Health Needs Assessment

Air Quality in Leeds

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June 2023

Leeds CITY COUNCIL

Acknowledgements

With sincere thanks to –

Maria White, Rafael Wortmann, Adam Taylor, and Suresh Perisetla for their wide-ranging support with public health intelligence and analysis.

Chad Newton and Paul Spandler for invaluable access to Leeds City Council Environmental Health data and contributions to the development of local recommendations.

Ryan Ford for undertaking a literature search via the NHS Trust Knowledge and Library Service.

Sharon Foster and Dawn Bailey for their guidance on the development of this report.

The Leeds Air Pollution and Health Group for their positive energy, commitment, and support for this agenda locally.

Contents

List of tables

List of figures

Chapter 1: Introduction

Poor air quality is the largest environmental risk to public health in the UK (Public Health England, 2018a). The tragic death in 2013 of Ella Adoo-Kissi-Debrah, a 9-year-old child from South London, led to a landmark case in 2020: a second Coroner inquest determined exposure to air pollution to be a significant contributory cause of illness and death. This case has brought the health impact of air pollution, particularly on those most vulnerable, into sharp focus in the UK, further emphasising the need for collective public health action at scale.

Over the last decade, there has been an increased focus on understanding the impact of air quality on population health. Epidemiological studies have shown that long-term exposure to air pollution (over years or lifetimes) reduces life expectancy, mainly due to cardiovascular and respiratory diseases and lung cancer. Short-term exposure (over hours or days) to elevated levels of air pollution can also cause a range of health impacts, including effects on lung function, exacerbation of asthma, increases in respiratory and cardiovascular hospital admissions and mortality. Additionally, the impact of air pollution tends to be disproportionately experienced, affecting children, the elderly, those who are pregnant, and those with existing heart and lung conditions. Individuals may also be at greater risk if they are more exposed to higher levels of air pollution because of where they live or work.

The mortality burden of long-term exposure to outdoor air pollution in England in 2019 was estimated to be equivalent to 26,000 to 38,000 deaths a year, as air pollution is considered to be a contributory factor to mortality (Whitty et al., 2022). This estimate was calculated by the UK Health Security Agency (UKHSA), based on recommendations from the Committee on the Medical Effects of Air Pollutants (COMEAP). In 2017, the total estimated healthcare cost to the NHS and social care was reported to be approximately £157 million (Public Health England, 2018b). It is estimated that 54 of every 1000 deaths that occur in Leeds can be attributed to air pollution (Fingertips, 2021).

Air quality in Leeds has improved significantly in recent years, continuing a long-term trend. However, it is widely recognised that there are no safe levels of air pollution and no threshold level below which air pollution will have no detrimental effects on health and mortality.

Methodology

A Health Needs Assessment (HNA) is a systematic method for assessing health related issues within a population. The purpose is to gather relevant information to understand the type and distribution of ill health and disease or conditions. This intelligence is then used to inform priority setting, resource allocation and commissioning, which aims to improve health and well-being and tackle health inequalities at a population level.

The purpose of this HNA is to:

- Assess and understand the level of need across Leeds in relation to air pollution.

The aim of this HNA is to:

- Understand the populations most at-risk to define a targeted approach to addressing health inequalities, including the development of local recommendations, and influencing local policy.

This HNA is the first in Leeds to survey air pollution and health; it is intended to be a springboard for further local public health action on this agenda.

Scope

Air pollution is transient and transboundary in nature, and therefore it is not an issue that is confined to a particular geographical area. As such, this HNA follows a citywide scope that takes into account the whole Leeds population across the life course, considering both outdoor and indoor air pollution.

This report uses a combination of quantitative and qualitative data sources from the following organisations, teams, and sources:

Environmental Health (Leeds City Council)	UK Health Security Agency	Public Health Intelligence (Leeds City Council)	Local views	Public Health (Leeds City Council)
• Air Quality monitoring network for Leeds • Air Quality Management Areas in Leeds	• Air quality and vulnerability tool using Air Pollution Exposure Surveillaince	• Long term conditions (with a focus on respiratory and cardiovascular conditions) • Prevalence, mapping, demographics across a PCN level using GP Audit data	• Citywide survey sent via Leeds City Council • Community group and workforce feedback obtained via Public Health (Leeds City Council)	• Already published HNAs on maternity, children and young people, and localities

From this, it is possible to build a picture of populations in the city who are most at risk of the short- and long-term health impacts of air pollution, as well as gain better understanding via local community intelligence on local views relating to health and air quality. However, it is not possible from the data presented in this report to draw conclusions about a definite association between disease prevalence and levels of air pollution at a local level.

Chapter 2: Air quality

What is air pollution?

Air pollution is a substance or complex mixture of particles and gases in the air that cause harm to health (Public Health England, 2018a). Air pollutants are emitted from both natural and human sources, affecting the quality of both indoor and outdoor air.

Transboundary air pollution refers to pollution transported in the atmosphere from one country or region to another, often undergoing chemical transformation in the process. As a result of the distances travelled, and the chemical changes that occur, it is often difficult to determine which emission source (e.g., sulphur dioxide emissions from a factory), in which location, has led to a specific impact in another location (e.g., increased acidity in a lake) (National Atmospheric Emissions Inventory, 2022).

This chapter will focus on two main pollutants of concern: particulate matter and nitrogen dioxide. An overview of the main air pollutants is provided in the table below.

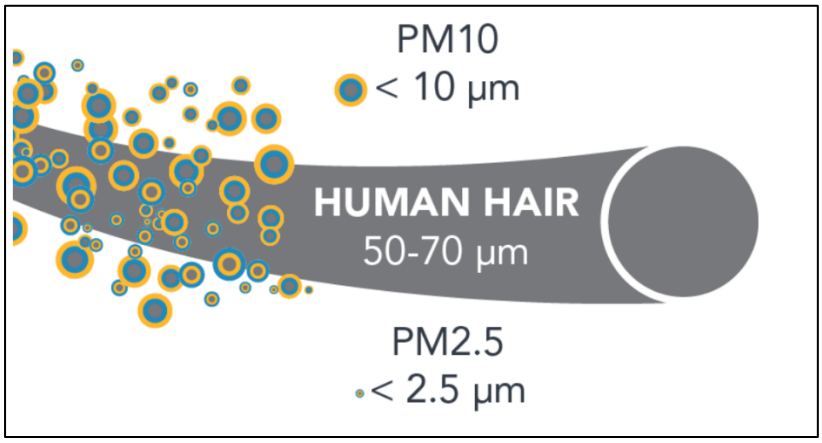
Table 1: Overview of main air pollutants

Pollutant	Components and sources
Particulate matter (PM)	A mixture of substances usually derived from human sources. Very fine particles can be breathed into the lungs and can pass into the bloodstream.
Nitrogen dioxide (NO_2) and nitrogen oxides (NO_x)	A mixture of natural and human-made gases that are released into the atmosphere when fumes are burned. Nitrogen dioxide is strongly associated with vehicle emissions, diesel engines, and the burning from power stations.
Sulphur dioxide (SO_2) and sulphur oxides (SO_x)	Along with particulate matter, sulphur dioxide contributes to the formation of winter-time smog. Fuel combustion accounts for the majority of UK SO_2 emissions with the main sources being the combustion of coal, heavy fuel oil and petroleum coke (a solid fuel produced in crude oil refineries).
Ammonia (NH_3)	Emissions in the UK mainly derive from agriculture, with the sector accounting for most total emissions in recent years. Emissions occur due to the use of nitrogen-based fertilisers and from livestock farming, and more than half of the agricultural sector emissions are related to cattle.
Volatile organic compounds (VOCs)	Volatile organic compounds can differ widely in their chemical composition, however the majority display similar behaviour in the atmosphere. VOCs are emitted to air as combustion products, as vapour arising from petrol and solvent use, and from numerous other sources including household and cosmetic products used within the home.

Particulate matter

Particulate matter (PM) refers to particles in the air that are not defined as a gas, and therefore consist of a huge variety of chemical compounds and materials (DEFRA, 2022). Due to the small size of many of the particles that form PM, some of these toxins may enter the bloodstream, lodging in the heart, brain, and other organs. Exposure to PM can result in serious impacts to health, especially in vulnerable groups of people such as the young, elderly, and those with respiratory or cardiovascular health conditions. Particulates are classified according to size. The UK currently focuses on measuring the fractions of PM where particles are less than 10 micrometres in diameter (PM_{10}) and less than 2.5 micrometres in diameter ($PM_{2.5}$) based on the latest evidence on the effects of PM to health (DEFRA, 2022). The size of particles and the duration of exposure are key determinants of potential adverse health effects.

Figure 1: Particulate size comparison



Source: California Air Resources Board

PM_{10} and $PM_{2.5}$ often derive from different emission sources. Human-source origins of PM include agriculture, the combustion of fuels (by vehicles, industry, and domestic properties), and other physical processes such as tyre and brake wear (Grigoratos and Martini, 2014). Contribution to this type of pollution is also generated from garden fires, wood burning stoves and barbeques. Natural sources of PM include windblown soil and dust, pollen, and sea spray particles. Other natural sources are released during extreme environmental events such as forest fires and volcanic eruptions.

PM pollution also occurs indoors and can be generated through cooking, combustion activities such as burning of candles, use of fireplaces, use of unvented space heaters, and cigarette smoking. The levels of particulate matter indoors are dependent on several factors including the outdoor levels, ventilation and filtration within the home, the number of occupants within the property and the activities of those occupants (Whitty et al., 2022). In homes without smoking or other strong particle sources, indoor exposure to particulate matter would be expected to be the same or lower than the exposure of it outdoors.

Nitrogen dioxide and nitrogen oxides

Almost all nitrogen oxides (NO_x) are emitted during the combustion of fuels. Emissions occur from all fuels, although the emission rate does vary from fuel to fuel and from sector to sector. Transport sources, and the energy and manufacturing industries are the most

significant sources of NO_x. In 2020, contributions to UK emissions of NO_x were 28% for road transport, 19% for other forms of transport (including off-road vehicles and mobile machinery), 10% from power stations and other energy producers, and 12% from other industrial sites. Most of the road transport emissions in 2020 were from diesel vehicles (National Atmospheric Emissions Inventory, 2022).

Although nitrogen oxides mainly contribute to outdoor air pollution, it can also be emitted indoors. This mainly occurs through unvented fuel burning appliances such as gas ranges, kerosene space heaters, and water heaters. Poorly maintained central heating boilers and gas fires can also contribute to the production of NO_2 indoors.

Outdoor air quality standards

The UK Clean Air Strategy (2019) sets out the air quality objective limits and target values within which the UK must comply for specific types of air pollutants for the protection of human health. The table below sets out the current UK air quality objectives for PM and nitrogen dioxide. Objectives tend to be expressed in terms of micrograms per cubic metre (µg/m3).

Table 2: National air quality objectives

Pollutant	Applies to	Objective	Concentration measurement	Achievement date
Particulate matter (PM_{10})	UK	40 µg/m3	Annual mean	2004
Particulate matter ($PM_{2.5}$)	UK (except Scotland)	25 µg/m3	Annual mean	2020
Nitrogen dioxide (NO_2)	UK	40 µg/m3	Annual mean	2005

Each year, air quality monitoring local authorities are required to evaluate their pollution levels against these standards to assess long-term trends in air quality management. It is the responsibility of the monitoring authority to address any Air Quality Management Areas (AQMAs) where the standards are exceeded for prolonged periods of time and to develop an action plan for improvement. Over the years, the number of AQMAs across the UK has decreased. This is the result of greener infrastructures, changes in burning regulations, and cleaner vehicles. There are, however, no safe levels of exposure to the main pollutants of concern and any exposure to these can have a detrimental impact on health across the life course.

The World Health Organisation (WHO) are responsible for integrating scientific evidence on the health impact of air pollution as well as monitoring the air quality progress across the world to recommend air quality guidelines. The latest 2021 update of the WHO air quality guidelines have been developed in response to the real and continued threat of air pollution to public health and as such are significantly more stringent than the UK air quality objectives currently outlined in the UK Clean Air Strategy.

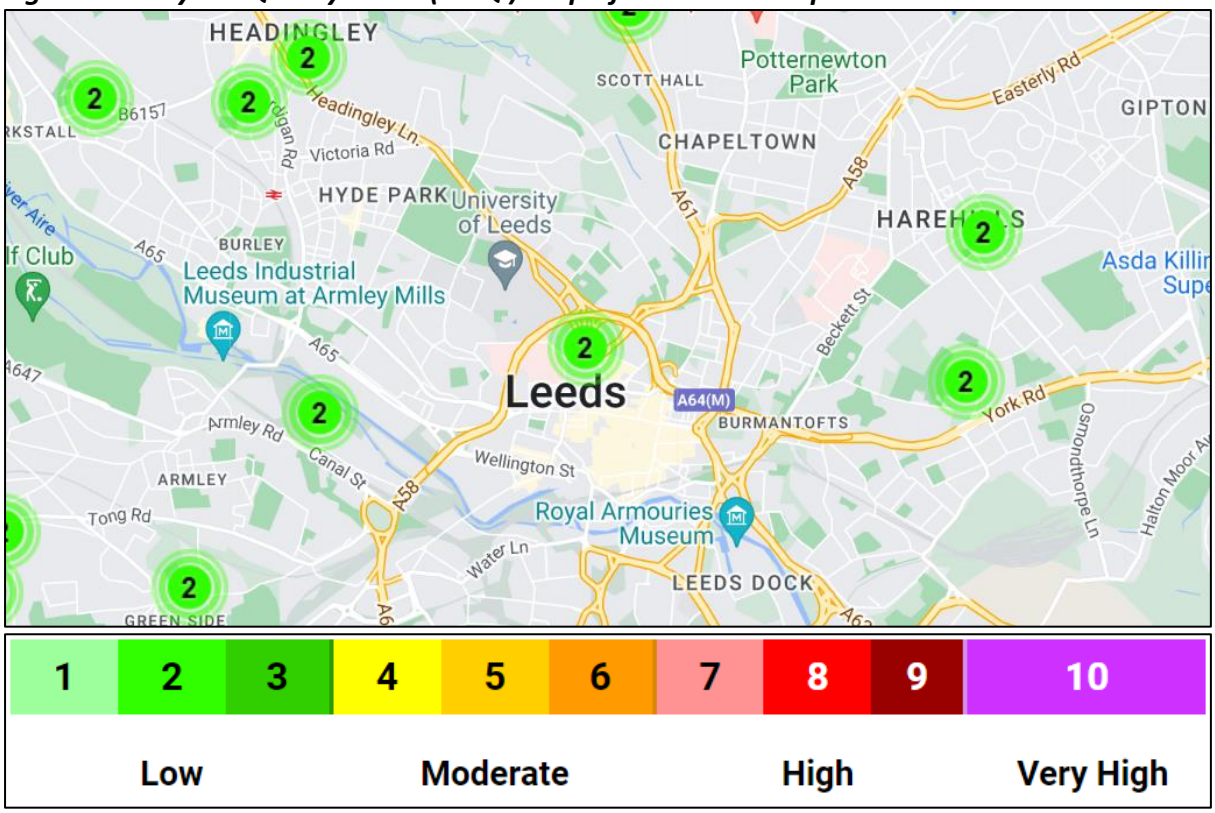
Table 3: Comparison between WHO guidelines and UK standards

Pollutant	WHO guidelines	UK guidelines
Particulate matter (PM_{10})	15 µg/m3	40 µg/m3
Particulate matter ($PM_{2.5}$)	5 µg/m3	25 µg/m3
Nitrogen dioxide (NO_2)	10 µg/m3	40 µg/m3

Monitoring and measuring air quality

The Environment Agency manage national monitoring sites on behalf of DEFRA. There are approximately 300 managed monitoring sites in total across the UK. The Automatic Urban and Rural Network (AURN) monitors concentrations of the five most prominent pollutants (nitrogen dioxide, sulphur dioxide, ozone, $PM_{2.5}$ and PM_{10}). The AURN monitors data hourly, in near real-time to the UK Air database. Once this data is received, it is analysed against the UK air quality standards, and an air pollution score is provided using a scale known as the Daily Air Quality Index (DAQI). This is a simple index recommended by COMEAP to provide an overall pollution score from 1-10, with 1 being low levels of pollution and 10 being very high levels of pollution. The overall air pollution index for a site or region is determined by the highest concentration of the five measured pollutants.

Figure 2: Daily Air Quality Index (DAQI) map of Leeds and air pollution scale



Source: UK AIR/ DEFRA

DEFRA apply the DAQI to five-day air quality forecast that informs the public of short-term levels of outdoor air pollution and their potential health effects. Health advice is provided to support each DAQI score to support the general population and those considered more at risk of the impact of poor air quality.

Figure 3: Health advice provided on the DAQI air pollution forecast

Air Pollution Banding	Value	Accompanying health messages for at-risk individuals*	Accompanying health messages for the general population
Low	1-3	**Enjoy** your usual outdoor activities.	**Enjoy** your usual outdoor activities.
Moderate	4-6	Adults and children with lung problems, and adults with heart problems, **who experience symptoms**, should **consider reducing** strenuous physical activity, particularly outdoors.	**Enjoy** your usual outdoor activities.
High	7-9	Adults and children with lung problems, and adults with heart problems, should **reduce** strenuous physical exertion, particularly outdoors, and particularly if they experience symptoms. People with asthma may find they need to use their reliever inhaler more often. Older people should also **reduce** physical exertion.	Anyone experiencing discomfort such as sore eyes, cough or sore throat should **consider reducing** activity, particularly outdoors.
Very High	10	Adults and children with lung problems, adults with heart problems, and older people, should **avoid** strenuous physical activity. People with asthma may find they need to use their reliever inhaler more often.	**Reduce** physical exertion, particularly outdoors, especially if you experience symptoms such as cough or sore throat.

Source: UK AIR/ DEFRA

Indoor air quality

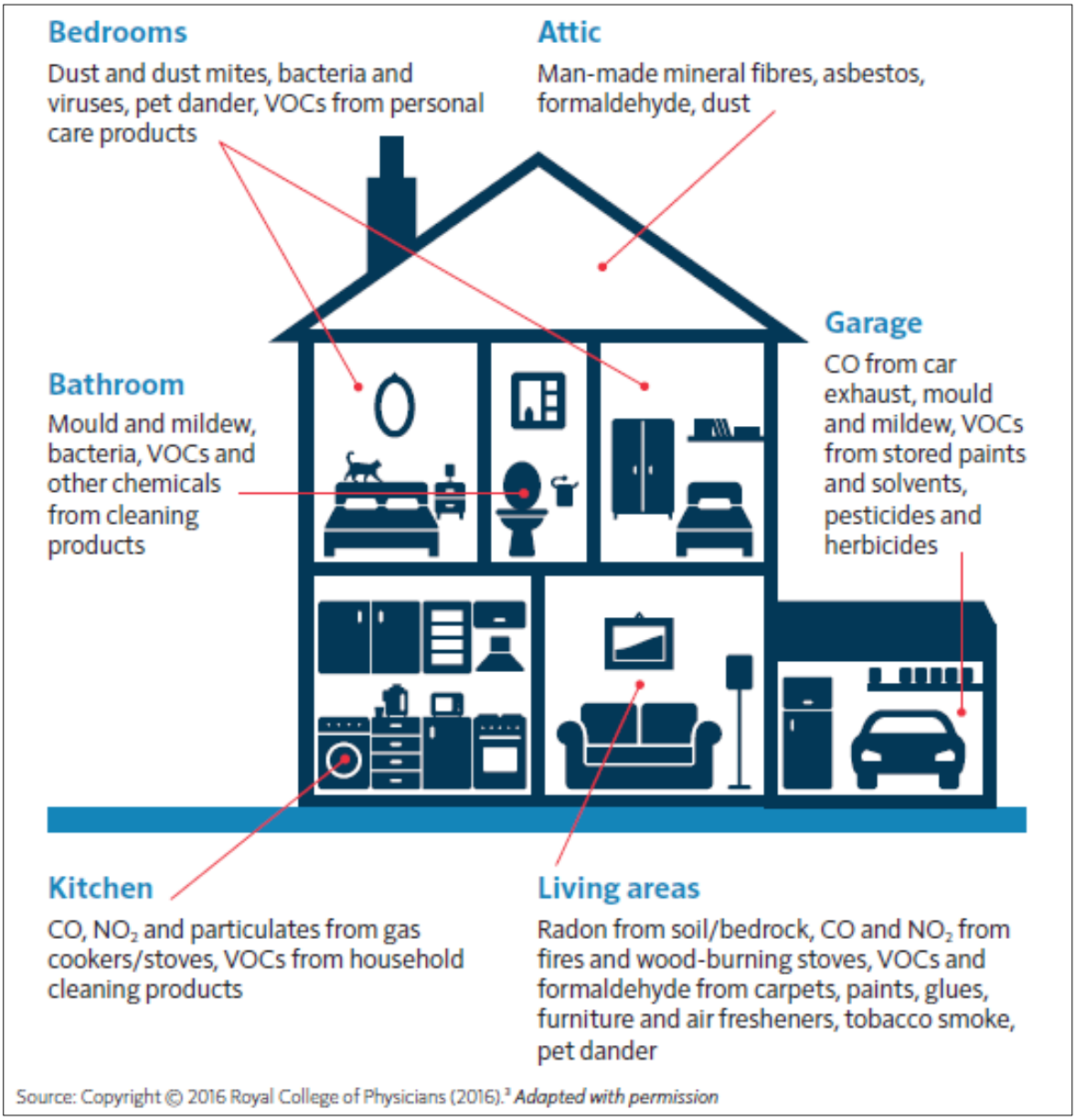
Exposure to indoor air quality is an increasingly significant public health concern. Over 80% of a typical adult day is spent indoors, making indoor air an area where greater monitoring, understanding, and action is required (Whitty et al., 2022). The routine use of cookers, heaters, stoves, and open fires release pollutants into the home. Burning wood and coal in a stove or on an open fire releases PM into the atmosphere both indoors and outdoors. Pollutants from burning wood on stoves and open fires creates a higher percentage of emissions than road traffic emissions (Whitty et al., 2022). Heating and cooking with gas releases particles of NO_2 and carbon monoxide (CO) into the air. CO is the most dangerous indoor air pollutant and is created when fuels such as gas, oil, coal, or wood do not fully burn.

Damp conditions can lead to condensation indoors, which encourages mould and other fungi to grow. Condensation is more likely to occur when homes are not adequately heated, insulated, or ventilated. Smoke and vapour, from tobacco products or burning incense and candles, also contribute to poor air quality indoors.

Products used to clean and decorate indoor spaces sometimes contain chemicals known as volatile organic compounds (VOCs). VOCs are common across the household and in workplaces and are found in cleaning products, air fresheners, paints, varnishes, and glues. These products, particularly those in aerosol form, can cause irritation and may increase the risk of developing an allergy or asthma (Asthma and Lung UK, 2023). VOCs are also present in personal care products, such as deodorants and perfumes.

Certain areas of the UK have high levels of radon, a natural radioactive gas that is found in rocks and soil in granite areas. Although the radon level in the air outside is low, it can be higher inside poorly ventilated buildings.

Figure 4: Sources of indoor air pollution in the home



Source: Royal College of Physicians (2016)

Air quality in Leeds

Monitoring and measuring outdoor air quality in Leeds

Pollution levels vary and can change on an hour-by-hour and street-by-street basis. When measured at different times of the day, air pollution levels can change significantly. Leeds City Council adhere to the national methodology for monitoring air pollution, which takes into account this variability. Measuring and assessing air quality is therefore based on yearly, daily, and hourly average levels of pollution.

Measuring the average pollution levels across an entire year provides an understanding of the typical levels of air pollution a person at a specific location would have been exposed to over a long-term period, as well as the ability to factor in any seasonal variations such as changes in the weather. Measuring the average pollution levels within a shorter timeframe, for example within any 24-hour or 1-hour period can demonstrate the day-to-day variations in air quality as well as the maximum levels of air pollutant a person at a specific location could have been exposed to over a short-term period.

Leeds City Council monitor a sample of locations where there are expected higher levels of pollution; this helps to provide a better understanding of the highest levels of pollution that the population are likely to be exposed to. However, caution should be taken when interpreting and using this data for modelling.

The Leeds City Council and DEFRA monitoring network for 2021 included:

- 9 automatic nitrogen dioxide (NO_2) monitors which allow the hourly average air quality objective to be assessed as well as the yearly average air quality objective
- 2 automatic particulate matter (PM) monitors which allow the 24-hour average and yearly average air quality objectives to be assessed
- 217 manual diffusion tubes which provide a monthly and yearly average concentration for NO_2

The changing picture for outdoor air quality in Leeds

Air quality in Leeds has improved significantly in recent years, continuing a long-term trend. This trend accelerated due to the Covid-19 pandemic in 2020, where the city experienced significant reductions in vehicle emissions and industrial activity and therefore reduced levels of nitrogen dioxide pollutants.

By 2021, most of the disruption from the pandemic had eased. Despite the return to more typical behaviours, pollution levels measured in Leeds remain notably lower than in 2019 or earlier years. This suggests that the long-term trend of improving air quality continues.

There are two pollutants of concern for Leeds:

- Nitrogen dioxide (NO_2) of which the main source is vehicle emissions and the burning of other fossil fuels.
- Particulate matter (PM_{10} and $PM_{2.5}$) of which a third of is from sources outside of the UK and a half comes from domestic wood burning or transport emissions.

Figure 5: Map showing all 9 automatic nitrogen dioxide monitors in Leeds

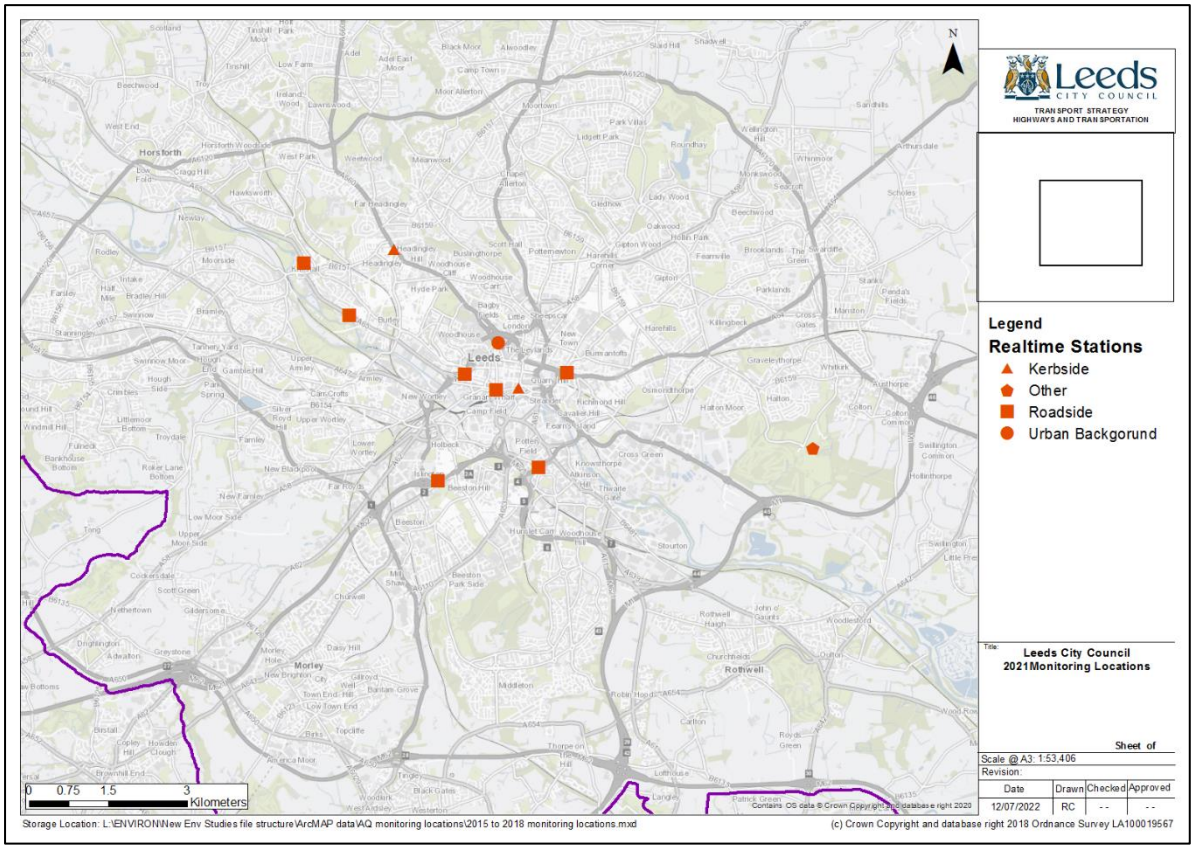
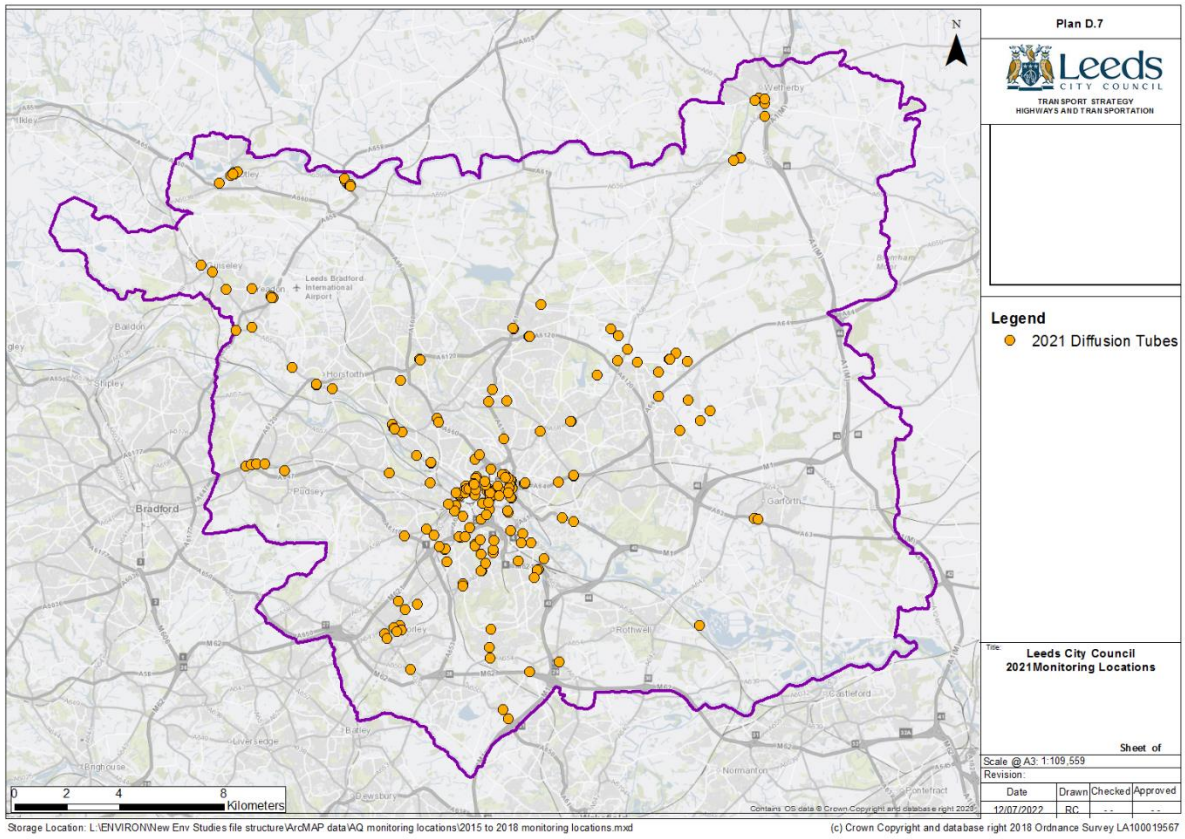


Figure 6: Map showing all 217 manual diffusion tube locations

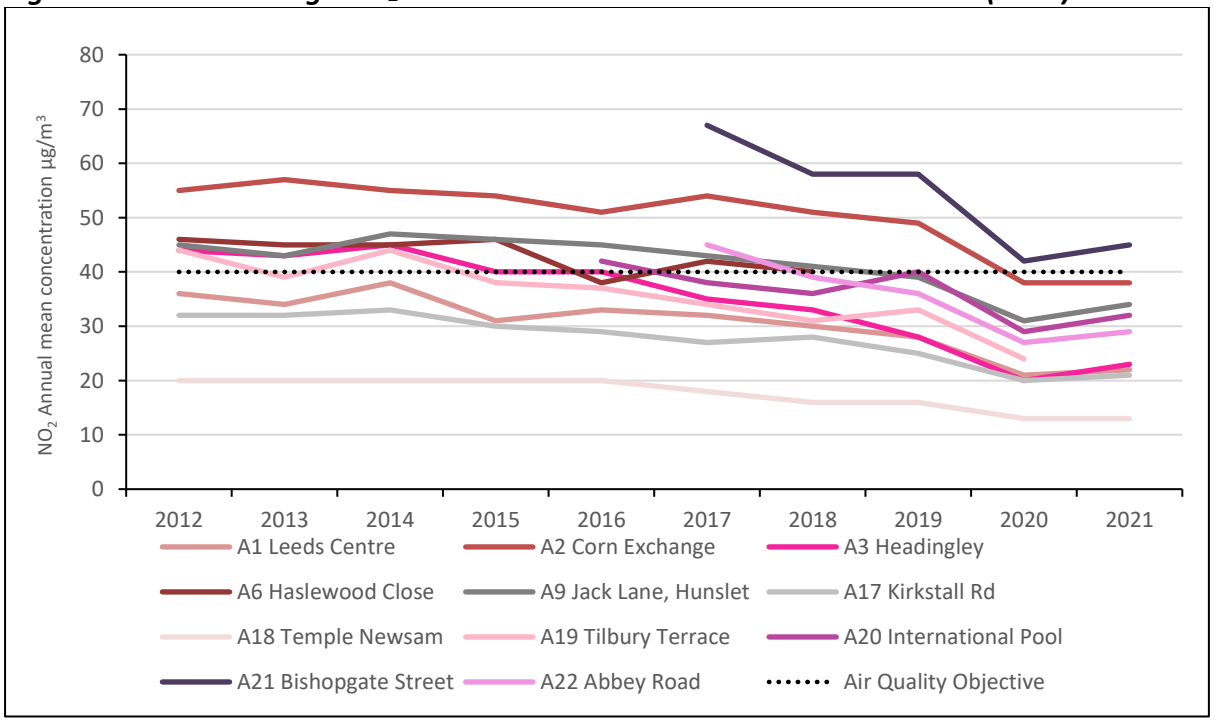


Air quality management areas (AQMAs)

Each local authority in the UK provides an assessment of air quality in their area. If a local authority finds monitoring in an area where the national objectives are not likely to be achieved, it must declare an air quality management area (AQMA). AQMAs are reported on each year in an Annual Status Report (ASR), which is compiled annually by the Council and is approved by the Director of Public Health before it is submitted centrally to DEFRA.

Leeds City Council has previously declared six AQMAs within the district due to exceedance of NO_2 objectives, however more recent monitoring shows that air quality is consistently improving within each of these areas. In 2021, all six AQMAs were measured with pollution levels within the UK objectives. With the exception of the the Pool-in-Wharfedale AQMA, each of these AQMAs have now been compliant for a number of years. The Council will begin the process of formally revoking all but the Pool-in-Wharfdale AQMA in 2023. The Pool-in-Wharfdale AQMA will continue to be kept under review to ensure the area permanently complies with the air quality objectives.

Figure 7: Annual average NO_2 concentrations at several locations in Leeds (2021)

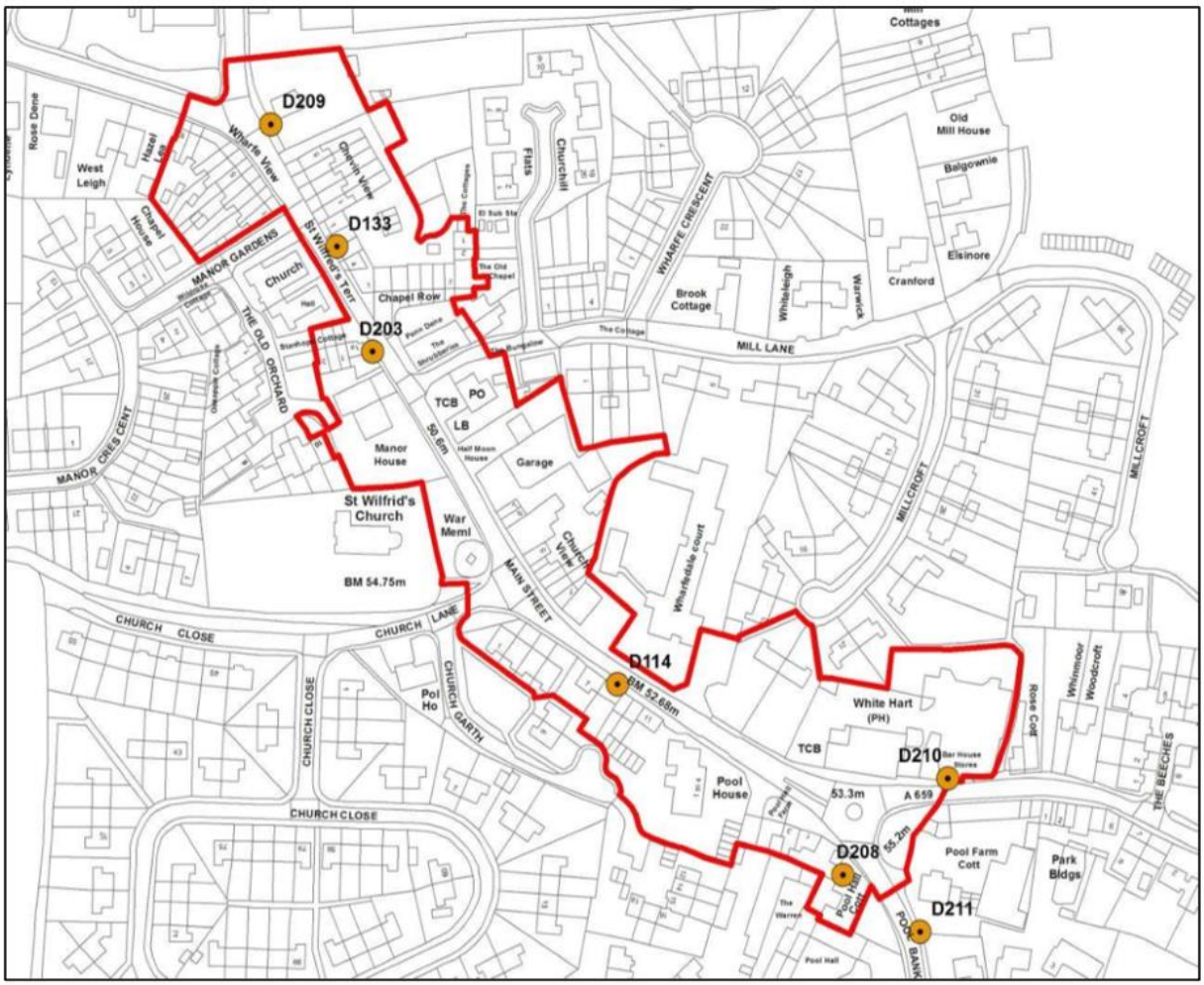


Source: Environmental Health (Leeds City Council) Annual Status Report (2023)

The UK Air Quality Objective sets a limit of 40µg/m^3 on the level of nitrogen dioxide that should be measured at each location and averaged over a one-year period. Outdoor air pollution in the city, its suburbs and surrounding rural areas complied with the UK Air Quality Regulations for nitrogen dioxide in 2021 with one exception. One monitor near Kirkstall Road measured annual mean NO_2 levels higher (42.3µg/m^3) than permitted.

The UK Air Quality Objective sets a limit of 40µg/m^3 for PM_{10} and 20 µg/m^3 for $PM_{2.5}$ on the level of particulates that should be measured at each location and averaged over a one-year period. Outdoor air pollution in the city, its suburbs and surrounding rural areas complied with the UK Air Quality Regulations for nitrogen dioxide in 2021.

Figure 8: Pool-in-Wharfdale Air Quality Management Area (AQMA)



Source: Environmental Health (Leeds City Council) Annual Status Report (2023)

Although the UK standards are largely met there are on average three short term air pollution episodes in Leeds annually where the UK objectives are exceeded and air pollution in Leeds measures as high or very high on the Defra Air Quality Indicator (DAQI). These episodes of air pollution can last from hours to several days and are often caused by a combination of increased man-made pollution coinciding with environmental factors such as natural disasters (such as sandstorms and wildfires) that happen outside of the UK.

Table 4: Leeds air quality measures at Headingley Kerbside AURN site compared to national UK objectives and local targets

Type of pollutant	UK objective	Air pollution measured at Headingley (annual)					Leeds annual target
		2012	**2014**	**2016**	**2018**	**2020**	**2030**
NO_2	**40 µg/m3**	44	45	40	33	20	40
PM_{10}	**40 µg/m3**	22	23	19	18	18	20
$PM_{2.5}$	**25 µg/m3**	17	14	11	11	9	10

Although the decrease in measured pollutants in Leeds suggest a positive image of the local work that has been undertaken over several years to improve the air quality across the city, it is important to remember that that there are no safe levels of the main pollutants of concern and any short- and long-term exposure to air pollution can have an impact on health. Risk factors, including location of houses and workplaces, or long-term health conditions, can impact on short term and long-term health.

Chapter 3: The strategic context

National strategy and policy

The national Clean Air Strategy was published in 2019 and set out action required across all parts of government and society to tackle all sources of air pollution. The legislation outlined in the strategy aims to create a stronger and more coherent framework for action to tackle air pollution, underpinned by England-wide powers to control the major sources of air pollution.

Chapter 2 of the strategy, *Protecting the nation's health*, draws attention to the health impact of poor air quality both by short-term, high-pollution episodes and by long-term exposure to lower levels of pollution. A key focus of this chapter is a commitment to progressively reducing public exposure to particulate matter pollution, as recommended by the World Health Organisation (WHO). The strategy aims to reduce $PM_{2.5}$ concentrations across the UK, so that the number of people living in locations above the WHO guideline level of 10 µg/m3 is reduced by 50% by 2025.

The national strategic focus on health and air pollution includes:

- A reduction in $PM_{2.5}$ concentrations across the UK alongside examining what action would be needed to meet the WHO annual mean guidelines.
- Providing an air quality messaging system to inform the public, particularly those who are vulnerable to air pollution, about the air quality forecast as well as clear information on air pollution episodes and health advice.
- Targeting local action in areas where poor air quality has been identified.
- Improving access to air quality forecasts via media outlets.
- Supporting work to help individuals and organisations understand how they could reduce their contribution to air pollution to protect themselves and others.
- Publishing appraisal tools and accompanying guidance to enable the health impacts of air pollution to be considered in every relevant policy decision that is made.
- Equipping health professionals to play a stronger role in considering air pollution by working with medical colleges and the General Medical Council to embed air quality into the health professions' education and training.

It is apparent that much of the strategic impetus at a national and local level on air pollution and health was paused due to the urgent demands of the global Covid-19 pandemic. The Environment, Food and Rural Affairs Committee published a report (2021) to government outlining the importance of ensuring future efforts to improve air quality take account of lessons learned during the pandemic. This included the need to consider health inequalities and the disproportional impact of poor air quality on communities experiencing the highest levels of social deprivation. It is likely that these same communities will be among the most vulnerable to the effects of other systemic and increasingly extreme environmental and climate-related events (for example, flooding and prolonged heatwave episodes) with climate change having the potential to further exacerbate existing health inequalities in the UK (Marmot et al., 2020).

More recently, the Chief Medical Officer's Annual Report (2022) called for a renewed commitment to reducing air pollution through improvements in engineering for transport and industry, modifications to agricultural practice, and improvements in the built environment to improve the health of the population. The report also draws upon the link between reducing air pollution and carbon emissions through limiting the use of fossil fuels for energy on a large scale, as well as the co-benefits between active travel and health. Furthermore, place plays a central role in this report: the places where people live, work and study, and where most people spend the majority of their time. Indoor air pollution is becoming an increasing proportion of the burden of air pollution in general, particularly as improvements in outdoor air pollution occur. Since many indoor spaces are public, including health facilities, schools, care homes and early years settings, as well as the retail and workplace sectors, there is a call from this report to better understand how to prevent and reduce harmful indoor air pollution.

The recently published Environmental Improvement Plan (DEFRA, 2023a) outlines Government's overarching strategy for environmental policy. For air quality, the plan is supplemented by a framework outlining the role of local authorities and the requirement for Government to assess local performance and monitoring, audit existing powers, while issuing guidance, tools, and greater funding opportunities (2023b). Other policy areas include a commitment to review and improve how Government communicates air quality information.

Local strategy and policy

The Leeds Air Quality Strategy 2021 – 2030 outlines a set of local ambitions and actions with ownership from across Leeds City Council that align to the national Clean Air Strategy. The strategy covers transport, industry, agriculture, and health.

Key elements of the strategy include:

- Making local transport cleaner by supporting the transition to zero emission vehicles and improving bus travel and local networks.
- Promoting pollution-free and active ways to travel to reap the co-benefits for improved health.
- Reducing emissions from homes and raising awareness of indoor pollution.
- Better understanding the agricultural sources of emissions so these can be reduced through local engagement, regulations, and enforcement.
- Working closely with health and care sector to ensure that the most vulnerable residents understand how to protect themselves from air pollution.

Connected to the Leeds Air Quality Strategy is the Leeds Best City Ambition, which sets out the vision of Leeds improving outcomes across three key pillars: health and wellbeing, inclusive growth, and becoming a net-zero carbon city by 2030. The Leeds Air Pollution and Health Group, accountable to the Leeds Health and Wellbeing Board, is responsible for owning and progressing the public health-related actions of the Leeds Air Quality Strategy, with a focus on mitigating the health impact of pollution on those most vulnerable.

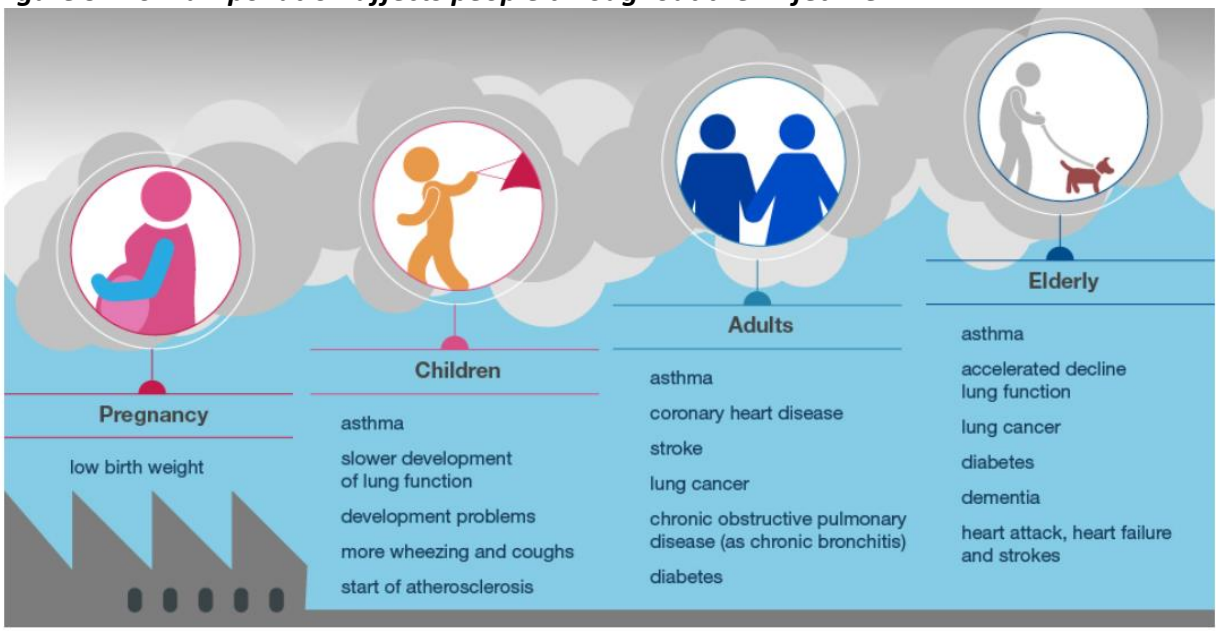
Chapter 4: The health impact of poor air quality

Long-term exposure to outdoor air pollution

Poor air quality can affect health at all stages of the life course, from preconception and childhood through to adulthood and long-term illness. The health effects of air pollution are complex and can range in severity and impact. In some cases, the damage to health caused by exposure to poor air is gradual and may not become apparent for many years (COMEAP, 2010).

Exposure to air pollution can affect health from conception as pregnancy is a critical time for the formation of body systems. In the womb, maternal exposure to air pollution can result in low birth weight, premature births, organ damage or stillbirth (COMEAP, 2010; Johnson et al., 2021). For children, there is evidence that exposure to air pollution can have a long-lasting effect on lung function growth, resulting in the emergence of breathing difficulties and asthma (Gonzales and Whalen, 2022; Vrijheid et al., 2016), while in adulthood it can be a causal factor in the development of conditions such as diabetes, heart disease and stroke (Bazyar et al., 2019). In children, long-term exposure to $PM_{2.5}$ has been shown to be associated with effects on lung development and asthma in children, whereas in the adult population it is associated with an acceleration of lung function decline and respiratory mortality. Furthermore, there is good evidence of an association between long-term exposure to $PM_{2.5}$ and cardiovascular mortality (Whitty et al., 2022). The understanding of the link between air pollution and heat, and the impact on population health, is emerging. Initial studies indicate that exposure to air pollution during high temperatures is likely to increase the odds of respiratory mortality and hospital admissions (Ariel et al., 2022).

Figure 9: How air pollution affects people throughout their lifetime



Source: Public Health England

Emerging evidence suggests that as well as affecting the respiratory and cardiovascular systems, exposure to poor air quality can also affect the brain with possible links to the development of dementia, cognitive decline, serious mental illness and common mental health problems (Menculini et al., 2021; Braithewaite et al., 2019). The Lancet Commission into dementia prevention, intervention, and care (2020) has included poor air quality as a new modifiable risk for dementia. The report authors suggest that reducing exposure to air pollution and tobacco smoke, as well as other contributing factors, could delay or prevent 40% of dementia cases (Livingston et al, 2020).

There is strong epidemiological evidence of the link between long-term exposure to $PM_{2.5}$ and mortality; this is causally associated with specific causes of mortality from cardiovascular and respiratory disease and from lung cancer. The fraction of mortality attributable to long-term exposure to $PM_{2.5}$ in England is 5.6% but this varies across different parts of the country (Whitty et al., 2022). This figure is broadly reflective at a local level: in Leeds, approximately 5.4% of deaths can be attributed to exposure to $PM_{2.5}$ (Fingertips, 2021). Emerging evidence suggests that some components and/ or sources of particulate air pollution are more detrimental to health than others. Ultrafine particles, diesel particles, and black carbon particles are more likely to pose a greater risk as they can be drawn deeper into the lungs, blood stream, and other organs (Whitty et al., 2022).

The long-term impact of air pollution therefore presents a complex challenge for public health across the life-course. Managing and preventing both the short- and long-term impacts of air pollution are likely to require distinct approaches as a result. Reducing the impact of long-term exposure to air pollution is likely to involve system-wide, collaborative efforts to reduce exposure, through decreasing the levels of air pollution overall.

Short-term exposure to outdoor air pollution

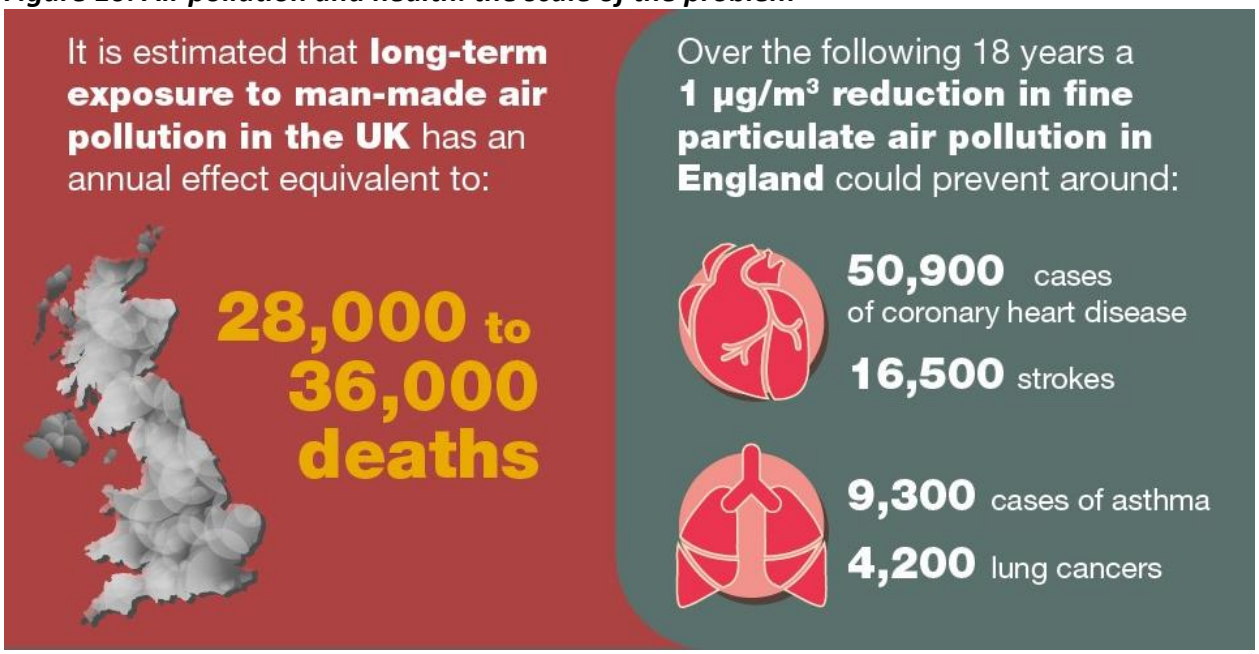
Exposure to both particulate matter and NO_2 are found to increase the burden on population health. There is a strong evidence base from epidemiological studies to demonstrate that short-term exposure to $PM_{2.5}$ is associated with cardiovascular, respiratory, and cerebrovascular mortality as well as increased hospital admissions for respiratory conditions, particularly due to the exacerbations of asthma and chronic obstructive pulmonary disease (COPD) and respiratory-related diseases (Whitty et al., 2022; Dominski et al., 2021; Manisalidis et al., 2020).

Furthermore, a recent review for WHO (2021) found a high level of confidence in the evidence of a positive association with short-term exposure (using a 24-hour average) to NO_2 and all-cause mortality, and a moderate strength of evidence associated with 1-hour average exposures.

During short-term episodes of high pollution, some people may experience new or worse symptoms, particularly those who are at higher risk. Adults and children with lung or heart conditions are more likely to become ill and need additional treatment when pollution outdoors is at a higher than usual level. For example, adults and children with asthma may notice that they need to increase their use of inhaled reliever medication on these days. Older people are also considered at a higher risk due to higher levels of heart and lung

conditions within this population. For the general population, when the air pollution outdoors is very high, some people will experience a sore or dry throat, sore eyes, and a cough. It is possible that some individuals may experience health effects even on days where air pollution is considered by the DAQI to be low. The impact of short-term episodes therefore requires a focus on populations at higher risk to these effects and mitigating the impact of these shorter spikes in air pollution levels.

Figure 10: Air pollution and health: the scale of the problem



Source: Public Health England

Exposure to indoor air pollution

It is widely accepted that the public health burden due to air pollution is likely to be even higher than published estimates, as these do not consider all outdoor air pollutants and they do not include the impact of short-term and long-term exposure to indoor air pollution. As outdoor air pollution improves, the burden of the effects of indoor air pollution will become an increasingly significant public health issue, particularly as most of the population spends most of their time indoors (Adams et al., 2021). Approximately 44% of personal exposure to $PM_{2.5}$ is the result of outdoor sources, and 74% of exposure to NO_2 derives from outdoor sources (Whitty et al., 2022).

In general, there is less information available about the typical indoor exposure to pollutants and the quantified health effects. The evidence of the health impacts of outdoor air pollution has been established over many years through extensive measurement of outdoor air pollution across multiple locations worldwide, with significant work undertaken to correlate measurements to population data on mortality and morbidity. The same data does not exist for buildings and indoor spaces; however, it is well recognised that exposure to pollutants indoors substantially impacts on health. Studies suggest that those with pre-existing respiratory or cardiovascular conditions or allergies are particularly affected by poor indoor air quality (Lee et al., 2020).

Health inequalities

Air pollution does not affect everyone equally. Specific population groups have a physiological susceptibility to the health impacts of air pollution, particularly those at the extremes of the life course and those with a wide range of underlying health conditions, such as respiratory and cardiovascular diseases. Exposure to poor air is also likely to be greater depending on where someone lives, works, or studies due to their proximity to high concentrations of air pollution. Physiological susceptibility and a higher risk of exposure are therefore factors that can overlap.

Areas of high deprivation are more likely to have higher levels of traffic or industrial activities; these more polluted areas are often more affordable to live in. In England, the most deprived 20% of neighbourhoods has higher levels of outdoor air pollution than the least deprived neighbourhoods, after adjusting for other factors (Whitty et al., 2022; Deguen et al., 2022). People in lower socio-economic groups are more likely to live and work in areas of deprivation, as well as be more likely to have pre-existing health conditions earlier in life. Higher exposures to air pollution may increase the greater burden of poor health on these communities.

Across the country, the highest levels of outdoor air pollution are present in neighbourhoods that are more ethnically and culturally diverse (defined as those where more than 20% of the population were not white). A recent analysis by the Office for National Statistics (2020) found a positive association between increased long-term $PM_{2.5}$ concentrations and communities with ethnically and culturally diverse populations. This is likely to be because these communities are over-represented nationally in areas of deprivation.

When taking into consideration indoor air quality, there is evidence that domestic air quality is related to social inequalities. People living in the most deprived areas, particularly in rented properties, are more likely to live in homes that are overcrowded with lower energy efficiency, inadequate heating and ventilation, with poor maintenance (Asthma and Lung UK, 2023).

Chapter 5: Populations in Leeds most at-risk of the health impact of air pollution

Introduction

As set out in Chapter 4, there is a strong evidence base to indicate the various ways in which air pollution interacts with the social and health environments to impact on health across the life course (see Figure 9). From pregnancy and the neonatal period to the development of children, right through adults and the older age population experiencing co-morbidities, there are significant health concerns for the population of Leeds in relation to the impact of indoor and outdoor air pollution.

This chapter presents data on air quality and heath, to help better understand and identify the populations at higher risk from the health impacts of short and long-term exposure to poor air quality. It is not possible from the data presented in this chapter to draw conclusions about associations between disease prevalence and levels of air pollution at a local level. Because air pollution is likely to be one factor among many interconnected factors at play in the contribution to and the worsening of disease and symptoms of disease, it is difficult to separate, particularly at a very local level, the impact specifically of poor air quality on a range of different health conditions. It is possible, however, from this data to build a picture of populations in the city who are most at risk of the short- and long-term health impacts of air pollution. Gaining a stronger understanding of these geographies, populations, and groups, will enable the development of a targeted approach to addressing and mitigating the health impact of poor air quality.

This chapter also presents findings from a citywide survey on air pollution and health, which helps to provide a level of local and community intelligence, which, alongside the data, provides some insight into perceptions, views, and opinions.

Pregnancy and children

There are approximately 10,000 births per year in Leeds, with one third attributed to women residing in the most deprived areas in Leeds (Goldsborough, 2020). There has been an increase in the proportion of births to women from culturally and ethnically diverse backgrounds since 2009, with these groups overrepresented in areas of highest deprivation.

There has also been an increase in births to non-British born mothers. The under 18 conception rate is rising in Leeds and is higher than national and regional rates: the majority of births being to mothers in in areas of highest deprivation in the city.

A recently published HNA on children and families in Leeds (Badger, 2022) provides an overview of the children and young people population in the city:

- There are 194,280 children and young people aged 0-19 years in Leeds. 33% of Leeds school-aged pupils (the equivalent of 43,210 children) live in the 10% most deprived areas nationally, which contain 24% of the lower super output areas (LSOAs) in Leeds.
- 4.5% of children under the age of 18 have at least one long-term health condition.

- There is a significant minority population of children and young people who are from culturally and ethnically diverse backgrounds (30% of children in Leeds).

Long-term conditions

This section presents a summary of local data on air quality and heath, to help better understand and identify the populations at higher risk from the health impacts of short and long-term exposure to poor air quality. Data for long-term conditions asthma, chronic obstructive pulmonary disease (COPD), stroke, and coronary heart disease (CHD) are presented, looking at demographics and geography using GP patient register audit data (2021/22). These have been identified within the evidence and literature as key long term-conditions that increase the health risks during and following exposure to air pollution. Data on vulnerability and risk, including deprivation, are also presented.

GP patient audit data is limited and is only representative of those patients registered to GP practices. It therefore does not include those populations who do not access primary care (such as inclusion health groups and underserved populations). The data is also limited in terms of including practice registered patients rather than all residents within a given geographical footprint. Furthermore, due to the Covid-19 pandemic, there are caveats in the data such as possible pauses in data collection, delays in diagnosis, and the impact the coronavirus had on the health of the population. Where possible, data is presented on a Primary Care Network (PCN) or Lower Super Output Area (LSOA) geographical footprint.

Asthma

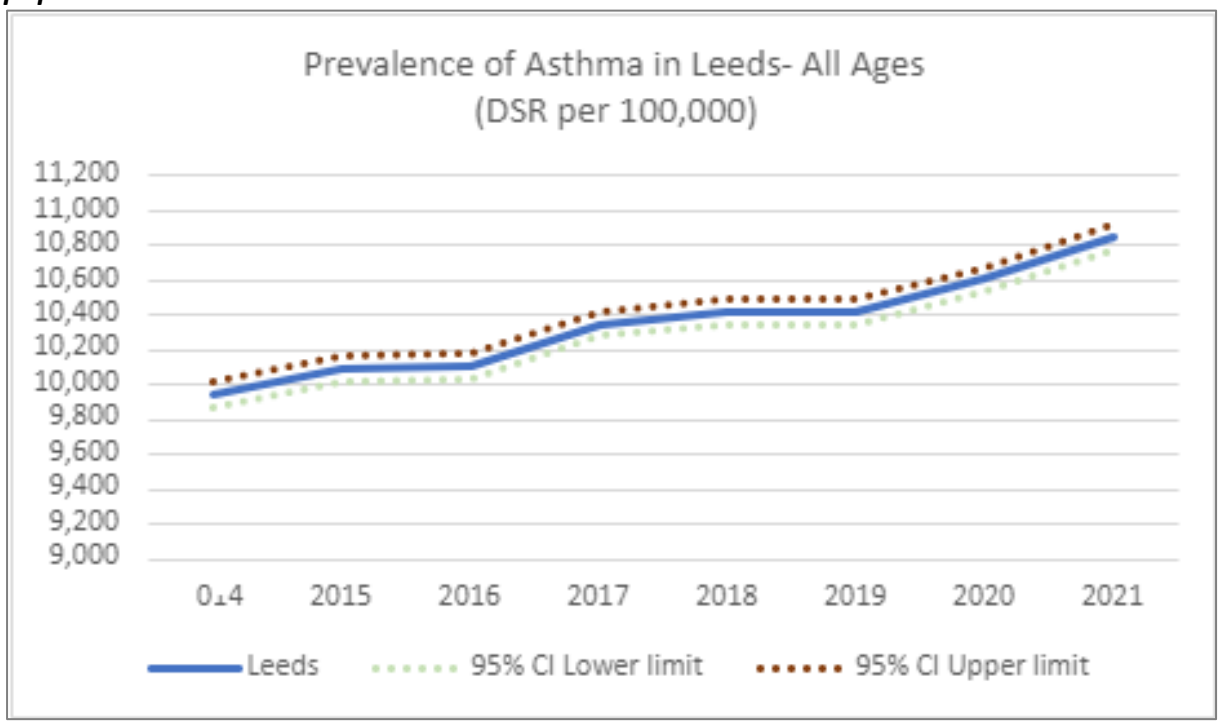
Common asthma triggers include allergies, smoke, pollution, cold air, and respiratory infections such as influenza. Asthma symptoms can therefore be exacerbated by poor air quality as pollutant particles can enter the lungs. Nationally, increased air pollution is associated with higher rates of admission for children living with asthma (Asthma and Lung UK, 2023). The UK has the highest rates of children living with lung conditions.

Prevalence of asthma in Leeds has increased significantly across the years 2020 and 2021 (Figure 11). GP register data for the year 2021-2022 provides a relatively current picture of the asthma prevalence in Leeds. 96,196 people have asthma listed on their healthcare records across the city. Prevalence of asthma in this year was highest in the 30–39-year group, with a higher proportion of men affected compared to women. This was closely followed by the 20-29 age group, where again there were a higher proportion of men compared to women. It is currently unclear what impact the Covid-19 pandemic has had on these figures. It is also important to note that prevalence is likely to be a cumulative figure, due to the GP patient register audit dataset used.

Rates of asthma are highest in areas of deprivation, with the most deprived 10% of the Leeds population having consistently higher levels of asthma prevalence than other deciles. In 2021-2022, 22,224 people with asthma listed on their healthcare records were from the 10% most deprived areas of Leeds, with 6,313 people in the 10% least deprived areas of the city having this diagnosis. Those of Asian ethnicity have had the highest rate of asthma each consecutive year since 2013. There is little difference in male and female prevalence within this ethnicity group.

Out of the 22,224 diagnosed asthma cases in the top 10% most deprived areas of the city, Burmantofts, Harehills and Richmond PCN has the largest proportion of patients diagnosed with asthma: 4308 (19%) of asthma cases are from this PCN. The 5 PCN areas with the highest numbers of registered patients with an asthma diagnosis are shown in Table 5.

Figure 11: Prevalence of asthma in Leeds (all ages): Direct standardised rate per 100,000 population



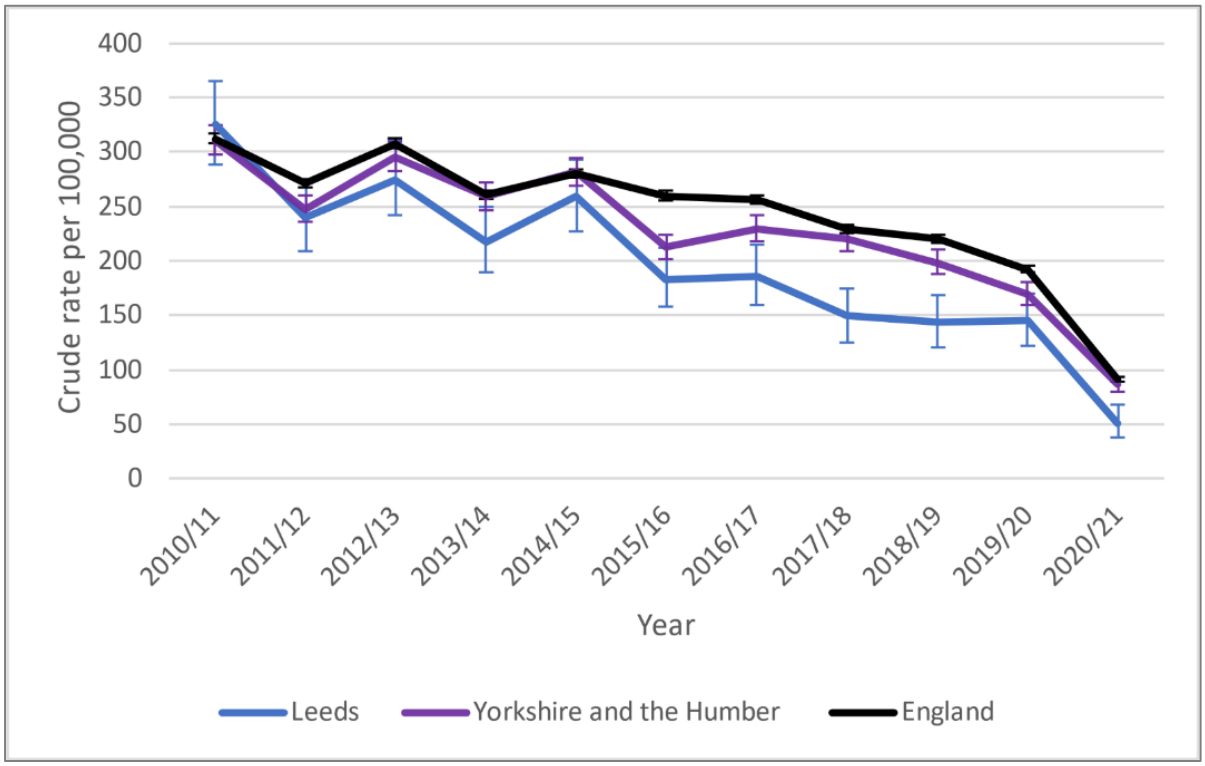
Looking more closely at Burmantofts and Richmond Hill, in 2021–2022 83.5% of those diagnosed were from deprived areas within the PCN footprint with 16.5% not being from deprived areas. The age group most effected was the 20-29 age group (1,102) followed by patients aged 30-39 (922). In line with Leeds average data, men were more represented in this population than women, and those of Asian background were twice as likely to be diagnosed as other ethnicities. It is important to note that the demographic makeup of this PCN has a younger population compared to the rest of the city, with more young men than the average PCN footprint. Furthermore, almost two thirds of the population are recorded as from an ethnically or culturally diverse background, which is approximately twice the Leeds rate.

Table 5: Registered patients with asthma per PCN

PCN area 21/22	**No. registered with asthma**	**% of total cases**
Burmantofts and Richmond Hill	4308	19%
Seacroft	3324	15%
Middleton and Hunslet	2496	11%
Beeston	2022	9%
York Road	1946	8%

Hospital admissions for asthma have steadily declined since 2010-2011 (Figure 12). Recent data shows Leeds at 50.3 admissions per 100,000, which is significantly lower than the rate for Yorkshire and the Humber (86.6 per 100,000) and England (91.2 per 100,000). Burmantofts and Richmond Hill PCN compares significantly higher when compared to the Leeds average with 103.5 per 100,000 admissions. Hospital admissions data is helpful to observe alongside prevalence, as this data can demonstrate the severity of symptoms across the population.

Figure 12: Hospital admissions for asthma per 100,000: Crude rate per 100,000 population



Chronic obstructive pulmonary disease

Chronic obstructive pulmonary disease (COPD) is the name for a group of lung conditions that cause breathing difficulties. It includes emphysema (damage to the air sacs in the lungs) and chronic bronchitis (long-term inflammation of the airways).

17,775 COPD diagnosis were recorded on health care records in 2020-2021, with 33.1% of those diagnosed being in the 70-79 age group. COPD is consistently more observed in this age group with males and females almost equally affected. The proportion of people with COPD is higher in the most deprived areas compared to the least deprived areas. Within the prevalence of COPD across the city, there is a higher proportion of COPD found in the 10% most deprived areas in Leeds, including the Inner Northeast, Inner South, and Inner West of the city (see Figure 13). The highest rate of COPD is in the Middleton Park ward, and the lowest rate is in the Adel and Wharfdale ward. Prevalence of COPD in Leeds is stable; there are no statistically significant changes from the previous data period (2019-2020) (see Figure 14).

Across the city, the highest rate of COPD is seen in people of a White background, which is statistically significantly higher than the remaining ethnic categories and the Leeds average. The remaining ethnic categories are statistically significantly lower than the Leeds average.

Figure 13: COPD prevalence by direct standardised rate (per 100,000) in Leeds by PCN boundary (January 2022) **

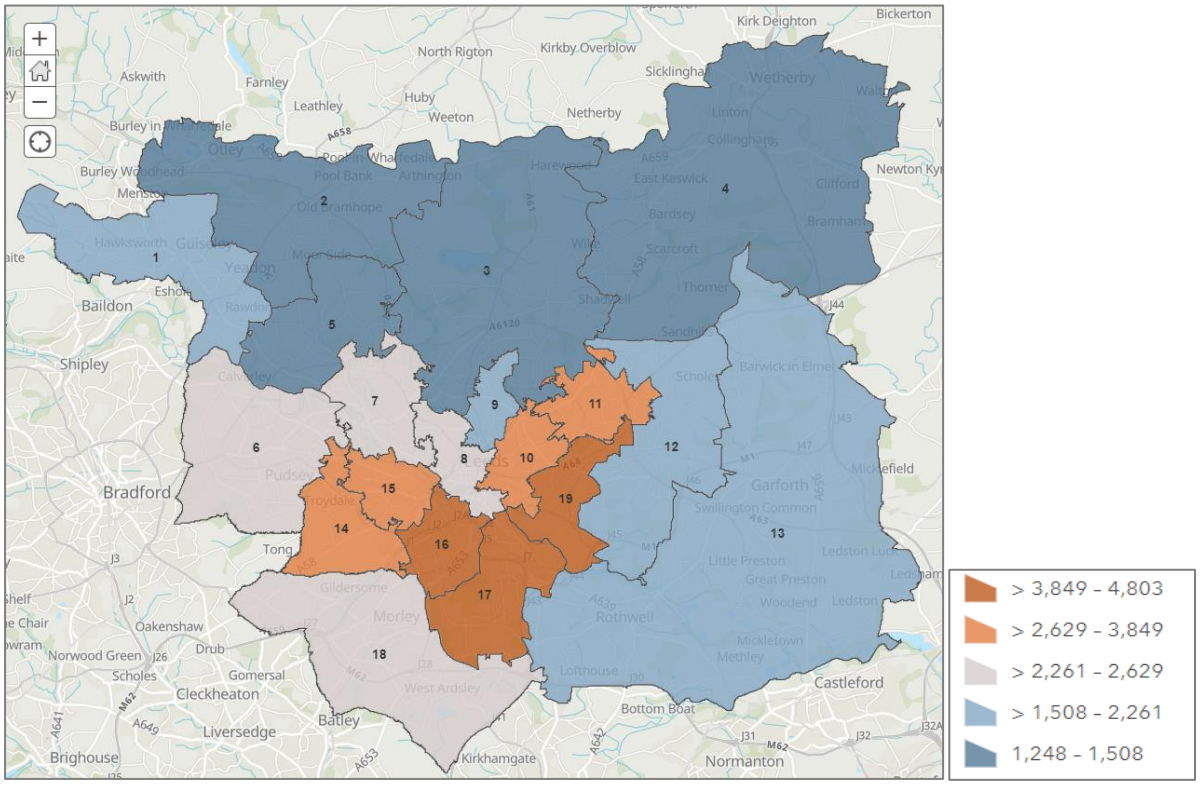


Figure 14: Prevalence of COPD in Leeds (all ages): Direct standardised rate per 100,000 population

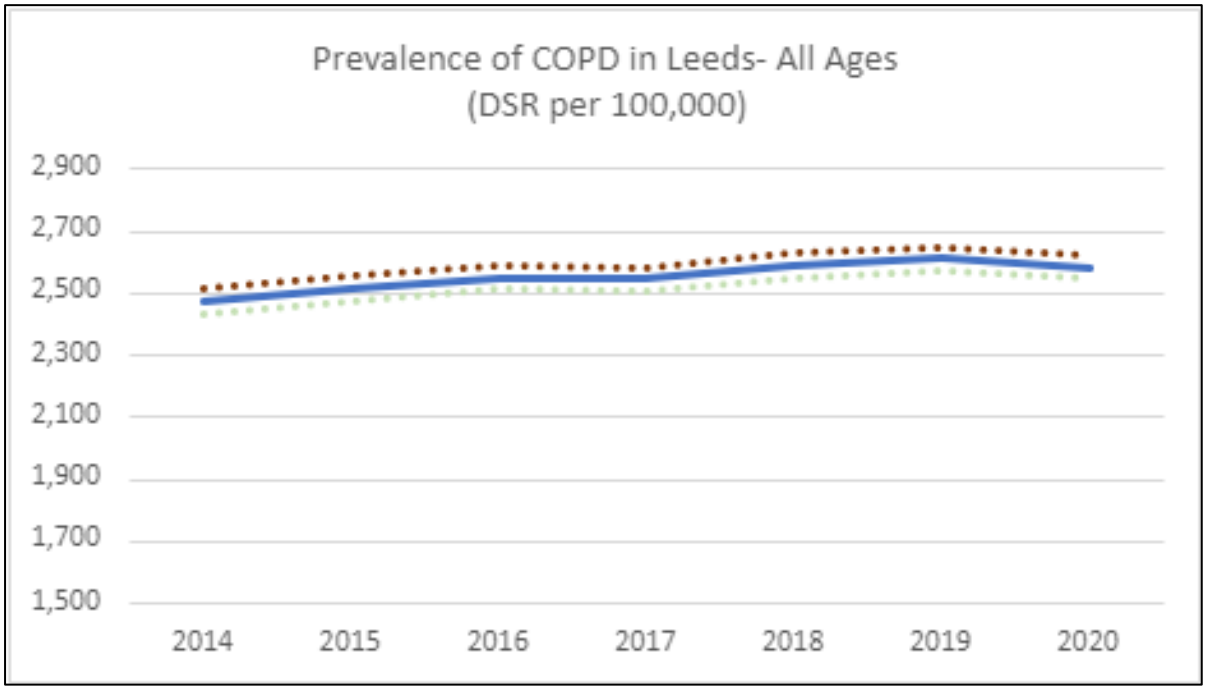


Table 6: Registered patients with COPD per PCN (Count, percentage, and age-standardised rate) (January 2022)

PCN Footprint	Count	Prevalence (%)	Age-standardised rate	Benchmark against Leeds
Middleton & Hunslet PCN	1333	3.35	4,803.6	Worse
York Road PCN	678	2.88	3,948.6	Worse
Beeston PCN	934	2.06	3,903.4	Worse
Burmantofts Harehills & Richmond Hill PCN	1072	1.6	3,849.9	Worse
Seacroft PCN	1105	2.82	3,803.8	Worse

Looking more closely at Middleton and Hunslet PCN, in 2021-2022 the PCN recorded a total of 1,333 patients with COPD, indicating an overall prevalence of 3.35% and an age-standardised rate of 4,803.6 per 100,000. This is a much higher rate compared to the Leeds average rate. COPD in the Middleton and Hunslet PCN overall affects more men than women: the 60-69 age group has the highest prevalence for men, whereas the 70-79 age group has the highest prevalence for women. The majority of patients with COPD in this PCN are of White British ethnicity.

In a recently published HNA exploring the health needs of Belle Isle North (Bailey and Kelly-Johnson, 2021), respiratory illness, particularly COPD, was an issue affecting residents of this particular area. While smoking rates in the area were viewed as contributing to the significance of this, there was also a discussion featured about the levels of congestion in the area. According to the HNA findings, there is only 50% car ownership in Belle Isle North, however there are approximately 17,000 journeys made through the wider Belle Isle area due to it being a thoroughfare for other areas of the city. Air pollution was also referenced by residents living in the Inner South LSOA Stratford and the Beverleys (Kelly-Johnson, 2020) as a key priority due to the impact on those living with existing health conditions.

Coronary heart disease

Air pollution can be harmful to the cardiovascular and circulatory systems in the body. Breathing in air of poor-quality air can cause air pollutants to travel deep within the bloodstream through the lungs and the heart, increasing the risk of developing heart and circulatory diseases. Air pollutants can damage blood vessels by making them narrower and harder (British Heart Foundation, 2022).

In Leeds, the highest rate of CHD is seen in people from an Asian background (5,529.3 per 100,000) (see Figure 15). The rate is statistically significantly higher than the remaining ethnic categories as well as the Leeds average (3,451.9 per 100,000 population). The rate for the White ethnic population is more aligned with the Leeds average (3,435.7 per 100,000). The remaining ethnic categories are statistically significantly lower than the Leeds average.

The highest rate of CHD is in the Hunslet and Riverside ward (4361.3 per 100,000), and the lowest rate is in the Harewood ward. There are seven wards with a rate that is statistically significantly higher than the Leeds average (see Figure 16).

Figure 15: Prevalence of CHD by ethnic background, all ages (per 100,000 population) (January 2022)

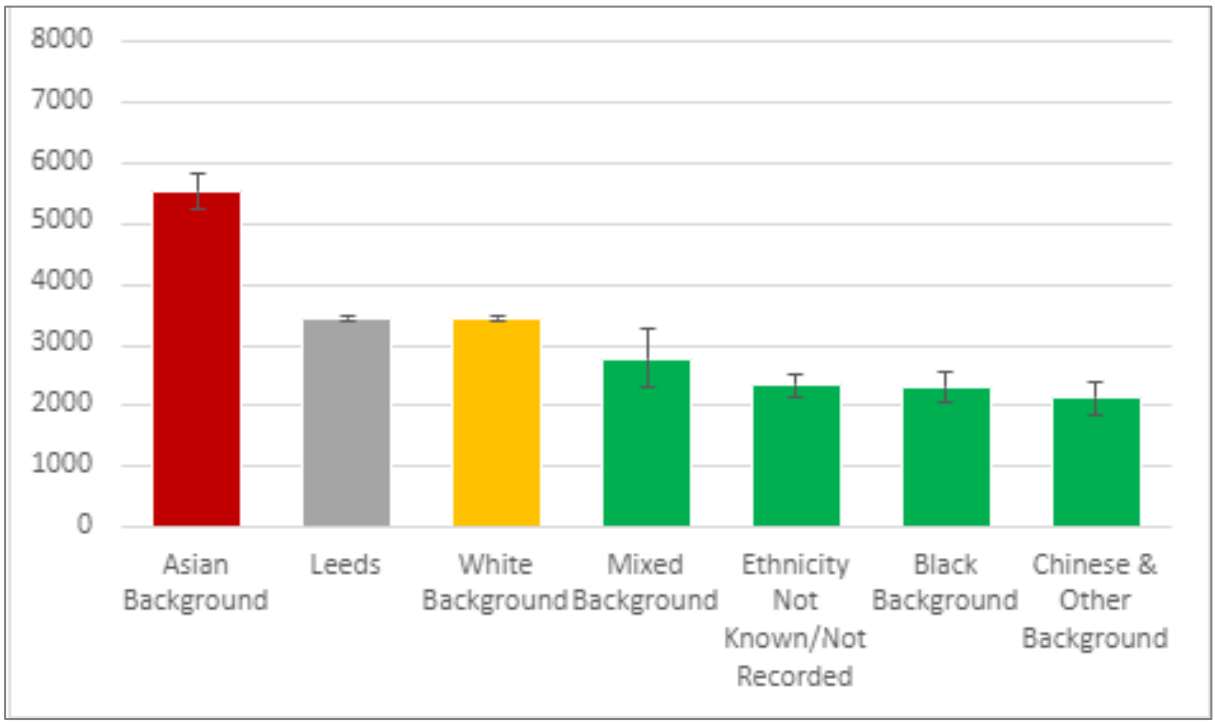
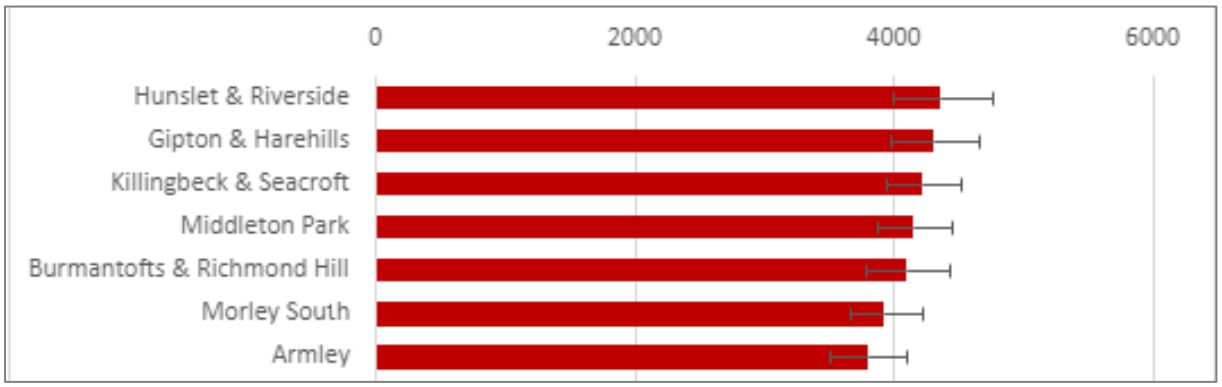


Figure 16: Snapshot of prevalence of CHD by ward, all ages (per 100,000 population) – N.B. Wards that are statistically significantly higher than the Leeds average



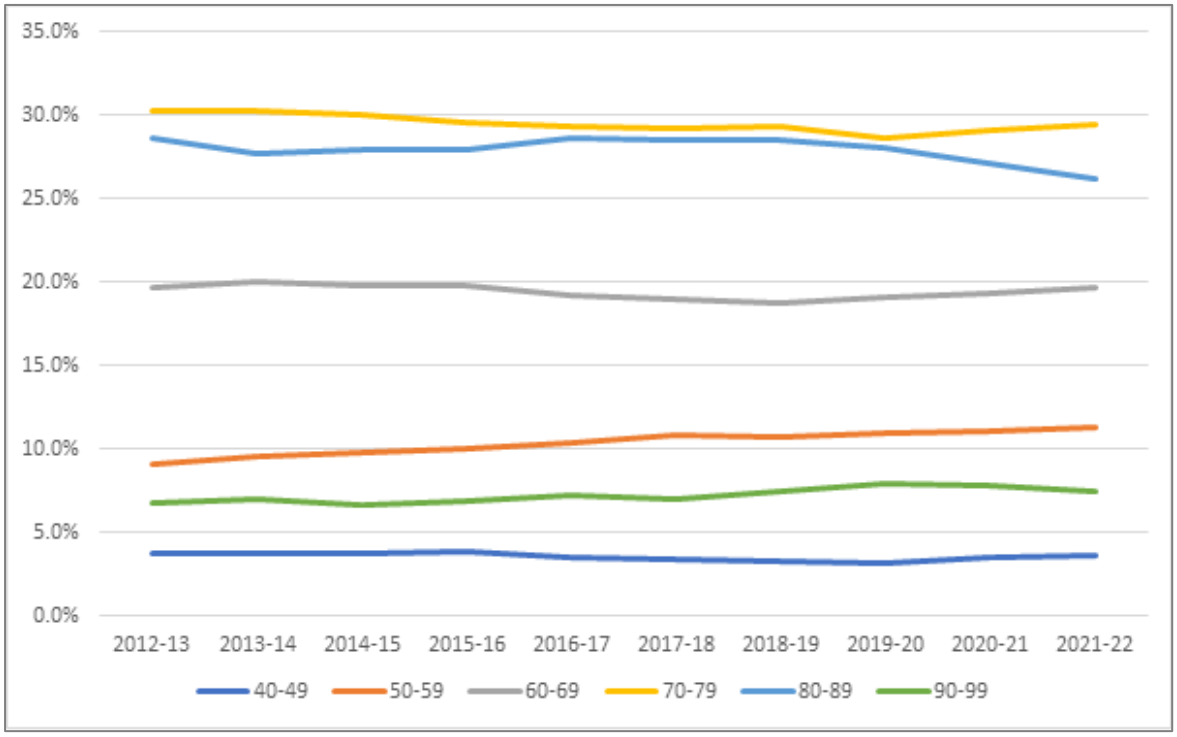
The highest rate of CHD across a PCN footprint is in the Burmantofts, Harehills and Richmond Hill PCN footprint. There are five PCN footprint areas that are statistically significantly higher than the Leeds average: Burmantofts; Harehills and Richmond Hill; York Road; Middleton and Hunslet; and Seacroft and Beeston.

Stroke

There are two main types of strokes: ischaemic stroke, where the blood supply is stopped because of a blood clot; haemorrhagic stroke, where a weakened blood vessel, that supplies oxygen and blood to the brain, bursts. A related condition to stroke is called a transient ischaemic attack (TIA); this is when the blood supply to the brain is temporarily interrupted, causing a mini stroke. Referring to stroke in this section can include ischaemic strokes, haemorrhagic strokes or TIAs.

In Leeds, there are a total of 170,544 people with stroke listed on their health care records. Of these, stroke is mentioned most in records for men (53% of all records; the equivalent of 90,101 men). Stroke is a condition that mostly affects the older adult population: it is most prevalent overall in those aged 70–79 and this age group has consistently had highest of prevalence of stroke since 2012. This may be attributable to the differences in average life expectancies in males and females.

Figure 17: Prevalence of stroke in Leeds by age since 2012 by age category 40+ per 100,000



People of a White background have the highest prevalence of stroke in Leeds. Of other ethnic categories recorded, including Black, Chinese, Mixed and Asian categories, it is the Asian population who have the highest burden of disease count from stroke, accounting for 47.1% of disease burden across these ethnic groups.

Stroke by deprivation deciles illustrates that those living in the 10% most deprived areas of Leeds are more likely to affected by stroke. This data has been consistent since 2013 where 24.1% (the equivalent of 3,244 people) of those living in the most deprived areas are living with illness or injury from stroke. This figure has steadily declined from 2013 to 2022 but the burden of disease for stroke remains largest in this group (23.2%).

In the year 2021 – 2022, there were 3462 people in the most deprived areas living with the effects and impacts of stroke. Of these the majority were from the Burmantofts, Harehills and Richmond Hill PCN where there was 88.5% burden of disease for those living in the most deprived decile. The 5 PCNs with the highest number of patients registered with stroke are set out in Table 6.

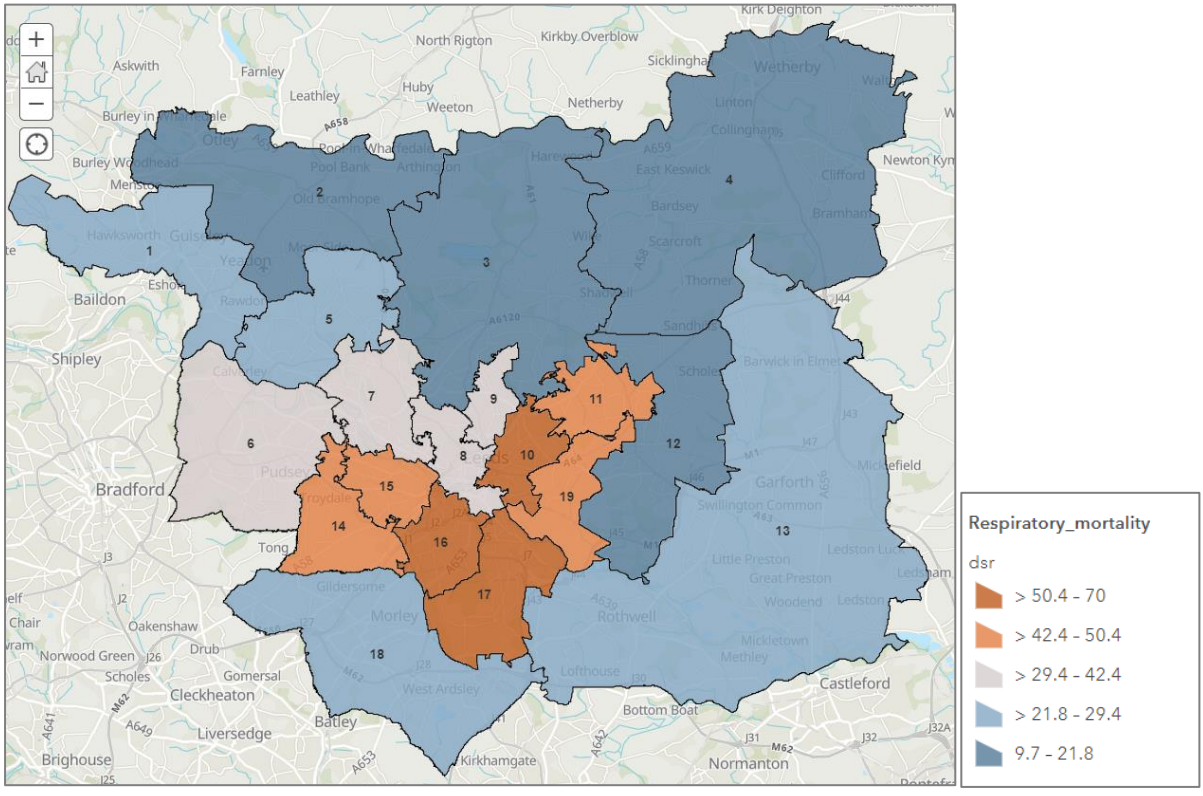
Table 7: Registered patients with stroke by PCN – Top 5 (by Decile 1, most deprived 10%)

PCN area 21/22	Number registered with Stroke	% of total cases
Burmantofts and Richmond Hill	600	88.5%
Middleton and Hunslet	573	70.9%
Seacroft	512	70%
York Road	277	68.9%
Beeston	324	55.9%

Respiratory mortality

The mortality rate for all ages, from all respiratory diseases (excluding pneumonia and influenza) is stable for Leeds. There are no statistically significant changes between the previous period of data (2017-2019) and the latest period of data recorded (2018-2020). The rate for those living the deprived areas of Leeds is statistically significantly higher than the Leeds average.

Figure 18: Respiratory mortality by direct standardised rate (per 100,000) in Leeds by PCN boundary (January 2022) **



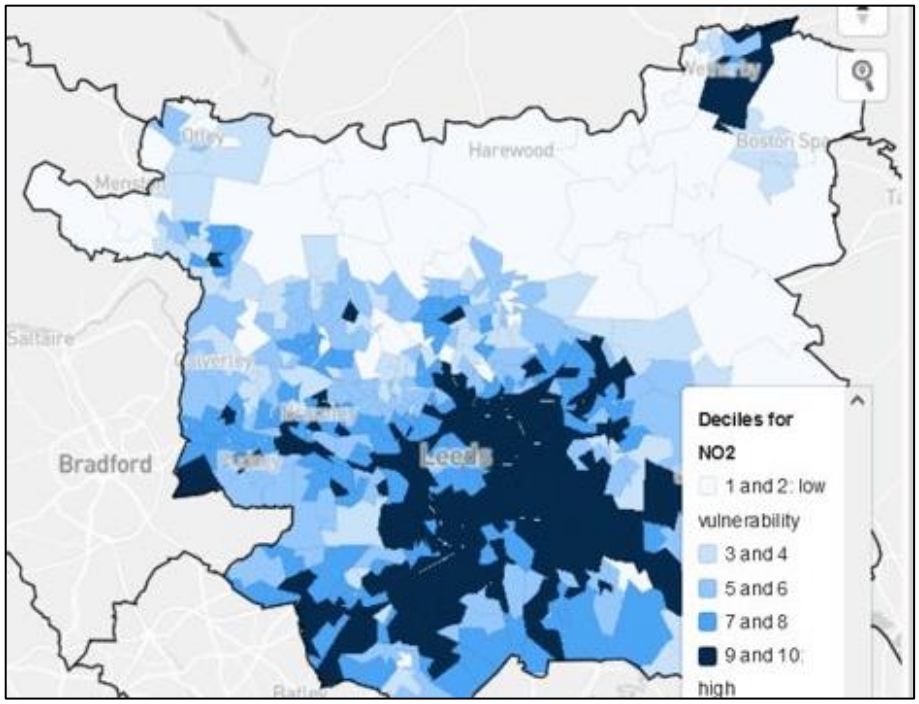
***Key for map**

ID	PCN boundary	ID	PCN boundary
1	Yeadon	**11**	Seacroft
2	Otley	**12**	Crossgates
3	Central North Leeds	**13**	LS25 / LS26
4	Wetherby	**14**	Bramley, Wortley and Middleton
5	Holt Park	**15**	Armley
6	West Leeds	**16**	Beeston
7	Woodsley	**17**	Middleton and Hunslet
8	LSMP & The Light	**18**	Morley and District
9	Chapeltown	**19**	York Road
10	Burmantofts, Harehills and Richmond Hill		

Vulnerability

An air pollution vulnerability indicator has been developed by the UK Health Security Agency (UKHSA) to demonstrate population-level vulnerability to air pollution at a lower super output area (LSOA) level. Vulnerability is ranked from low (1-2) to high (9-10). Vulnerability is a composite indicator is based on a range of sub-indicators, including: demographic characteristics such as the percentage of young (<16 years) and elderly (65+ years) people within the LSOA; socio-economic status using the index of multiple deprivation (IMD) score; the number of local settings serving vulnerable populations (for example hospitals, care homes, schools, and childcare facilities) and the level of air pollution of NO_2 and $PM_{2.5}$ for the year 2018.

Figure 19: UKHSA Air pollution vulnerability indicator: Vulnerability to NO_2 in Leeds

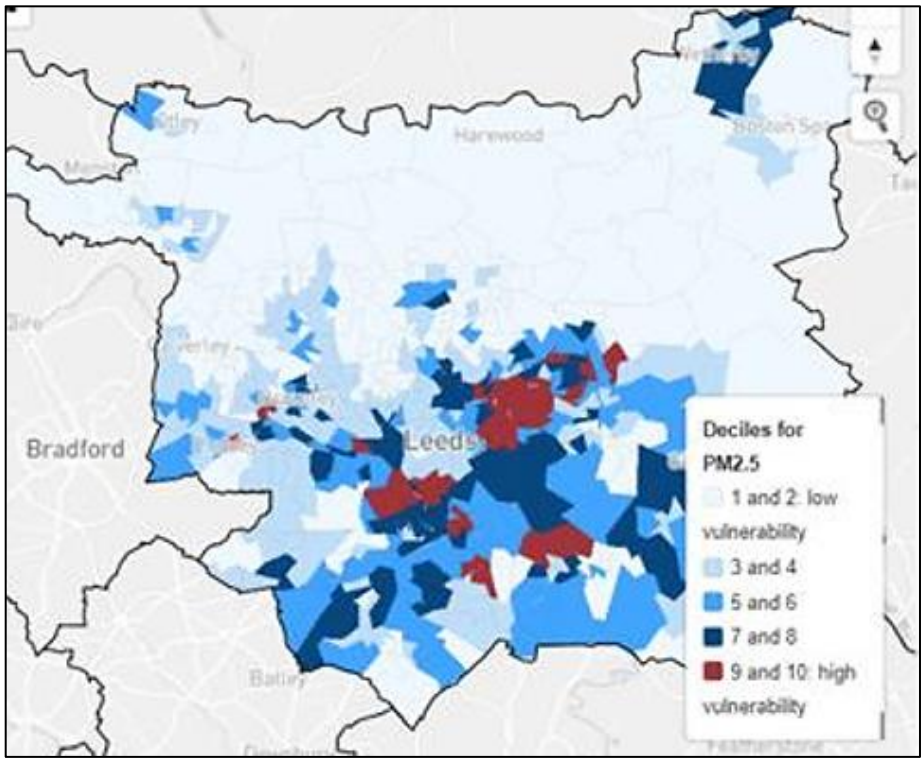


Source: UKHSA Air Pollution Exposure Surveillance (updated 2022)

For vulnerability from NO_2in Leeds, 30.6% of the population are in the most vulnerable deciles 9 and 10 (the equivalent of 241,873 people) (see Figure 19). The top 4 deciles of the highest vulnerability contain 54.7% of the population. For vulnerability to $PM_{2.5}$ in Leeds, 9.6% of the population are in the most vulnerable deciles, 9 and 10, which is the equivalent to 75,993 people (see Figure 20). The top 4 deciles of highest vulnerability to $PM_{2.5}$ contain 23.7% of the population.

The proportions of the Leeds population most vulnerable to the health impact of both NO_2 and $PM_{2.5}$ are not insignificant for a population the size of Leeds. Looking at vulnerability using UKHSA's surveillance tool also helps to reframe the importance of inequalities within the context of air pollution and the health impact, for example considering the outer, traditionally more affluent areas of Leeds where there may be older-age populations and higher levels of pollutants due to agricultural factors, farming, or domestic burning.

Figure 20: UKHSA Air pollution vulnerability indicator: Vulnerability to $PM_{2.5}$ in Leeds



Source: UKHSA Air Pollution Exposure Surveillance (updated 2022)

The indicator is still in development by UKHSA and therefore subject to change, however it provides a useful overview of population-level risk to the health impact of air pollution of the two most significant outdoor air pollutants of concern. Using the LSOA data provided in this tool could be a useful way of targeting resources and activity towards those most vulnerable to the impact of air pollution at a localised level.

Local views

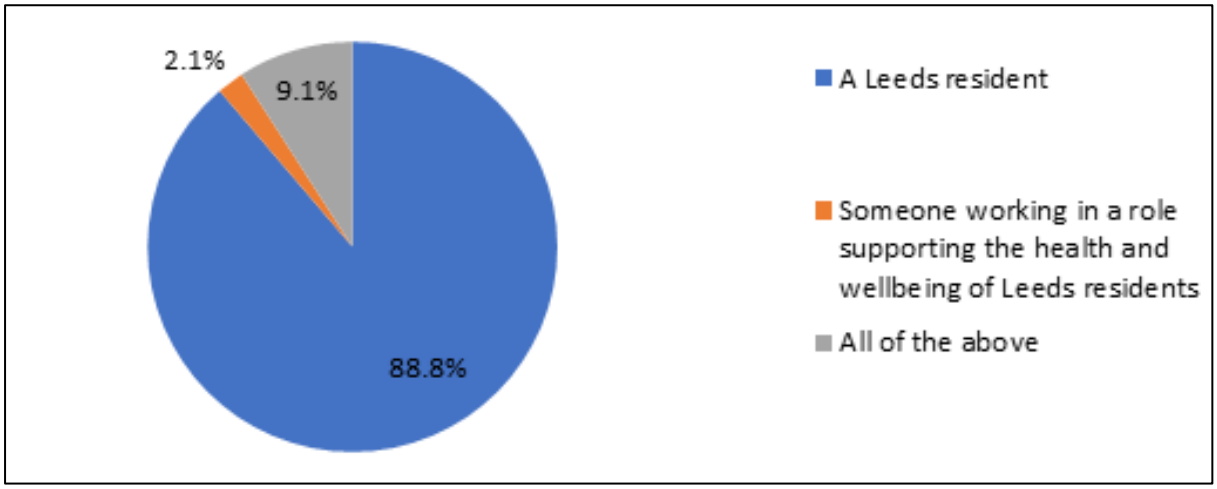
Along with collecting quantitative data, a survey was developed with the aim of gathering the views of residents and those working to support the health and wellbeing of Leeds

residents in relation to air pollution and health. The survey was distributed across the city across a range of local media channels, bulletins, newsletters, and websites. The survey was designed with support from the Public Health Intelligence and the Sustainable Energy and Air Quality teams in Leeds City Council. The survey findings are not intended to be representative of whole Leeds population but can provide a useful level of insight into current perceptions and views around air quality.

Profile of the survey respondents

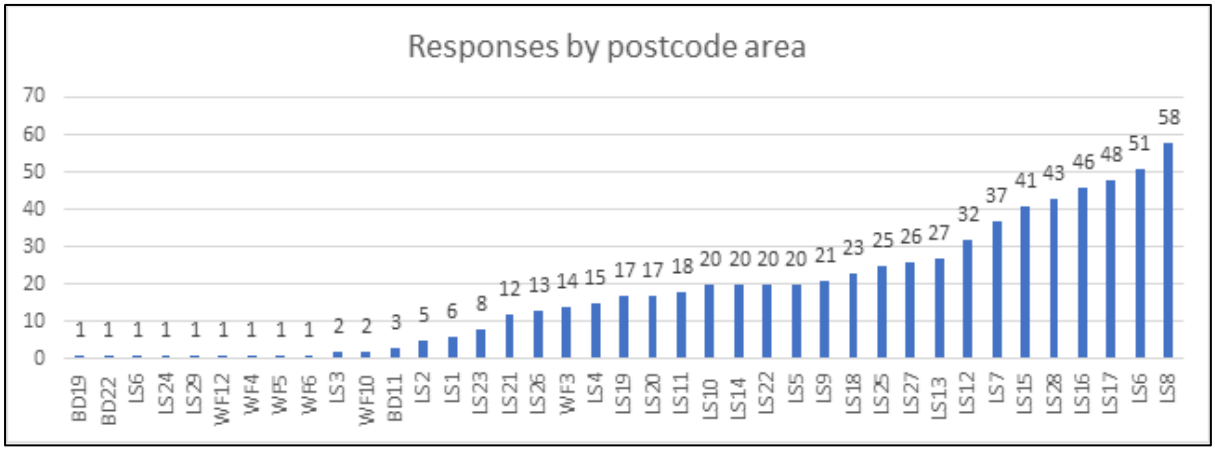
The survey was available to complete online for four weeks between June and July 2022. During this period, the survey was completed by 703 people.

Figure 21: Breakdown of survey respondents



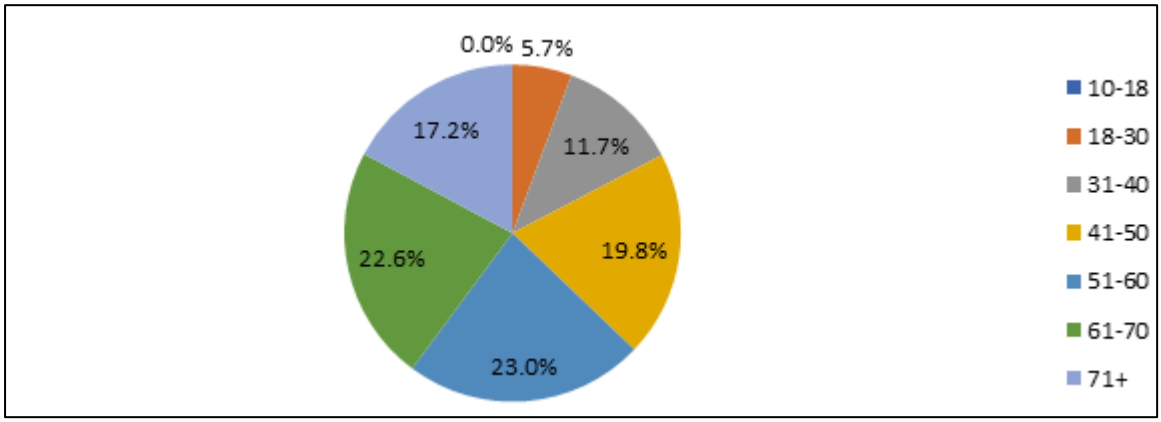
624 (88%) of the respondents identified as Leeds residents, 15 respondents (2.1%) responded from a professional perspective, and 64 respondents (9.1%) responded from a professional and a personal perspective.

Figure 22: Responses by postcode area



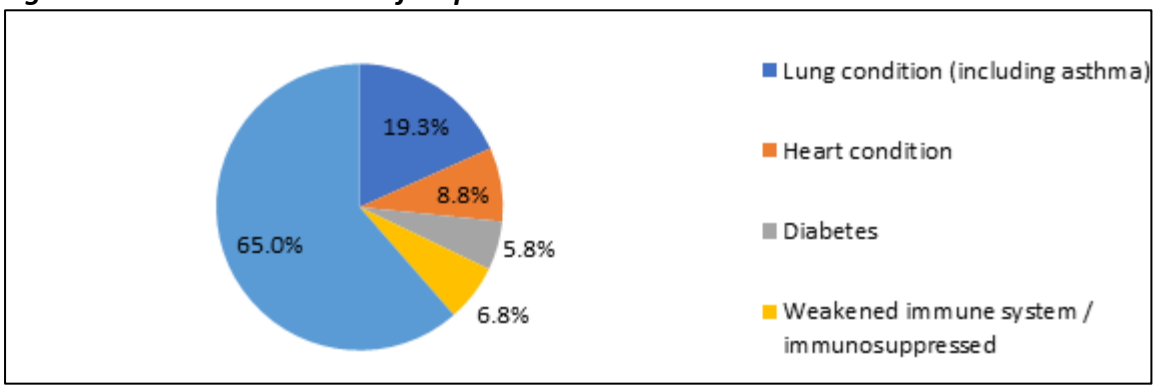
More than 40 responses were received from 6 postcode areas representing different and varying parts of the city: LS15, LS28, LS16, LS17, LS6, and LS6 (see Figure 22).

Figure 23: Age brackets of the survey respondents



Respondents of the survey varied in age with the youngest being in the 18–30-year-old category (5.7%). Most responses were from those aged 51-60 (23%) or 61-70 (22.6%).

Figure 24: Health conditions of respondents



65% of respondents (457 out of 703) did not report a health condition that would put them at higher risk of the health impact of air pollution.

136 people (19.3%) completing the survey had been at some point in their life diagnosed with a lung condition, including COPD or asthma, and an additional 8.8% (62) people had been diagnosed with a heart condition.

41 people (5.8%) who responded had a diagnosis of diabetes (Type 1 or Type 2) and 6.8% considered themselves to have a weakened immune system that impacts on their body's ability to fight infections and other diseases.

Of those respondents who reported a diagnosis or long-term health condition that could be exacerbated by poor air quality, only 10.2% (25 out of 246 respondents) reported that their health care professional had discussed the impacts of air quality on their health. The remainder (89.8%) did not report ever having experienced a discussion with a health care professional on how exposure to poor air quality could affect the management of their condition.

Survey results

The survey was designed to gather local views on air quality. As such, many of the questions asked of participants required a qualitative response rather than a quantitative measure. The free text responses allowed participants to share their views, opinions and understanding of air quality and were then themed into popular responses. Answers that did not offer a direct or relevant response to the question were omitted from the analysis.

Perceptions of air quality

"If we can't breathe clean air, we will all die sooner than we should, from illnesses that we shouldn't have."

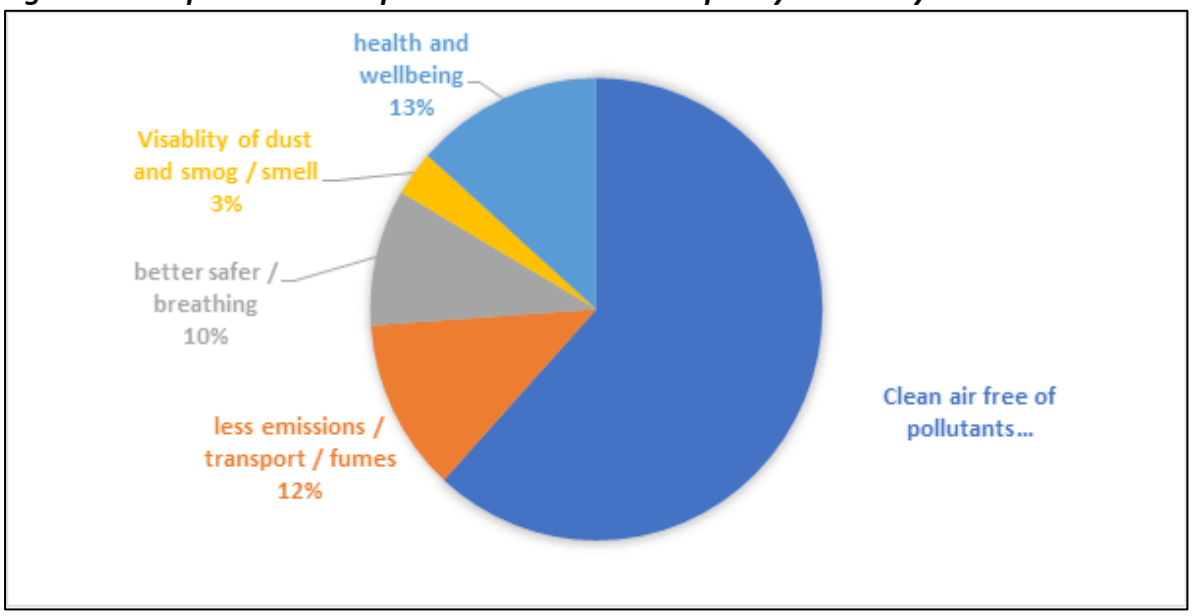
668 respondents provided an answer when asked what the term air quality meant to them. Most of the responses (62%) referred to air quality being 'clean air' or 'air that is free of pollutants'.

12% made links between the term air quality and travel, all highlighting that air quality is better without the presence of vehicle emissions and fumes. 79 respondents (10%) linked air quality with the safer breathing and the ability to breathe easier, often referring to how air feels cleaner and healthier to breathe in more remote parts of the country.

Health and wellbeing were another clear theme that participants associated with the term air quality: 111 responses (13%) suggested that poor air quality has a negative impact on health and wellbeing, recognising that poor air quality can cause 'irreversible health conditions' or lead to 'health issues'.

75% of those who took part in the survey regard air quality as being very important to them, with only 3% (21 people) regarding it as not important.

Figure 25: Responses to the question 'What does air quality mean to you?'



A total of 443 responses around the importance of air quality referred to poor air quality being detrimental to health and lives. Of these, 266 (60%) responses were concerned with

the effects of air pollution on the health of the general population, 121 respondents were concerned about the direct impact poor air quality has on their own health, often referring to worsening of their own medical conditions when air pollution is noticeable, and a further 56 were concerned about the future of their family and their health.

52 responses made direct reference to air quality and children, expressing concerns on how this will affect future generations.

30 responses (5.2%) linked the importance of air quality with spending time outdoors. Many who noted this reported that they liked to enjoy outdoor exercise such as running, cycling, and walking but identified that this is often impacted by vehicle fumes and other visible pollutants that make breathing more difficult. Location was noted to be significant to exercise with respondents noting the difference in their health when exercising in busy built-up areas (commuting via cycling during rush hour) and doing so in quieter rural environments.

"I want to go outside and breathe the freshest air possible – it's good for my mental and physical health. It was great during lockdown when I could go out on my bike, cycle around local parks and really smell the difference."

Location was also a key indicator from those respondents who identified traffic and idling as a reason why air quality was important to them.

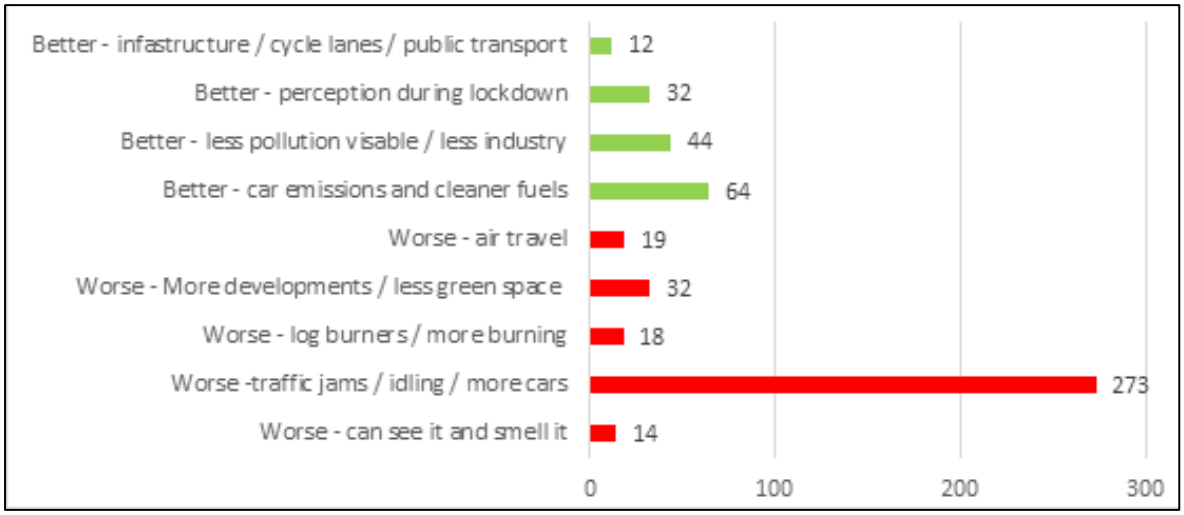
16 out of 50 participants described living near motorways or congested arterial roads and an additional 12 participants lived or worked in or surrounding the city centre. All respondents reported feeling disadvantaged or more at risk of the effects of air pollution, with some reporting they could taste and smell the difference in the air and others reporting heightened problems with breathing, coughing, and wheezing.

Despite air quality in Leeds improving over the past 10 years, 51.8% (364 people) who completed the survey believed that the air quality in the city is worse now than in previous years.

Most respondents reported that this is due to traffic congestion, an increase in the numbers of vehicles on the road and idling, with 273 of the responses noting this as the reason why air quality in Leeds has worsened.

Other responses indicated that there is a noticeable reduction in green spaces with changes in infrastructure and new developments as well as the emergence of wood burning stoves as a source of heating.

Figure 26: Perception of air quality in Leeds over the past 10 years



20.1% (141 people) responded that air quality in Leeds over the past 10 years has improved, with cleaner fuels, car emissions and the introduction of electric vehicles being the main reason of note. Respondents also referred to a decline in industry throughout the city which has resulted in pollution being less visible.

32 respondents considered the Covid-19 pandemic to have a positive impact on air pollution noting that the level of pollution during lockdown were significantly reduced and the air appeared cleaner, while 51% of respondents feel that the air quality is changing back to pre-pandemic levels. This mirrors the findings outlined in the Leeds Air Quality annual status report which identified that there have been significant reductions in traffic and industrial activity in 2020 due to the pandemic. This has resulted in reduced emissions of nitrogen dioxide across the city more significant than the long-term trend would have predicted.

Understanding of air pollution

Respondents were asked about their current understanding of air pollution. Half (50.1%) of these stated that they knew about different types of air pollution. The word cloud (Figure 27) shows the most used words when describing sources of air pollution. 76% of respondents reported knowing how short-term and long-term exposure to air pollution could impact on their health.

Respondents were asked to provide examples of how air pollution influences health over the long-term. The terms ‘respiratory’, ‘asthma’ or ‘COPD’ were mentioned 429 times from respondents, the equivalent to 51% of all responses to this question. Respondents also recognised the impact air pollution can have on cardiovascular illnesses in particular heart disease and heart attack, and lung cancer.

In terms of short-term impact, 54 respondents referred to air pollution causing irritation to eyes and skin and referenced how it can result and exacerbate the symptoms of allergies.

Figure 27: Word cloud of reported air pollution sources

Respondents were asked to identify who is most at risk from the impacts from poor air quality. Most respondents (24%) stated that children and babies were most affected due to their reduced immune systems and developing bodies. This was followed by older people (17%) and those with respiratory conditions (15%). 1% of respondents (21 people) stated that those who spend time outdoors, either working or exercising in places where air pollution is high are more exposed to its effects. This was mentioned specifically in respect to cycling near built-up, busy industrial areas.

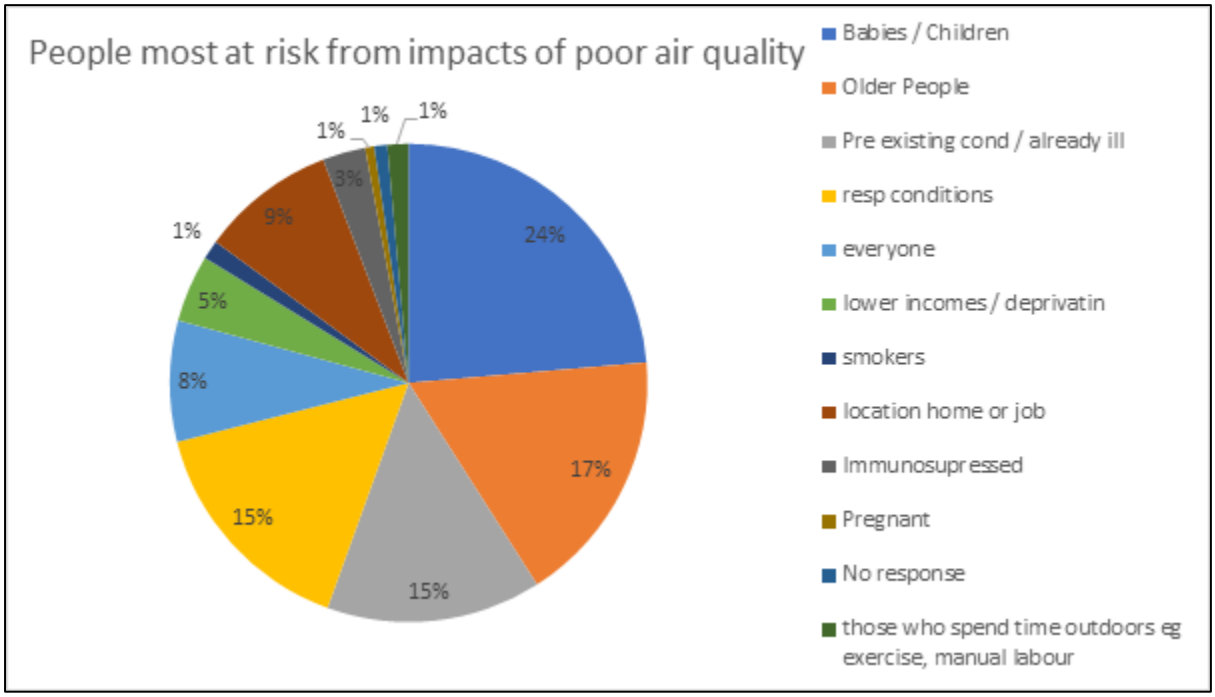
"*People from more deprived backgrounds who do not have a choice about whether they live close to busy roads etc.*"

5% of responses (66 people) noted that those most at risk from the impacts of air pollution are from lower income families or deprived areas. Of these, respondents stated that lack of green space, poorer living conditions and living in densely populated and congested location were the main contributing factors to exposure.

10% of respondents reported that those with lower incomes have less opportunity to mitigate their exposure to air pollution due to having little choice over their living conditions and location.

It was mentioned that those living in deprivation are often disproportionately affected by poor air quality as they are often the people who are most exposed to air pollution and yet are more likely to contribute less to poor surrounding air quality.

Figure 28: Perception of those most at risk from the impacts of poor air quality



Monitoring and managing air quality

Respondents were asked how they would find out about air pollution in Leeds and how to protect themselves.

626 out of 703 respondents answered the question with the majority (34%) stating that they would do this via an internet search such as Google.

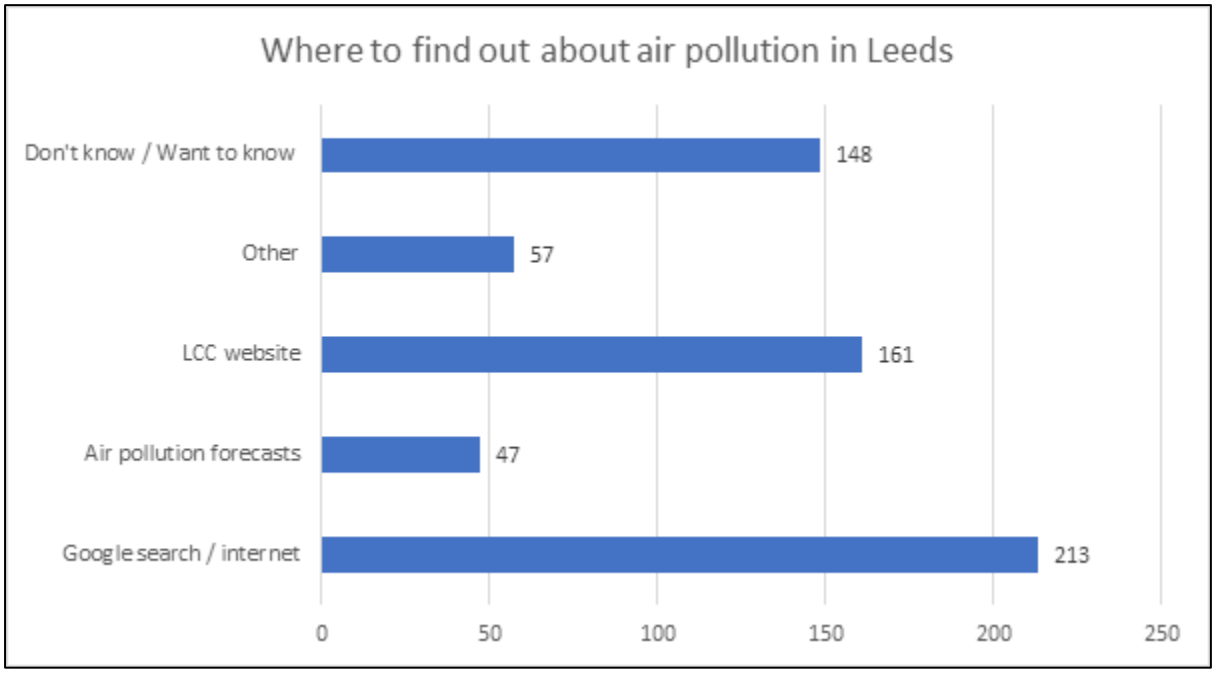
25% of people stated they would access the Leeds City Council website to direct them to this information and only 7% of people referred to accessing the online air pollution forecast via DEFRA or UK Air.

A high proportion of those who did respond to the question (23%) did not know how to access information on air pollution in Leeds.

Respondents were asked 2 questions around exposure and contribution to air pollution during high pollution episodes.

Over half of the respondents (51.5%) did not know what steps they could take to reduce their exposure to air pollution during a forecasted high pollution episode and the remaining 48.5% (353 people) reported some knowledge and provided examples of how they would do this. 30% of respondents who answered this question believed staying indoors when there is a high pollution episode forecast is the best way to protect themselves with 15% also emphasising the importance of closing windows and doors.

Figure 29: Where to find out about air pollution in Leeds



19% (228 people) proposed the use of PPE during high pollution episodes with 108 respondents directly referring to the wearing of face masks. Some respondents answered this question with solutions to improve air quality such as creating more green space (2% of responses), avoiding congestion (8% of responses) and taking action to avoid creating more pollution such as not driving or burning (8% of responses) during these episodes. 60.9% of respondents stated that they were aware of steps they could take to reduce their own contribution to air pollution when air quality was forecast to be poor, with the remaining 39.1% unaware of what action they could take.

Figure 30: Steps to reducing air pollution when air quality is poor

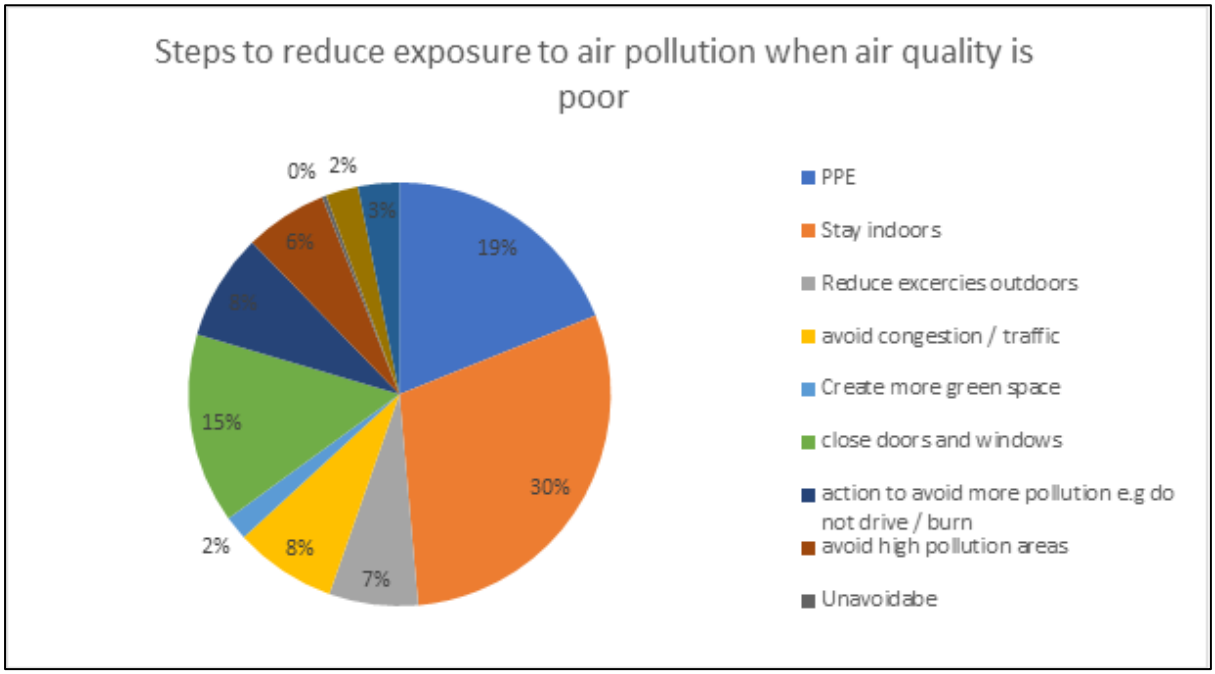
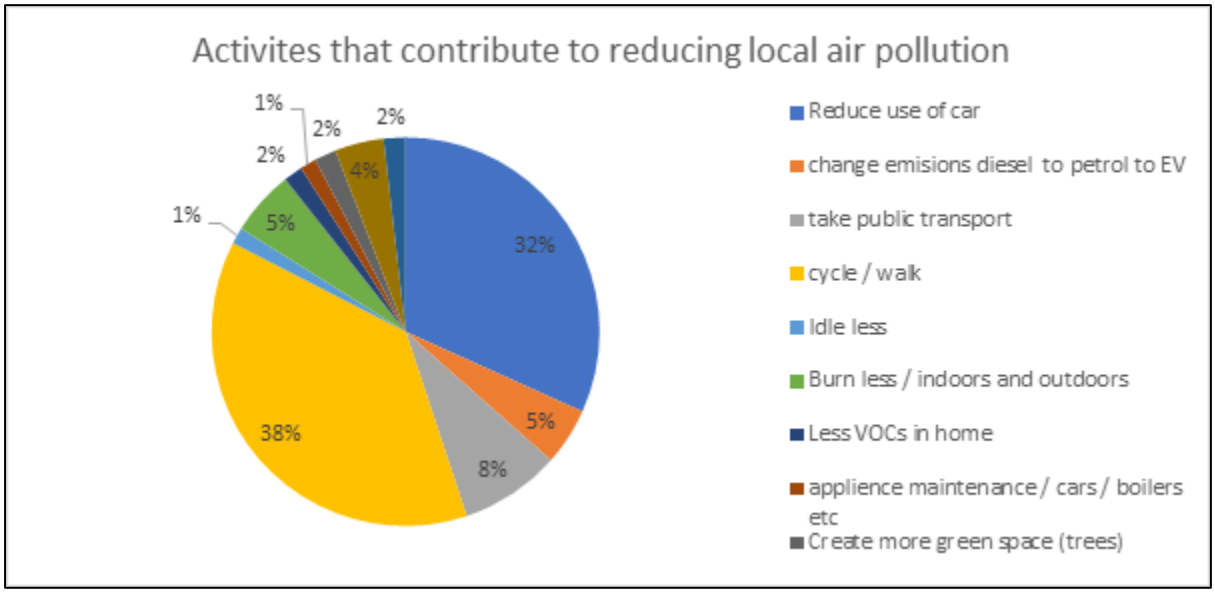


Figure 31: Activities that contribute to reducing local air pollution



Of those that responded to the question, 78% considered this in terms of transportation and travel. Respondents suggested that reducing car use and choosing alternative transport or active travel such as walking, and cycling was the best way they could reduce their contribution to air pollution. An additional 5% proposed a change in vehicle fuel sources to a leaner fuel such as electric or hybrid vehicles to be an effective way to reduce contribution to air pollution.

A small proportion of people (8%) referred to reducing their contribution to indoor sources of air pollution by burning less, better maintenance of appliances and reducing the use of products that contain Volatile Organic Compounds (founds in some cleaning products, paints, and solvents).

Summary

Although air quality is generally improving in Leeds, it is widely recognised that there are no safe levels of air pollution and it impacts the whole population. However, it is important to gain a better understanding of the populations, geographies and settings in the city that are at a higher risk of the health impacts of poor air quality. These at-risk groups are the most vulnerable to the health harms, and where activity and interventions could be targeted to greater effect. It is imperative that as much as possible these groups are protected from these harms:

- Those who are pregnant, especially living in areas of deprivation and from minority ethnic and culturally diverse backgrounds.
- Children and young people including those with existing respiratory conditions such as asthma.
- Adults with long-term conditions:
    - Asthma
        - Predominantly a younger age adult population

        - Areas of deprivation, particularly Inner East Leeds where there are higher rates of hospital admissions for asthma
        - Minority ethnic populations, particularly the South Asian population
    - COPD
        - Predominantly an older age adult population
        - Areas of deprivation, particularly Inner South Leeds
        - White British populations, particularly men
    - CHD
        - Areas of deprivation, particularly Inner East Leeds where there is higher prevalence than the Leeds average
        - Minority ethnic populations, particularly the South Asian population
    - Stroke
        - Predominantly an older age adult population
        - Areas of deprivation, particularly Inner East Leeds where there is higher prevalence than the Leeds average

- The older adult population, particularly those aged 65 and above.
- Key settings where higher-risk groups are supported, for example early years settings, schools, care homes, and hospitals.
- Key LSOAs of the city where vulnerability to air pollution have been identified, taking into account inner city as well as more rural, outer city populations.

Alongside this, soft intelligence suggests that for those with long-term health conditions, particularly respiratory and cardiovascular conditions, there is an opportunity to improve the quality and frequency of conversations between people and healthcare conversations regarding the risks of poor air quality on health. Although air quality is often invisible, anecdotally residents do percieve a difference in the air they are breathing, for example when there are higher levels of road traffic. The survey findings also suggest there is more that can be done at a local level in terms of improving access to robust air pollution information and forecasts, as well as guidance and key messages on health risks and reducing exposure.

The data presented on health can help better understand and identify the populations at higher risk from the health impacts of short and long-term exposure to poor air quality in Leeds. It is worth reiterating, however, that it is not possible from the data presented to draw conclusions about the associations between disease prevalence and levels of air pollution at a local level. Air pollution is a contributing factor, among many, to the development, onset, and progression of long-term health conditions. However, it is widely accepted from the evidence-base that there are particular populations with a higher vulnerability to the health effects of both short- and long-term exposure to air pollution.

Chapter 6: Summary of interventions

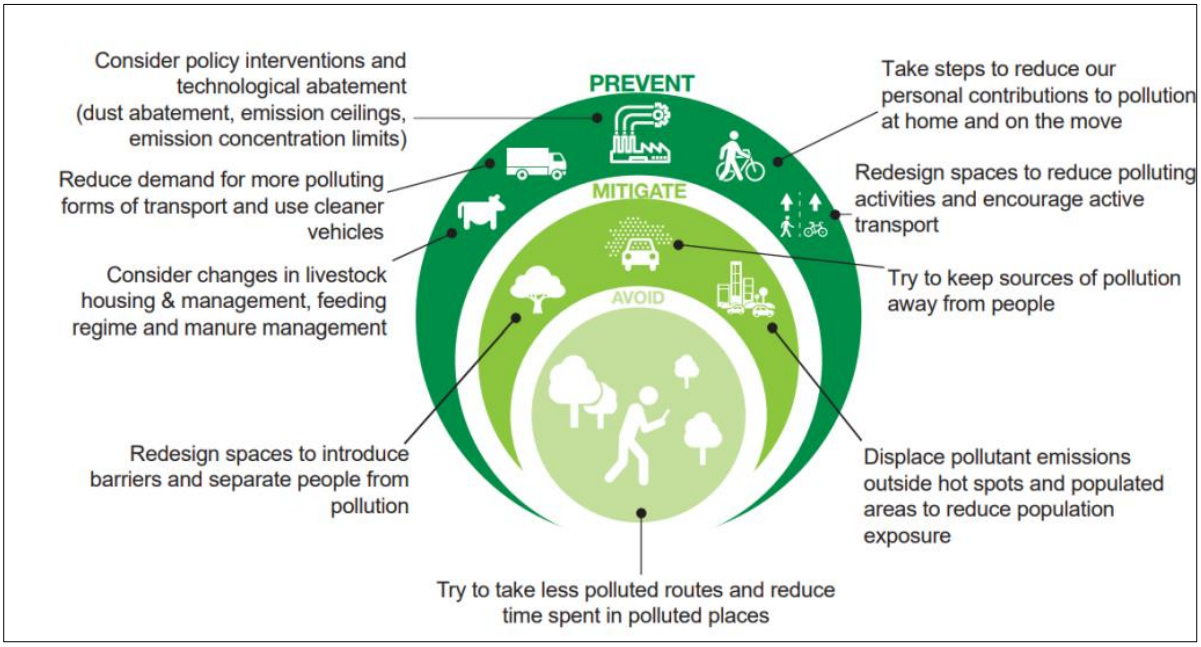
Given the complex nature of air pollution and its connection to health, it is important that this report acknowledges the interventions and activity that are currently recommended to support the mitigation of the health impacts of poor air quality. Through understanding what is effective and what is recommended through national policy and guidance, local recommendations can be developed that take into consideration the context and population, including the high-risk groups and settings identified in this report, of Leeds.

In 2019, Public Health England (PHE) published a review of interventions to improve outdoor air quality and public health. The review provided local practitioners and policymakers a range of available interventions across five areas of focus: vehicles and fuels, spatial planning, industry, agriculture, and behaviour change. According to this review, there is some strong evidence to suggest that interventions across these five areas can reduce emissions of harmful pollutants and because of that, a reasonable assumption can be made in terms of the health benefits of these interventions.

General interventions

In 2020, a document was produced to supplement the review and summarised the general approach recommended for applying air quality interventions and the principal interventions available to local authority practitioners when taking action on air quality. The general approach as advised by PHE (2020) is to prioritise implementing measures aimed at preventing or reducing pollution (emission reduction) over those that reduce air pollution once it has occurred (concentration reduction) or rely on avoiding existing pollution (exposure reduction).

Figure 32: Illustration of air pollution interventions: hierarchy approach



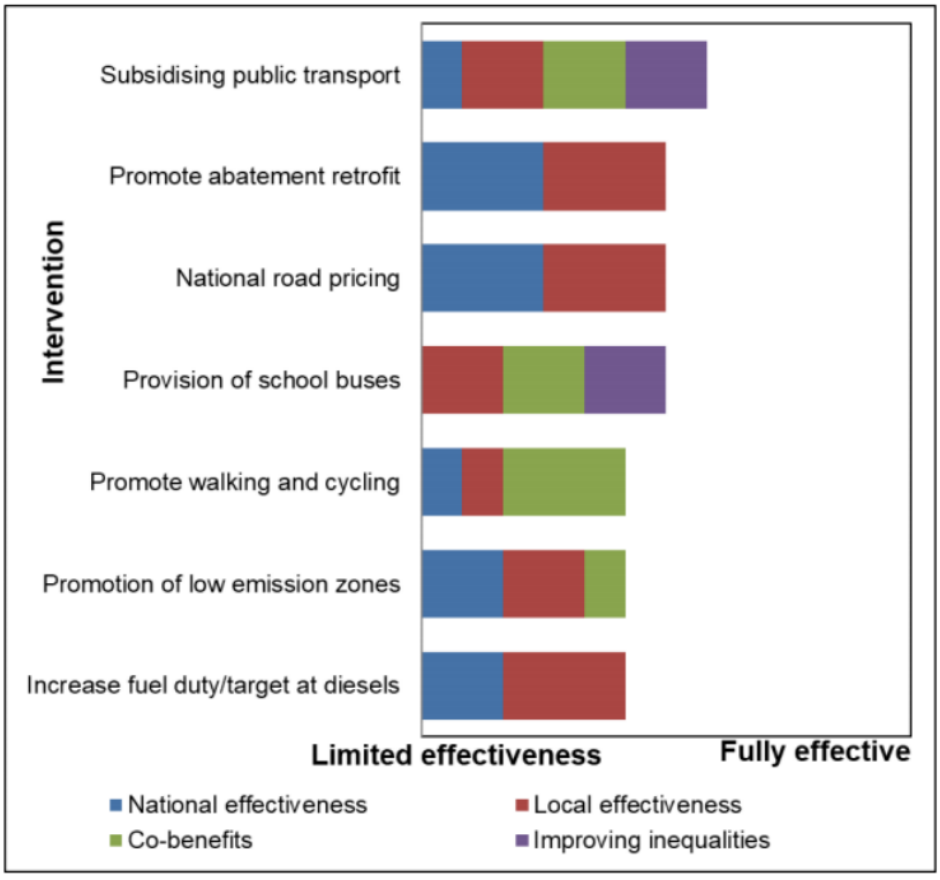
Source: Public Health England

Other general approaches recommended by the report include adopting a 'net health gain' principle across any new policy or work programme that affects air pollution. For example, any new development or proposal for change to existing developments should be clean by design and therefore all local housing and community developments underway should be well-designed to reduce pollution, support active methods of travel, encourage clean public transport, and support the infrastructure for future low emission vehicles. In line with this, PHE also recommend the systematic evaluation of all interventions to inform best practice in the future.

Vehicle and fuel interventions

Air quality within urban areas is likely to be improved by any intervention that promotes the uptake of low and zero-exhaust emission vehicles, particularly electric vehicles. Traffic management interventions, such as road pricing and access restrictions, have the potential to improve air quality and encourage the public to consider travel behaviour change and active travel options. Active travel interventions on a limited scale do not generally improve air quality significantly, but the added physical exercise benefit makes them very effective for improving public health outcomes. In general, road transport interventions need to be combined to achieve a greater impact, as most existing measures on their own may only generate a small reduction in road vehicle emissions.

Figure 33: Selected transport interventions' evaluated public health impact



Source: Public Health England

Planning and structural design interventions

The interventions with the highest potential to be effective at national and local levels are related to traffic. According to PHE, driving restrictions produced the largest and most consistent reductions in air pollution levels. Potential to improve air quality and public health outcomes is associated with the co-implementation of a mix of various measures that provide or improve green and active travel infrastructure, prioritise road safety, provide public transport and discourage travel in private cars, together with policies focussing on reducing the emissions of vehicles.

Green infrastructure is potentially effective not only to improve air quality related public health outcomes, but also to improve health inequalities in urban areas and promote health and well-being. Green infrastructure has also the potential to impact positively on urban heat islands and reduce the negative impacts of flooding. For speed limitations (traffic calming measures) and encouraging active transport, the public health 'co-benefits' are larger than benefits associated with reduction of exposure to air pollution alone, as speed limitations are associated with a reduced risk of pedestrian injury and traffic collisions, and increased physical activity is associated with multiple public health benefits (improved cardiovascular outcomes and improved weight status among children, adults and older adults).

Industrial and agricultural interventions

There is a clear distinction between policy-level interventions that set overarching targets and have the potential to widely reduce industrial air pollutants, and technological interventions implemented at the individual installation level (to meet policy-level intervention targets) that have potential benefits for local air quality and national air quality if implemented at scale. The evidence mainly relates to evaluations of interventions' effects on emissions (sources), from which consequent benefits to air quality and health are inferred. Few interventions directly evaluated effects on environmental concentrations, and fewer still directly evaluated health outcomes. Therefore, more evidence is required to identify the links between specific interventions, air quality and improved health outcomes.

There are several promising opportunities identified for reducing ammonia emissions at a farm-level, however the impact of these interventions depends on the extent of uptake on farms as current mitigation strategies rely on voluntary uptake. A combination of regulations, incentives, and awareness-raising measures will be needed to overcome the barriers to widespread adoption. To maximise co-benefits and minimise negative trade-offs, it will be important to align agricultural interventions with other sector strategies and policies.

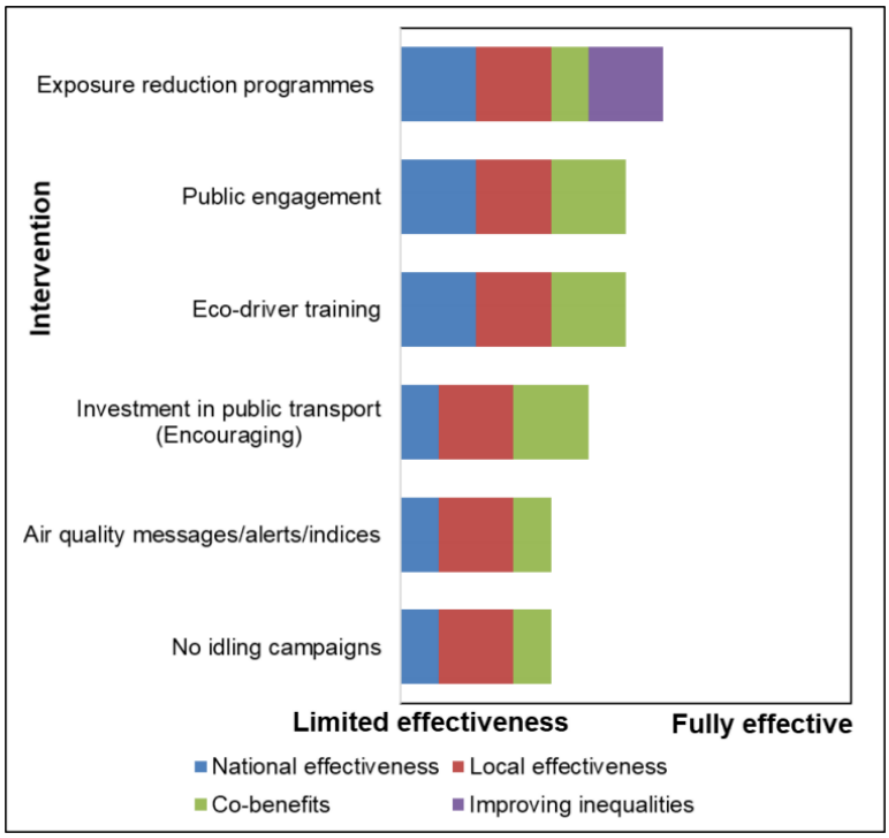
Behavioural interventions

Behavioural interventions comprise educational, awareness-raising initiatives, incentivisation, and training. The highest potential to improve air quality and public health outcomes is associated with combining behavioural interventions with other policy or infrastructure-based interventions (for example, improving public transport or cycling

infrastructure and then using behavioural interventions to maximise its use). In this way, behavioural interventions can be used in parallel with other interventions and maximise their potential effectiveness. Little evidence was identified of behavioural interventions that promote alternative methods of transport as having a direct impact on air pollution or health outcomes. However, they should not be discounted, as there is a wealth of evidence showing that removing vehicles from the road can reduce emissions. There is also strong evidence for the health benefits of physical activity associated with active travel, such as walking and cycling.

Raising awareness in itself is not enough to effect change: it must be done in conjunction with other behavioural and non-behavioural interventions. Exposure-reduction programmes have strong potential benefits to vulnerable groups, especially in providing advice on how to reduce personal exposures to air pollutants. These interventions included educational programmes to inform the most vulnerable, with wider potential to help people make better choices about their lives. Such programmes can be targeted to specific groups, with local tailoring of national advice. A lack of stakeholder engagement was identified as a key barrier to their feasibility, however there is a need to improve public awareness of air quality and public health and strengthen the role and awareness of health care professionals for this to be successful.

Figure 34: Selected behavioural interventions' public health impact



Source: Public Health England

Awareness raising

Outdoor air pollution

NICE guidance on outdoor air quality and health (2017) includes recommendations on raising awareness of road-traffic-related air pollution that are based on NICE's guidelines on general and individual behaviour change approaches and community engagement. There is role within awareness raising to focus on engaging the health and care workforce, particularly with regards to ensuring healthcare professionals are aware that information on air quality is available, what it means for patients, and what actions are recommended, to better support meaningful conversations between healthcare professionals, patients, and service users. In addition, local businesses could also be engaged to encourage reducing road-traffic-related air pollution.

NICE recommend providing information on an individual level that includes promotion of the Daily Air Quality Index (DAQI), weather and pollen forecasts, via local communications channels. Other key messages include information on how health is affected by exposure to air pollutants in the long term, as well as during specific periods of poor air quality; the impact of local pollution inside – as well as outside – a vehicle; and how to reduce air pollutants and people's exposure, including the need to reduce the number of motor vehicle journeys where possible, drive in a style that minimises emissions, and change routes to avoid highly polluted areas. Messages can then be maximised through public awareness initiatives such as car-free days and national campaigns such as the annual Clean Air Day.

Advice to vulnerable groups, who are particularly affected by poor outdoor air quality, is recommended by NICE to be provided from healthcare professionals. During any contact with these vulnerable groups, healthcare professionals are recommended to provide general advice on how to avoid contributing to levels of air pollution and raise awareness of how to minimise exposure. This could include advice to avoid or reduce strenuous activity outside, especially in highly polluted locations and particularly if experiencing symptoms, as well as the use of an asthma reliever inhaler more often as necessary.

This is further recommended in the CMO report on air pollution (Whitty et al., 2022), which states that GPs and allied healthcare professionals in the community are well placed to advise patients who are vulnerable to harm from air pollution, in addition to healthcare professionals in other specialities such as paediatrics, cardiology, respiratory medicine and nursing. Training of healthcare staff would support these conversations whereby healthcare professionals are confident to ask vulnerable patients about their air pollution exposure, through increasing the understanding of the health effects of air pollution and how to minimise these.

Furthermore, NICE have also published a research question on the topic of awareness raising, highlighting the need for a robust evidence base on behaviour change interventions, to understand what the effectiveness and cost-effectiveness is of different methods of awareness raising about air pollution (including air pollution alerts) on people's behaviour and on acute and chronic health outcomes.

Indoor air pollution

For indoor air quality, NICE has set out guidance on ways to reduce exposure to indoor air pollution in everyday life as well as measures local councils, landlords, architects, and builders can take (2020). The guidance encourages people to ensure rooms are well ventilated, by opening windows or using extractor fans when cooking, drying clothes inside, using household sprays or solvents and paints. This advice on an individual level, however, must take in to account the current socio and economic landscape, including the cost-of-living crisis, to ensure existing inequalities are not exacerbated. Again, a focus on those who are most vulnerable is imperative: those with compromised immune systems such as pregnant women are advised to reduce their use of aerosols and household cleaning sprays which can all emit pollutants. The risk is higher for older people, pregnant women, young children, and people with existing long-term health conditions, as well as those who may have to spend a lot of time at home.

Architects, planners, and builders are also being asked to consider the adoption of a whole-building approach to heating and ventilation in their designs in order to minimise exposure to particulate matter. This includes situating windows away from sources of outdoor air pollution and using building materials that emit low levels of formaldehyde and volatile organic compounds (VOCs).

The CMO report on air pollution (Whitty et al., 2022) recommends that improving indoor air quality starts with raising awareness of the health impacts of indoor air and how to create healthy environments at home, in workplaces, social settings and public spaces. There is evidence to suggest that indoor air quality is often considered to be good, even when measurements indicate that is not. Furthermore, because many indoor spaces are public – such as health facilities, schools, public buildings, shops and workplaces – there are potentially greater opportunities to sustaining good air quality in indoor spaces. The report also makes the case for improving indoor air within homes, as potentially inhabitants have greater control over the indoor air, through their behaviours and choices about produces and building ventilation.

Chapter 7: Recommendations

There is a strong commitment from Leeds City Council to address air pollution and the air quality of the city. In recent years, the multi-agency citywide Air Pollution and Health Group (chaired by the Chief Officer of Health Protection and Sexual Health, Public Health, Leeds City Council) has brought together different partners to focus on mitigating the health impact of those most at risk of the harms of poor air quality. This group provides a forum for partners to ensure a collaborative approach for action, planning, and prevention to address the direct impact of air pollution on health in Leeds and is accountable to the Leeds Health Protection Board. It would therefore serve as an appropriate and accountable partnership to support the translation of recommendations and findings from the HNA into implementable actions across the wider public health system in Leeds.

The following recommendations draw together the findings from across all chapters of this report. Although particular departments, services, and teams may take a lead role on some or all aspects of a recommendation, every recommendation requires a multi-agency partnership approach to responding to the key issues highlighted by both the data and community intelligence presented in the HNA. Draft recommendations were presented and discussed by wider partners at a workshop held in March 2023.

1. Improve access to reliable information and key health messages across the city.

The findings from the survey suggest that there is more that can be done at a local level to improve access to reliable and trustworthy air pollution and forecasts, as well as promote guidance and key messages on health risks and reducing exposure. Existing public information is available via the national Daily Air Quality Index (DAQI), the Clean Air Leeds website, and the Leeds air quality alerts system.

The local air quality alerts system has been developed in partnership by the following Leeds City Council teams: Environmental Health, Resilience and Emergency (RET), Climate, Energy and Green Spaces, and Public Health. This system sends an e-mail bulletin when air pollution levels are forecast to be High or Very High according to the DAQI that sets out the current health advice as promoted nationally by DEFRA (Figure 3). Currently, the local alerts system has all care homes, schools, early years, and GP practices signed up to receive the bulletins. Posters have also been developed to promote sign-up to the alerts system within the city's respiratory clinics.

There is therefore already a good level of information infrastructure in place, however there are considerable opportunities to improve access across the city as well as adapt and target messages where needed to particular communities, populations, and settings.

2. Build stronger engagement with communities at higher risk of the impacts of air pollution.

The data presented on health is helpful for understanding and identifying the populations at higher risk from the health impacts of short and long-term exposure to poor air quality in Leeds. It is worth reiterating, however, that it is not possible from the data presented to

draw conclusions about the associations between disease prevalence and levels of air pollution at a local level. Air pollution is a contributing factor, among many, to the development, onset, and progression of long-term health conditions. However, it is widely accepted from the evidence-base that there are particular populations with a higher vulnerability to the health effects of both short- and long-term exposure to air pollution.

These include:

- Those who are pregnant, especially living in areas of deprivation.
- Children and young people including those with existing respiratory conditions such as asthma.
- Adults with long-term conditions, including asthma, COPD, CHD, and stroke.
- The older adult population, particularly those aged 65 and above.
- Key settings where higher-risk groups are supported, for example early years settings, schools, care homes, and hospitals.
- Key LSOAs of the city where vulnerability to air pollution have been identified, taking into account inner city as well as more rural, outer city populations.

This recommendation will involve effective work that is targeted across the life course and adds value to existing services, projects and pathways. It will be important to ensure that engagement is developed at a system-wide level and does not rely solely on individual-level interventions so that exisitng health inequalities are not exacerbated. Guaranteeing strategic links are made across Leeds, for example with the Marmot City initiative, will support with this.

3. Develop a strong workforce development offer that supports the training needs of the wider public health workforce.

A key mechanism for building engagement with communities also includes support for the workforce that supports them with their health and wellbeing. The wider public health workforce, for example the third sector, housing teams, and social prescribing workers, are a significant asset to the city that have a role in adapting and sharing key messages, advice, and guidance. Ensuring there are a range of workforce development and training opportunities, that are co-developed based on the needs of different sectors and teams, can support to increase the confidence and knowledgebase of the wider public health workforce in terms of air pollution and health.

4. Support health professionals to understand the links between air pollution and health, helping to facilitate meaningful conversations with patients and service users.

The survey highlights that for those with long-term health conditions, particularly respiratory and cardiovascular conditions, there is an opportunity to improve the quality and frequency of conversations with healthcare professionals regarding the risks of poor air quality on health. Both NICE guidance and the CMO report on air pollution also recommend interventions to support this specific section of the workforce. In order to do this, it is

important to understand what the needs of teams are in terms of development, training and resources as well as identifying any existing good practice that can be adapted or shared.

5. Support owners and operators of private buildings and public spaces to promote good indoor air quality

The majority of an adult's day is spent indoors. A focus on indoor air quality remains a relatively emerging area of public health practice, however as per NICE guidance and the CMO report recommendations there are opportunities to influence action on mitigating the health impact of poor indoor air. A first step would be to gain a better understanding of the standards of good air quality indoors, including establishing monitoring where necessary. This recommendation is likely to involve partners from Planning, Health and Safety, and key settings to support with implementing related actions.

6. Promote protective behaviours people can adopt to improve the health effects from indoor air quality.

Unlike outdoor air pollution, indoor air quality is likely to be a health and environmental concept that is less familiar to the general population. It is important that messages are developed that promote evidence-based advice to communicate health and risk, while also taking into consideration the wider social and economic landscape, including the current cost-of-living crisis. Behaviour change initiatives should be embedded within existing pathways and interventions to add value, for example around respiratory health, and should be evaluated where feasible.

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