1. Introduction

1.1 My name is Colin Davis. I hold the Degree of Bachelor of Science in Psychology (First Class Honours and University Medal) from the University of New South Wales (Sydney, Australia) and a PhD in cognitive psychology, also from the University of New South Wales. Since 2013 I have been Chair in Cognitive Psychology at the University of Bristol.

1.2 I have previously given evidence to this inquiry in which I noted the impacts of aircraft noise on cognitive processes (and in particular, children's learning) and on climate anxiety. I also drew the Enquiry's attention to recent scientific work estimating the mortality cost of carbon emissions, and the implications for planned expansion of Bristol Airport.

2. New evidence on air pollution

2.1 Since I gave evidence to the inquiry a new report has been published by the World Health Organisation[1] that is highly germane to the issues that have been considered by this inquiry. In the light of this new evidence Inspector Ware has given me specific permission to comment on this new report and its significance for this inquiry.

2.2 The World Health Organization (WHO) guidelines are recognised as the international benchmark for setting air quality standards, and have informed air quality goals set by the UK. WHO guidelines are devised by a global group of experts based on a robust and comprehensive review of the scientific literature, following a rigorously defined methodology. The process is overseen by a steering group hosted and coordinated by the WHO European Centre for Environment and Health.

2.3 The WHO report issued in September introduces new guidelines on the safe levels of a number of well-studied air pollutants. These new guidelines have been motivated by accumulating scientific evidence concerning the negative effects of exposure to these pollutants.

2.4 The last time that WHO air quality guidelines were updated was in 2005 (*Air quality guidelines – global update 2005. Particulate matter, ozone, nitrogen dioxide and sulfur dioxide*;

[1] World Health Organization. (2021). WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. World Health Organization. https://apps.who.int/iris/handle/10665/345329.

WHO Regional Office for Europe, 2006; ISBN 92 890 2192 6). In the intervening years there has been a considerable advance in our understanding of the effects of air pollution on human health and a substantial increase in the evidence base. New studies have combined ground-based measurements with satellite remote sensing instruments, as well as advances in chemical transport models. These studies have provided further evidence of adverse health effects. Indeed, as the new report notes, "Since [the 2005 guidelines] were issued, air pollution has become recognized as the single biggest environmental threat to human health based on its notable contribution to disease burden" (p. 2).

3.What has changed?

3.1 There are now large-scale studies that have reported adverse effects on health at much lower levels of air pollution than previously. Health effects of air pollution have now been studied in most WHO regions; in contrast, almost all evidence underpinning the *Global update 2005* came from studies in Europe and North America.

The new evidence base includes large-scale collaborations such as the Multi-Country Multi-City (MCC) Collaborative Research Network[2], which combines multiyear data from 652 cities across the world in a single joint analysis of the short-term effects of PM2.5, ozone, nitrogen dioxide and carbon monoxide, the European Study of Cohorts for Air Pollution Effects (ESCAPE)[3], which includes data from 36 different cohorts, and the Global Exposure Mortality Model (GEMM)[4], which includes data from 41 cohorts from 16 countries across the globe.

3.2 There has been progress in understanding which sources and/or physicochemical characteristics of airborne particulate matter contribute most greatly to toxicity. In addition, there have been refinements in methods for assessing exposure to air pollution, larger data sets, advances in statistical analysis techniques, and developments of causal modelling in epidemiology.

3.3 There have been recent systematic reviews and metanalyses of the effect of long-term exposure to pollutants on all-cause and cause-specific mortality; notable reviews have focused on PM (Chen & Hoek, 2020), NO_2 and O_3 (Huangfu & Atkinson, 2020). There have also been systematic reviews and metanalyses of the effect of short-term exposure to sulfur dioxide (SO_2; Orellano, Reynoso & Quaranta, 2021) and the impacts of short-term

[2] Chen et al., (2021); Liu et al., (2019); Meng et al., (2021); Vicedo-Cabrera et al., (2020).
[3] Beelen et al., (2014)
[4] Burnett et al., (2018)

exposure to ozone, nitrogen dioxide, and sulfur dioxide on emergency room visits and hospital admissions due to asthma (Zheng et al., 2021).

3.4 Air pollution has now been implicated in the development or worsening of several health conditions not considered in previous research. These include, among others, asthma, diabetes, reproductive outcomes and several neurocognitive end-points.

4. Nitrogen dioxide (NO_2)

4.1 Nitrogen dioxide is spontaneously produced when nitric oxide emissions from surface traffic and aircraft is exposed to air, resulting in a reddish-brown gas with a pungent odour.

4.2 The contribution of airports to ambient levels of NO_2 has recently been confirmed during the pandemic. During 2020, with passenger numbers down by about 90%, the levels of NO2 near Heathrow and Gatwick were around half the pre-pandemic levels.

4.3 The proposed development is associated with an increase in NO_2 levels at 137 of the 138 human exposure locations for which data are provided in Table 7A.1 of the Environmental Statement Addendum (ESA).

4.4 The criterion level of NO_2 against which air quality impacts are assessed in the Environmental Statement is an annual mean concentration of 40 $\mu g\ m^{-3}$ (micrograms per cubic metre), which corresponds to the guideline specified in the WHO *Global update 2005*. According to the original Environmental Statement, expansion to 10 or 12 million passengers per annum (mppa) would result in some concentrations above this air quality objective, but these levels would be confined to the airfield and areas close to the A38, areas where members of the public are not regularly present.

4.5 These effects can be seen in Figure 1, which is reproduced from the Environmental Statement Addendum (Fig 7.1, p. 100). The areas shaded dark orange and red have annual mean NO_2 concentrations above 40 $\mu g\ m^{-3}$ in the 10 mppa scenario (these areas are larger in the 12 mppa scenario).

4.6 According to the submission BAL/3/1 by Martin Peirce, expansion would result in 'moderate' or 'slight' impacts at >50 receptors, but "concentrations at all receptors remain comfortably below the AQO, with a maximum NO_2 concentration of 35 $\mu g\ m^{-3}$".

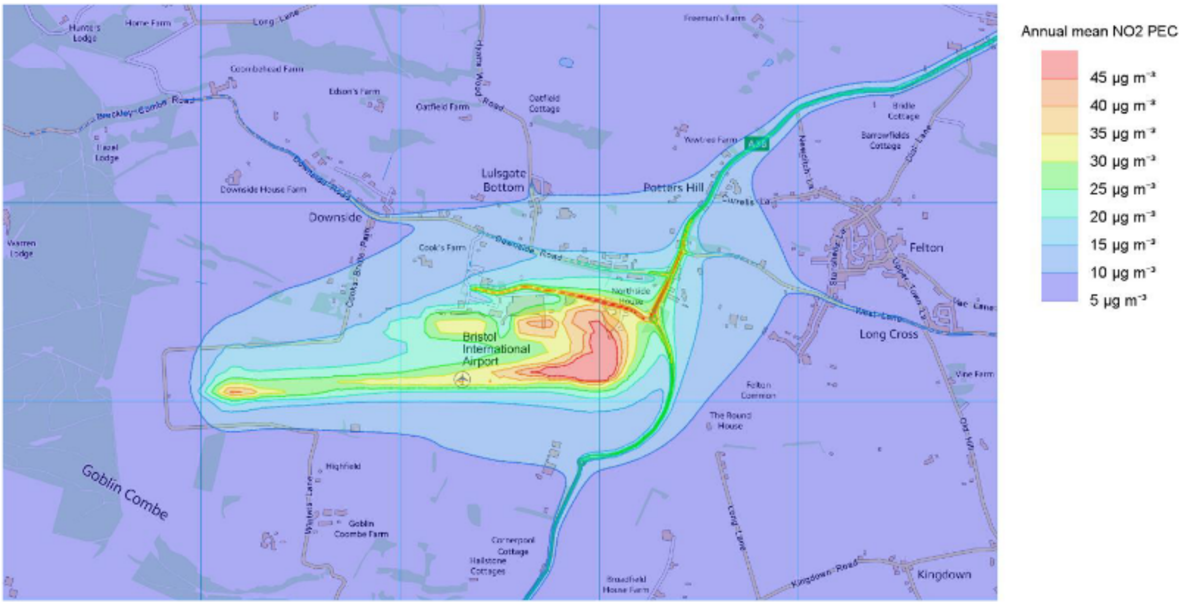

Figure 1. Annual mean NO_2 concentrations for the 10 mppa scenario (reproduced from Figure 7.1 of the Environmental Statement Addendum).

4.7 Table 7A.1 in Appendix 7A of the ESA lists modelled annual mean concentrations of NO_2 for 138 receptors representing locations where people are present [5], together with the Predicted Environmental Concentration (PEC) as a percentage of the Air Quality Assessment Level (AQAL), set at 40 µg m^{-3}. None of these percentages exceed 100%, with the highest being 72.6%, and the mean value being 35.4%. These values (plotted in Figure 2a) were presented as support for the conclusion that the air quality impacts of the Appeal Proposal were "not significant."

4.8 However, the WHO guideline update recommends a reduced Air Quality Guidance (AQG) level for No_2 of 10 µg m^{-3}. This represents a 75% reduction of the 40 µg m^{-3} recommended level from 2005.

4.9 As a consequence, the regions shaded blue, green and yellow in Figure 1 are all greater than the new WHO AQG level. For example, the areas marked in green would have annual mean NO_2 concentrations 2.5 times greater than the new guidance level. Rather than being "comfortably below the AQO", a maximum NO_2 concentration of 35 µg m^{-3} would be 3.5 times greater than the new guidance level.

[5] 5 of the receptors have subsequently been excluded because they "have been confirmed not to represent relevant exposure".

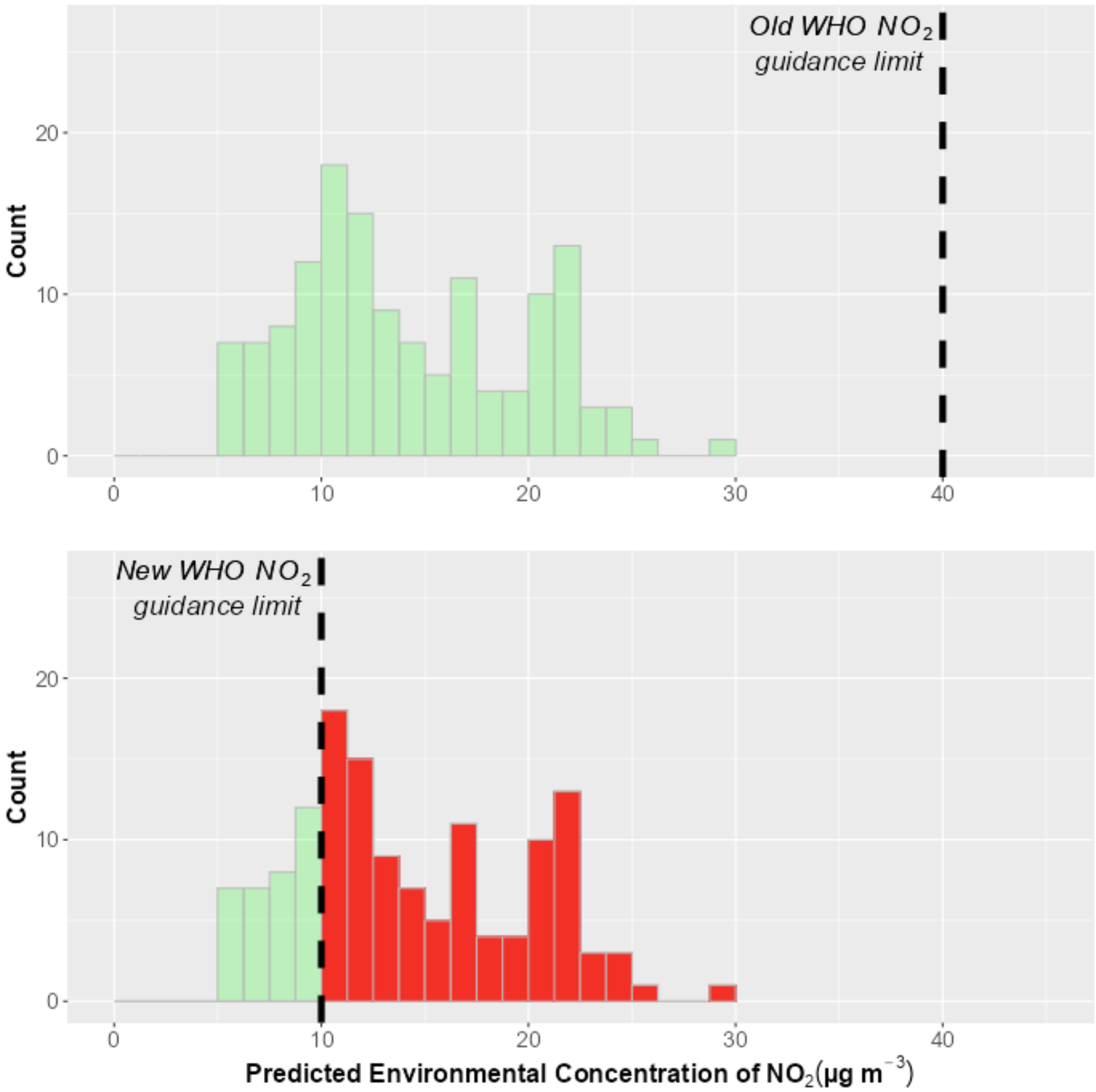

Figure 2: (a) Top panel. Predicted annual mean NO_2 concentrations, plotted relative to the old WHO air quality guidance limit of 40 $\mu g\ m^{-3}$. (b) Lower panel. The same concentrations plotted relative to the new WHO air quality guidance limit of 10 $\mu g\ m^{-3}$. Bars in red represent exposure locations that exceed the new guidance limits.

4.10 As can be seen in Figure 2(b), with the revised AQG level of 10 $\mu g\ m^{-3}$, 104 (75%) of the receptors exceed 100%, with the mean value being 141.7%. That is, based on the airport's own environmental statement, most of the assessed areas in the vicinity of the airport will exceed the new WHO AQG level, with 22% having mean concentrations of at least double the recommended level.

4.11 The new recommended level is informed by evidence discussed in a systematic review commissioned by WHO (Huangfu & Atkinson, 2020). The certainty of the evidence was rated as high for COPD mortality and moderate for non-malignant respiratory mortality and acute lower respiratory infection mortality. A 10 µg m^{-3} increase in NO2 was associated with a RR of 1.03 for COPD mortality. That is, if COPD mortality in a population exposed to nitrogen dioxide at the AQG level is arbitrarily set at 100, then it will be 103, 106 and 109, respectively, in populations exposed to nitrogen dioxide at concentrations of 20 µg m^{-3}, 30 µg m^{-3}, and 40 µg m^{-3}.

5. PM 2.5

5.1 $PM_{2.5}$ refers to particulate matter smaller than 2.5 µm in diameter. $PM_{2.5}$ particles are chiefly produced through the combustion of fuel. Because of their microscopic size, these tiny particles can penetrate deep into the lungs and can also enter the bloodstream, making them extremely hazardous to human health.

5.2 The WHO *Global update 2005* set a guideline level for $PM_{2.5}$ concentrations of 10 µg m−3 as an annual mean. England's Clean Air Strategy sets an exposure reduction target of reducing the number of people living in locations above the WHO guideline by 50% by 2025, compared to a 2016 baseline.

5.3 There were 10 exposure locations modelled in the ES that showed annual mean $PM_{2.5}$ concentrations over 10 µg m−3 in at least one of the 2017, 10 mppa and 12 mppa scenarios. Submission BAL/3/1 noted that, "The number of receptors over 10 µg m−3 decreases from nine in 2017 to four in 12 mppa. This trajectory is consistent with the target in the Clean Air Strategy (noting that the evaluation years in the Strategy are 2016–2025 rather than 2017–2026)." As can be seen in Figure 3(a), the predicted annual mean $PM_{2.5}$ concentrations listed in Table 7A.3 are all below 10 µg m−3.

5.4 Once again, though, the revised WHO guidelines reduce the recommended threshold value, to 5 µg m−3 in the case of $PM_{2.5}$. Consequently, as can be seen in Figure 3(b), all of the measured locations exceed the new recommended value.

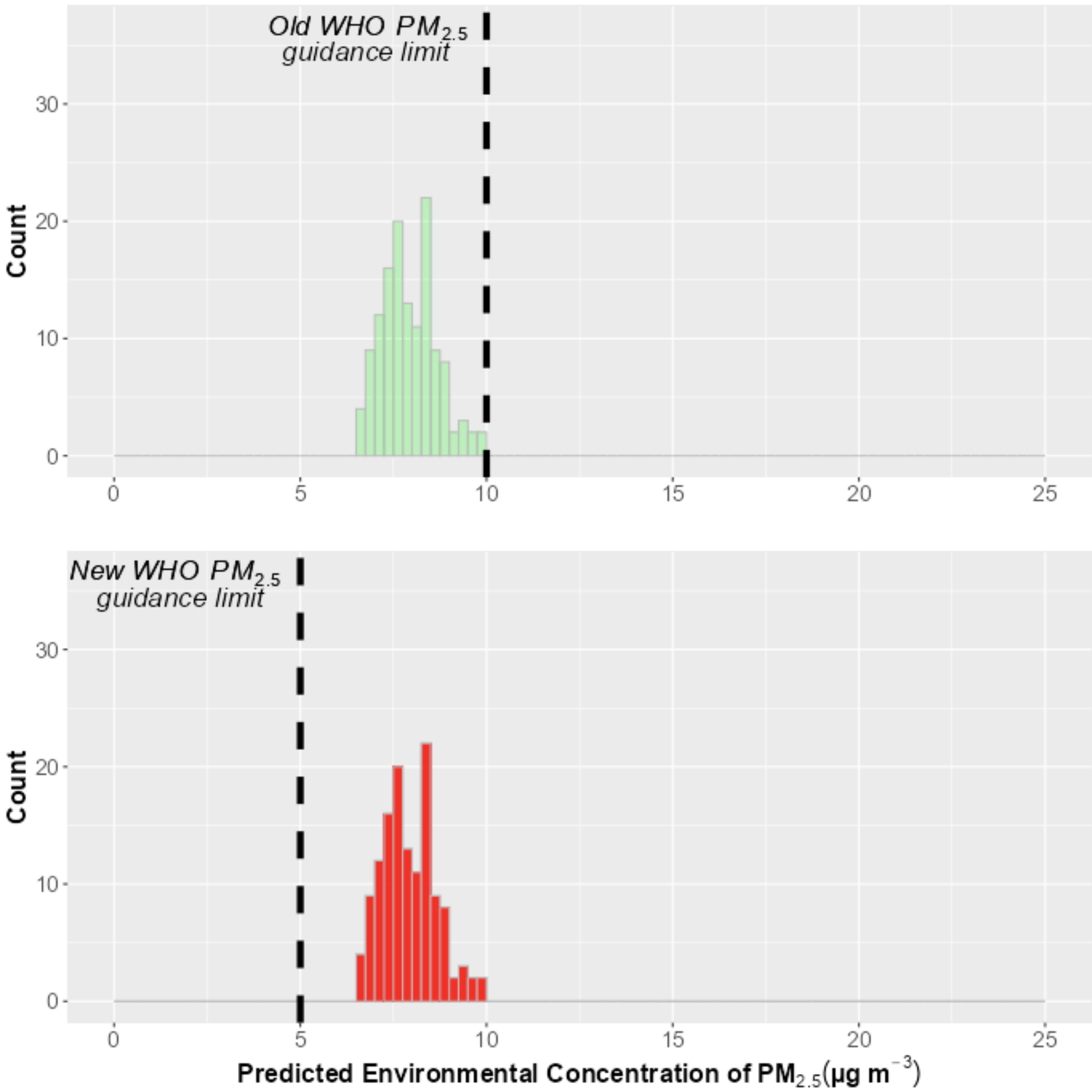

Figure 3: (a) Top panel. Predicted annual mean $PM_{2.5}$ concentrations, plotted relative to the old WHO air quality guidance limit of 10 $\mu g\ m^{-3}$. (b) Lower panel. The same concentrations plotted relative to the new WHO air quality guidance limit of 5 $\mu g\ m^{-3}$. Bars in red represent exposure locations that exceed the new guidance limits.

5.5 The new recommended level is informed by a wealth of new evidence. There is now strong evidence of causal relationships between PM2.5 air pollution exposure and all-cause mortality, as well as acute lower respiratory infections, chronic obstructive pulmonary disease (COPD), ischaemic heart disease (IHD), lung cancer and stroke (Cohen et al., 2017; WHO, 2018). A growing body of evidence also suggests causal relationships for type II diabetes and impacts on neonatal mortality from low birth weight and short gestation.

5.6 The systematic review by Chen & Hoek (2020) includes 25 studies on long-term PM2.5 exposure and all-cause mortality, around half of which were published within the last five years. Many other studies were included that examined the effect of long-term PM2.5 exposure in circularity mortality and respiratory mortality.

5.7 The systematic review reports a linear HR of 1.08 per 10-µg m³ increase in PM2.5 for all non-accidental mortality. That is, if mortality in a population exposed to PM2.5 at the new WHO guidelines of 5 µg m−3 is arbitrarily set to 100, then it will be 104 in populations exposed to PM2.5 at a mean concentration of 10 µg m−3.

6. Other pollutants

6.1 Similar concerns apply to other pollutants considered in the new WHO guidelines.

6.2 PM_{10} refers to particulate matter where the particles have an aerodynamic diameter equal to or less than 10 µm. The new report reduces the guideline annual mean values from 20 µg m−3 to 15 µg m−3.

6.3 The Who report released in September 2021 also specifies new recommendations for ozone, sulfur dioxide and carbon monoxide, pollutants not considered in the Environmental Statement.

7. Summary

The airport's own measurements for pollutants including NO_2 and $PM_{2.5}$ are referenced in the airport's Environmental Statement, the Environmental Statement Addendum and various airport Operating Reports. These estimated mean annual concentrations were below WHO guidelines, which was offered as critical evidence in support of the airport's claim that the air quality impacts of the Appeal Proposal are not proper grounds for refusing the Appeal. However, given the new WHO air quality guidelines -- which are based on a substantial evidence base concerning adverse impacts of these pollutants on public health -- these estimated mean annual concentrations are now above the recommended annual maximum exposure. The proposed development would result in increases in air pollution that would present increased risks to the health of those living and working in the vicinity of the airport.