Diesel exhaust and cancer risk

Emissions from diesel engines are a mix of gaseous compounds and particulate matter. Gaseous compounds include carbon dioxide, water vapour, oxygen, sulphur and nitrogen compounds, carbon monoxide, and low molecular weight hydrocarbons and their derivatives. Particulate matter can contain elemental carbon, organic compounds (including Polycyclic aromatic hydrocarbons, a number of which are known or suspected carcinogens), metals, and other trace compounds. These particles are a public health concern due to their small size (Particulate Matter of ~10 micrometers or less (PM10)) which makes them easy to breathe in and able to reach the deep lung.\(^2,3\)

In June 2012, the International Agency for Research on Cancer updated the diesel engine exhaust classification from *probably carcinogenic to humans* (Group 2A) to *carcinogenic to humans* (Group 1). This category is used when there is sufficient evidence of carcinogenicity in humans.\(^4\) This International Agency for Research on Cancer classification indicates that diesel exhaust damages the DNA, or genetic material, in body cells in a way that leads to cancer, and that this happens in humans. However, this classification does not indicate the extent of exposure required to cause this DNA damage, or the significance of the problem for the general population.\(^5\) The International Agency for Research on Cancer classification of diesel exhaust is based on 'in vitro' (studies of cells in laboratory settings), animal and human studies.\(^6,7\)

*In Vitro Studies*

Studies conducted of cells in laboratory settings such as Petri dishes have shown that diesel exhaust can cause changes in the DNA of those cells. These types of changes are usually necessary for cancer to develop, although not all substances that cause DNA changes also cause cancer.\(^6,7\)

*Animal Studies*

Animal studies have demonstrated that tumours can develop when diesel exhaust particulate is either applied to the skin or administered internally. A number of studies conducted among laboratory animals such as rats have also shown that long-term inhalation of high concentrations of diesel engine exhaust causes lung cancer in these animals.\(^6-8\)

*Human Studies*

People are exposed to diesel exhaust mainly as a result of inhaling the particles and gases, which then enter the lungs. People may be exposed to diesel exhaust at work, at home, or while travelling; and the amount of diesel exhaust to which individuals may be exposed varies. The main challenges in studying the possible health effects of diesel exhaust among people include: difficulty in defining and measuring the level of exposure, as diesel exhaust is chemically complex and many parts of it are also found in other sources; and difficulty in separating out the impact of other cancer risk factors, such as cigarette smoking.\(^3,5,7\)

Lung cancer is the major cancer thought to be linked to diesel exhaust. Most of the recent evidence comes from studies looking at cancer rates among populations that have high levels of exposure to diesel exhaust. Several studies of workers exposed to diesel exhaust have shown small but significant increases in risk of lung cancer. Men with the heaviest and
most prolonged exposures, such as railroad workers,\(^9\) heavy equipment operators, miners,\(^10\) and truck drivers,\(^11\) have higher lung cancer death rates than men who are not exposed to diesel exhaust fumes as a result of their occupation.\(^5,7,12\)

The International Agency for Research on Cancer decision to upgrade diesel exhaust from probably carcinogenic to humans (Group 2A) to carcinogenic to humans (Group 1) followed two papers arising from the Diesel Exhaust in Miners study which were published in the first half of 2012 in the *Journal of the National Cancer Institute*.\(^13,14\) This study looked at exposure levels and cancer rates in a population of more than 12,000 miners at eight non-metal mines in the US, and found substantially higher lung cancer rates among those with the highest exposure. The full cohort results showed significant increases in the risk of lung cancer mortality among underground workers as the level of diesel exposure increased, especially among those who had been employed in the mines for more than five years. This nested case-control study, in which miners who died from lung cancer were compared with matched control miners, showed that, after taking smoking and other lung cancer risk factors into account, miners with heavy exposure to diesel exhaust were three times more likely to die from lung cancer than miners with the lowest exposures.\(^5,7\)

The relationship between lung cancer and exposure to diesel exhaust outside of the workplace has not been studied extensively. Therefore Cancer Council NSW agrees with the conclusion of other reputable cancer organisations, including Cancer Research UK, that diesel exhaust does cause cancer, but the overall risk to the general population is low compared to other risk factors such as tobacco, excess bodyweight, and alcohol.\(^5\)

**M5 East Tunnel Air Quality**

The M5 East tunnel is an especially long – 4km – urban tunnel which is subject to heavy traffic conditions with frequent congestion. Since opening in December 2001 the tunnel has been the subject of controversy surrounding air quality and associated health implications.\(^15\)

In Australia, national air quality standards are set by the Department of Sustainability, Environment, Water, Population and Communities for the following six air pollutants: carbon monoxide, nitrogen dioxide, ozone, sulphur dioxide, lead and airborne particles (Table 1). These standards are based on scientific studies of air quality and human health globally and take into consideration standards that are set by leading organisations, such as the World Health Organization.\(^16\)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Concentration and averaging period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon monoxide</td>
<td>9.0 ppm (parts per million) measured over an eight hour period</td>
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<tr>
<td>Nitrogen dioxide</td>
<td>0.12 ppm averaged over a one hour period</td>
</tr>
<tr>
<td></td>
<td>0.03 ppm averaged over a one year period</td>
</tr>
<tr>
<td>Ozone</td>
<td>0.10 ppm of ozone measured over a one hour period</td>
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<tr>
<td></td>
<td>0.08 ppm of ozone measured over a four hour period</td>
</tr>
<tr>
<td>Sulfur dioxide</td>
<td>0.20 ppm averaged over a one hour period</td>
</tr>
<tr>
<td></td>
<td>0.08 ppm averaged over a 24 hour period</td>
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<tr>
<td></td>
<td>0.02 ppm averaged over a one year period</td>
</tr>
<tr>
<td>Lead</td>
<td>0.5 µg/m³ (micrograms per cubic metre) averaged over a one year period</td>
</tr>
<tr>
<td>Particles as PM(_{10})</td>
<td>50 µg/m³ averaged over a 24-hour period</td>
</tr>
<tr>
<td>Particles as PM(_{2.5})</td>
<td>Advisory reporting standard: 25 µg/m³ over a one day period; 8 µg/m³ over a one year period</td>
</tr>
</tbody>
</table>
Air pollutants of particular interest to cancer risk are particles. The Australian air quality standards relevant to this risk are PM$_{10}$ and PM$_{2.5}$ concentrations, however most current air quality monitoring systems generate data based on PM$_{10}$ measurement only. The Australian air quality standards provide a maximum concentration level averaged over a 24 hour period which acts as a short term exposure guideline. Meeting the guideline values for the 24 hour average will protect against peaks of pollution that would otherwise lead to substantial excess morbidity or mortality.\textsuperscript{17} A study conducted on behalf of Channel 7 by CETEC Professional Scientific Solutions, a technical risk management consultancy, to investigate air quality within a car while travelling through the M5 East tunnel, found that the net exposure of particles for an individual would be below the 24 hour exposure limit.\textsuperscript{18} In addition, the NSW Roads and Traffic Authority monitors M5 East air quality at four monitoring sites. Table 2 shows the September 2012 validated air quality monitoring data, with monitoring site U1 of most relevance to the M5 tunnel air quality. Across the month the particle levels ranged from 5.5 at monitoring site T1 to 34.7 at monitoring site CBMS. The highest PM$_{10}$ (µg/m$^3$) did not however exceed the Australian air quality standards.\textsuperscript{19}

<table>
<thead>
<tr>
<th></th>
<th>T1 Thompson St</th>
<th>U1 Jackson Pl</th>
<th>X1 Wavell Pde</th>
<th>CBMS Gipps St</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest PM$_{10}$ (µg/m$^3$)*</td>
<td>32.9</td>
<td>32.0</td>
<td>30.9</td>
<td>34.7</td>
</tr>
<tr>
<td>Lowest PM$_{10}$ (µg/m$^3$)*</td>
<td>5.5</td>
<td>7.6</td>
<td>7.6</td>
<td>6.5</td>
</tr>
</tbody>
</table>

* averaged over a 24-hour period

The sole epidemiological study that has specifically investigated lung cancer risk in association with the M5 tunnel concluded that a causal association between air pollution from the M5 East tunnel and lung cancer is unlikely. This conclusion was based on a number of observations, including that: overall levels of air pollution are consistent with levels in other areas and appear to be dominated by sources other than the tunnel; overall trend in air pollutants tend to be decreasing; and increases in lung cancer in the areas around the tunnel appear to have predated the tunnel opening.\textsuperscript{20}

While there may be other health implications associated with diesel exhaust in the M5 tunnel, the evidence does not support a causal association between lung cancer and diesel exhaust in this setting. Cancer Council NSW supports the continued monitoring of air quality in the M5 East tunnel, as well as lung cancer incidences in the tunnel surrounding areas.
References


15. Longley I, Kelly F. *Air quality in and around traffic tunnels*. Commonwealth of Australia, as represented by the National Health and Medical Research Council; 2008.


