instant safety device. Solid fuel appliances are mostly batch fed i.e. they have a fixed load of fuel which can be left to burn out quite quickly, whereas gas and oil appliances have a continuous fuel feed, so most solid fuel appliances won't just burn on and sustain a dangerous condition whereas older gas appliances can do so there are mitigations. Most solid fuel appliances require ventilation either provided by adventitious ventilation (that which exists in properties and is difficult to stop), or by purpose provided ventilation whereas room-sealed gas appliances would not have the same combustion air vents. Therefore there are areas of higher risk as well as areas of reduced risk from solid fuel appliances.

4.1.4 Mitigations of the highest risks in the solid fuels sector

The need for education has been identified by stakeholders, particularly for consumers and users as an area for improvement. In particular, this includes CO awareness, using appliances and fuel safety in the solid fuel source sector. The use of incorrect data has been highlighted for solid fuel appliances, which leads to incorrect information being provided, although no further information was provided by stakeholders.

4.2 Overview of the gas sector with regards to the risk of CO exposure

4.2.1 Regulatory and policy landscape

From the outcome of the literature review, the regulatory and policy landscape is more developed than that of the solid fuel sector. For gas, relevant regulations include the manufacture, safety and installation of appliances. For the manufacture, there is similar requirements as that for solid fuel appliances including UKCA marking. For installation of gas appliances, these include requirements under the Building Regulations and the requirements of CO alarms installation where a new or replacement combustion appliance is fitted (including gas). There are specific requirements for reporting CO incidents under RIDDOR for gas and other safety requirements set out in the Gas Safety (Installation and Use) Regulations 1998 and the Gas Safety Management Regulations 1998. Stakeholder engagement identified that the gas sector is more robust and more regulated than the solid fuel sector currently despite similar potential issues.

4.2.2 Incident data

The literature review identified sources reporting the number of CO incidents. Sources of CO incidents include public health bodies, ONS data, the Cross Government Group on Gas Safety and Carbon Monoxide (CO) Awareness, the GST CO incident database and NPIS. However, none of these identified sources for CO data breakdown further by incident type, such as fuel type (e.g. solid fuel). Specific CO incident data for the gas sector is readily available, unlike for the solid fuel sector, where HSE RIDDOR data is available for the number of CO incidents for the gas sector reported under the RIDDOR Regulation. These numbers, generally show the number of CO incidents decreasing (146 incidents were reported in 2015/2016 compared to 96 incidents reported in 2019/2020).

However, for the emergency services, as for the reporting solid fuel CO incidents from gas sources, data was limited. As for the solid fuel sector, no information was available from the Police for the number of CO incidents and where the CO incident numbers were reported by the Ambulance services, this could not be further broken down by fuel type (i.e. gas), apart from by one service. The same observation is noted for the number of CO incidents from gas as that of solid fuel source from the FRSs. The data provided for gas CO incidents is mixed and cannot be compared due to the nature of recording incidents. For example, responses received from the Fire and Rescue services highlighted that there is no specific field in the incident reporting system for gas appliances and there is no CO flag in the incident system (i.e. a keyword search has been used to retrieve data). Free text has also been used for recording incidents, which is also the case for solid fuel incidents by some of the data returned from the emergency services FOI requests. The following responses highlight these issues:

The responses received that shows the difference in data reporting for solid fuel CO incidents are illustrated below:

- Norfolk FRS: Unable to supply information for CO incidents, as the cost would exceed the appropriate amount for an FOI. The response included that solid fuel appliances

are not specifically identified in a coded manner within the Home Office system. Information can be recorded optionally in a 'free text' field;

- Northumbria FRS: No specific field in IRS for indicating a gas appliances. Within the last three year period, 35 fire-related incidents and 3 incidents for gas leaks/gas left on premises have been reported;
- North Wales FRS: 40 incidents in 1028, 51 incidents in 2019 and 35 incidents in 2020. However, carbon monoxide is not always a category in the IRS, so groupings were used for the response.

As per the solid fuel sector, the differing reporting and data collection for gas incidents between emergency services means that it cannot be certainly stated the numbers of incidents and fatalities relating to the use of gas in dwellings, although unlike the solid fuel sector there is an obligation under RIDDOR to report gas incidents.

4.3 Comparison of the current situation for solid fuels and gas

4.3.1 Regulatory and policy landscape

As discussed in section 4.2, the regulatory and policy landscape from the literature review and stakeholder engagement is more developed for the gas sector than the solid fuels sector. The main factor that has been identified for this is enforcement of the regulations by HSE as a designated regulatory authority.

4.3.2 Incident data

Commencing with CO incident data only, the challenges are similar for the gas and solid fuel sectors. Incident data available from ONS and other bodies (which is presented in the Cross Government Group on Gas Safety and Carbon Monoxide (CO) Awareness) does not provide a breakdown to the fuel type. One key difference in the available incident data is that publically available information is available for the number of CO incidents from gas available from HSE RIDDOR. There is no equivalent of the RIDDOR data for the solid fuel sector.

However, a similar data exists for the emergency services for the reporting of CO incidents from gas and solid fuel appliances, in that only some of the FRS can provide a breakdown of CO incidents of fuel types, this is also not collected consistently.

4.4 Gap analysis

A gap analysis has been performed for the current landscape for the regulatory and policy position and incident data for solid fuels. This illustrates the current data and where there are information gaps. The gap analysis for the regulatory and policy landscape is presented in Table , with the gap analysis for incident data presented in

Table 2.

Table 10: Gap analysis for the regulatory and policy landscape for solid fuel

Current State	Desired State	Gap	Remedies
Regulations may be difficult to follow	Relevant stakeholders need to know requirements of regulations they need to follow	Easy to use and follow requirements of regulation	Simplified guidance documents and/or checklists.
Enforcement of regulations may be mixed.	Enforcement of all the relevant regulations and for stakeholders to be aware	Enforcement needs to be clear i.e. who is responsible for this.	Education and awareness around who is responsible for enforcement, for example HSE and GasSafe have been identified for the gas sector. Set up an equivalent to GasSafe.
Homeowners may be unaware of regulations	Homeowners understand requirements for installation and maintenance	Homeowners are a stakeholder needing engagement	Providing easy to follow information on requirements. Provide education to homeowners.
Stakeholders unaware of some regulations	Stakeholders aware of all relevant regulations for solid fuels	Gaps in regulatory knowledge for some stakeholders	Use of checklists for different stakeholders and education.
Solid fuel sector not as regulated and robust as the gas sector	Solid fuel to be regulated in the same manner as gas.	Enforcement between the sectors	Stakeholders have identified the enforcement of the regulations. Need for CO alarms for all installations.
Mixed views of whether the solid	Stakeholders to view the solid fuel	There may be areas where regulations	Education programmes. More focus on the

Current State	Desired State	Gap	Remedies
fuel sector is regulated sufficiently	sector is sufficiently regulated	could be tightened/modified	requirements and positioning of CO alarms.

Table 2: Gap analysis for the number of incidents for solid fuel

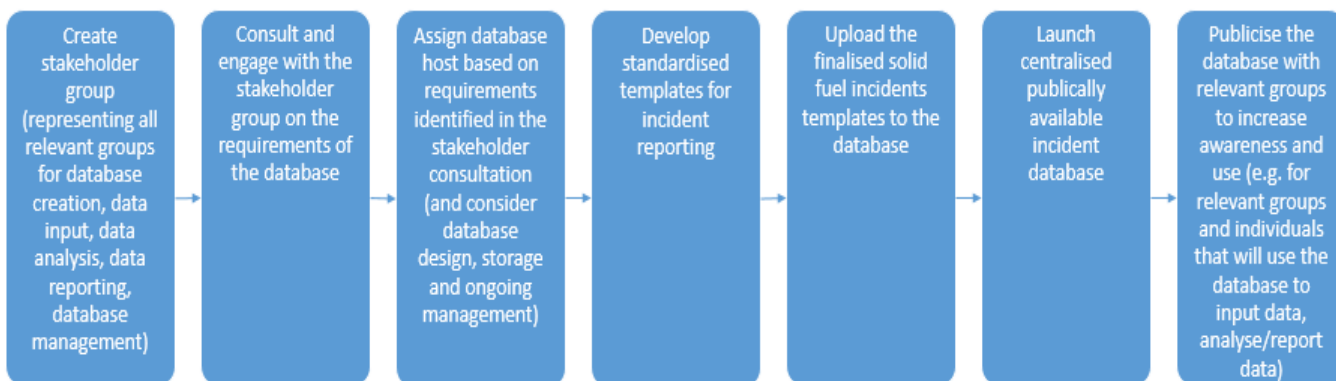
Current State	Desired State	Gap	Remedies
No easily accessible data for number of CO incidents from solid fuel appliances. Mixed responses for incident data from emergency services	Readily available data for solid fuel CO incidents, such as RIDDOR for gas	Current data easily available to interested parties for solid fuel CO incidents	Possibility of standardised templates for recording CO incidents to be collected by emergency services and health authorities. Also limit the use of free text boxes for recording. One approach is also extending RIDDOR to solid fuel.
No centralised system for incident reporting	Centralised system which also allows a consistent approach to data gathering	Gap in data collection and verification	Centralised database for reporting incidents with the use of standardised templates. Designate an authority/organisation such as HSE for hosting the system.

4.5 Roadmap for improving CO incident data collection in the solid fuel sector

A suggested potential roadmap for improving CO incident data collection in the solid fuel is presented in Figure 4.4 based on the discussion of incident data and the gap analysis presented in section 4.4. This roadmap involves two interlinked stages, these are:

- Developing a centralised database for collecting incident data; and
- Developing a standardised template to be used for recording solid fuel CO incidents (which could be developed in parallel).

1. Development of a centralised database



2. Data collection templates



Figure 7: Roadmap for data collection

4.6 Identified knowledge gaps and research opportunities for CO Research Society

A number of knowledge gaps have been identified in the review. These are described in the gap analysis in section 4.4 of this report. A number of research opportunities have been identified by stakeholders as part of the stakeholder engagement process. Potential opportunities highlighted are the following:

- The requirement for providing awareness to consumers and users for CO exposure;
- Providing awareness for the monitoring of appliances and for burning solid fuels safely to consumers and users;
- Conduct research on testing solid fuel appliances to see if they are working correctly. This includes research on solid fuel appliance testing and also investigating if appliances remain safe over time.

Further research opportunities are also available for creating data collection templates for recording CO solid fuel incidents and testing the templates with various authorities and organisations such as the emergency services.

4.7 Conclusions

The key conclusions from this study and suggested actions are shown in Table 3 for the solid fuel sector. These conclusions have been drawn from the literature review and from stakeholder engagement.

Table 3: Key conclusions and potential actions

Conclusions	Potential Actions
Regulatory and policy landscape for solid fuels is less developed than that of the gas sector	Continued developments of regulations. Stakeholders have identified possible gaps in regard to CO alarm positioning and also the changing leisure market such as increase in glamping. Need to consider social housing as part of the regulations.
There may be a lack of awareness of regulations for groups of stakeholders and consumers/users of solid fuel installations	Providing guidance documents and education/training opportunities for a wide variety of stakeholders on the solid fuel regulatory requirements.
Publicly available incident data for CO is available, however only two sources are publicly available that report solid fuel incidents (CO Gas Safety Society and GST CO Incident Database)	Develop a centralised incident reporting database.
For the emergency services, only the FRS have solid fuel CO incident data, but this is mixed due to reporting of incidents such as the use of free text fields and no IRS flag for CO. Ambulance Services have some CO data, whilst no CO data is easily accessible for the Police	The use of standardised templates for reporting CO incidents from solid fuel appliances. Where possible, free text fields should be kept to a minimum.
Need to mitigate areas of highest risk in the solid fuel sector	Education of consumers, users and other stakeholders around CO awareness and appliance and fuel safety.

Appendix 1: FOI questions for incident data

Total number for all incidents attended by (emergency service name):

- 1) What are the total number of all incidents attended within the last three-year period?
- 2) What are the total number of injuries from all incidents (this includes those treated by (emergency service here) attended within the last three-year period?
- 3) What are the total number of deaths from all incidents attended within the last three-year period?

Numbers for incidents involving carbon monoxide (CO):

- 1) What are the total number of incidents for CO attended within the last three-year period?
- 2) What are the total number of injuries from all CO incidents attended within the last three-year period?
- 3) What are the total number of deaths from all CO incidents attended within the last three-year period?

Numbers for incidents involving solid fuel appliances:

- 1) What are the total number of incidents due to a solid fuel appliance attended within the last three-year period?
- 2) What are the total number of injuries from CO exposure due to a solid fuel appliance attended within the last three-year period?
- 3) What are the total number of deaths from CO exposure due to a solid fuel appliance attended within the last three-year period?

Numbers for incidents involving gas appliances:

- 1) What are the total number of incidents due to a gas appliance?
- 2) What are the total number of injuries from CO exposure due to a gas appliance attended within the last three-year period?
- 3) What are the total number of deaths from CO exposure due to a gas appliance attended within the last three-year period?

Appendix 2: Stakeholder interviews

Background details

- What company/group do you work for?
- What is your job role?
- What is your role in relation to GST research? (researcher, advisor...)

Data in the solid fuel sector

- What sources of CO incident data are you aware of in the solid fuel sector which are available?
- Do you know how many solid fuel related incidents there are every year, if so do you believe the figures are correct?
- How are data relating to CO incidents and solid fuel collected?
 - What is the process?
 - Which stakeholders are involved?
- Do you feel there are barriers in obtaining the CO incident data in the solid fuel sector?
 - If yes, what are these barriers?
 - If yes, how might the barriers be mitigated?
- Do you feel there are barriers to accessing the data for CO incident data in the solid fuel sector?
 - If yes, what are these barriers?
 - If yes, how might the barriers be mitigated?
- How do you think the CO incident data in the solid fuel sector could be improved?
 - Reporting
 - Access
 - Usefulness
 - Coverage
 - Relevance/applicability
- Which stakeholders do you think access and use the CO incident data in the solid fuel sector or would be interested in accessing and using the data?
- What are your views on a comparison of the CO incident data in the solid fuel sector and the CO incident data in the gas industry (for example RIDDOR data from HSE)?

Current regulations - installation

- What CO safety related regulations are you aware of which are relevant for appliance installation in the solid fuel industry?
- Do you feel that the solid fuel industry is suitably regulated in the area of appliance installation and CO safety?
- What are your views on the current CO safety related regulations in the solid fuel industry for appliance installation?
 - How could these regulations be improved?
 - How could the regulations be further developed?
 - Where are the biggest gaps?

Current regulations – control on manufacture

- What CO safety related regulations are you aware of which are relevant for control on appliance manufacture/supply in the solid fuel industry?
- Do you feel that the solid fuel industry is suitably regulated in the area of control on appliance manufacture/supply and CO safety, if indeed at all?
- What are your views on the current CO safety related regulations in the solid fuel industry for control on appliance manufacture/supply?
 - How could these regulations be improved?
 - How could the regulations be further developed?
 - Where are the biggest gaps?

Comparison between solid fuel and gas industry regulations

- What are your views on the current regulations in the gas industry compared to the solid fuel industry?

Risk of CO exposure

- Where do you see the highest risks of CO exposure in the solid fuel sector?
- In your opinion, what are the specific CO related risks in the solid fuel sector?
- What are your suggestions for how the highest risks for CO exposure might be mitigated in the future in the solid fuel sector?

Future opportunities

- Where do you think there are knowledge gaps and research opportunities around CO exposure in the solid fuel sector? Please provide suggestions and specifics.

Future comments

- Do you have any other comments that you would like to add?

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