

## Air Pollution Levels Outside the Capital's Maternity Hospitals

S. A. Lee<sup>1</sup>, K. Flynn<sup>1</sup>, G. Delaunay<sup>2</sup>, M. M. Kennelly<sup>1</sup>, M. J. Turner<sup>1</sup>

1. UCD Centre for Human Reproduction, Coombe Women and Infants University Hospital, Dublin, Ireland.
2. Pollutrack SAS, 91220 Brétigny, France.

### Abstract

#### **Introduction**

The World Health Organisation has identified air pollution as the single biggest environmental threat to human health. There is growing evidence in the literature that air pollution is associated with negative outcomes in pregnancy. The purpose of this study was to measure pollution levels in the immediate surroundings of the three Dublin maternity hospitals by measuring fine particulate matter <2.5 micrometres (PM<sub>2.5</sub>).

#### **Methods**

Data pertaining to levels of PM<sub>2.5</sub> at the three Dublin maternity hospitals were obtained from Pollutrack's records for the time period 25/6/2021-2/12/2021. Results were compared to the 2021 WHO Air Quality Guidelines.

#### **Results**

Average PM<sub>2.5</sub> levels were 9µg/m<sup>3</sup> around the National Maternity Hospital, 10µg/m<sup>3</sup> around the Coombe Hospital and 13µg/m<sup>3</sup> around the Rotunda Hospital. Levels were higher during the day, weekdays and in December. No matter when the PM<sub>2.5</sub> levels were measured, results were higher than those recommended by the World Health Organisation's Air Quality Guideline.

#### **Discussion**

Air pollution levels across Ireland's capital city are higher than recommended by the WHO. This is concerning for the public and in particular for the pregnant population. Going forward, further research is required on the relationship between levels of air pollutants and adverse pregnancy outcomes in Dublin.

**Keywords** - Air pollution, obstetrics, pregnancy, planetary health, environmental health, obstetrics and gynaecology

## Introduction

In the context of the current climate and biodiversity crises, the effects of a changing environment on human health are of increasing importance to health professionals. The World Health Organisation (WHO) has identified air pollution as “the single biggest environmental threat to human health”<sup>1</sup>. The EPA has estimated there to be over 1000 premature deaths caused by air pollution each year in Ireland<sup>2</sup>. The principal air pollutants that cause damage to our health include gases, ozone and fine particulate matter (PM). Fine PM is composed of particles that are suspended in the air and can be in either solid or liquid form, including black carbon, sea salt, dust and condensed particles from chemicals. PM<sub>2.5</sub>, particulate matter particles with an aerodynamic diameter equal to or less than 2.5 µm, is a particularly concerning pollutant for human health. Exposure to these pollutants has been shown to have a positive association with death from natural causes, respiratory disease and cardiovascular disease<sup>3</sup>.

The WHO published updated air quality guidelines in 2021<sup>1</sup>. These guidelines offer quantitative health-based recommendations for air quality management, expressed as long- or short-term concentrations for a number of key air pollutants, including PM<sub>2.5</sub>. Exceedance of these levels is associated with important risks to public health.

There is growing evidence in the literature that air pollution is associated with negative outcomes in pregnancy. A study in 2019 showed that black carbon, a form of fine PM, was found on the maternal and fetal side of term placentas<sup>4</sup>. The black carbon particle load was directly associated with the black carbon load exposure of the woman noted during her gestation. A further study published in 2021 also found particulate matter on the placenta of fifteen women<sup>5</sup>. This study demonstrated that fine PM travels from the lungs to the placenta, where it is absorbed by placental resident cells and then translocated to fetal circulation.

Air pollution has been shown to be associated with low birth weight and intrauterine growth restriction<sup>6</sup>. A 2017 London-based study demonstrated that PM<sub>2.5</sub> was consistently associated with increased risk of term low birthweight<sup>7</sup>. A study in Victoria looked at the link between air pollution and a number of adverse pregnancy outcomes, and found that air pollution was associated with fetal growth restriction<sup>8</sup>.

Studies have suggested a link between air pollution and hypertensive disorders of pregnancy, particularly with exposure to fine PM in the first or second trimester<sup>9-11</sup>. Some studies have demonstrated an association between air pollutants and pre-eclampsia<sup>12,13</sup>. Many of the studies looking at rates of pre-eclampsia also demonstrated a link between air pollution and preterm birth<sup>10,12</sup>. A 2017 systematic review found a significantly increased risk of preterm birth with increase in PM<sub>2.5</sub> exposure throughout pregnancy<sup>14</sup>. In a study of ambient air pollution and pregnancy outcomes, exposure to particulate matter and ozone during pregnancy was associated with higher risk for preterm birth<sup>15</sup>.

Research has suggested air pollution exposure may increase the risk of gestational diabetes<sup>9</sup> - this has also been demonstrated in American and Australian studies looking at pregnancy outcomes after wildfires, which cause increased levels of air pollution<sup>16,17</sup>.

Exposure to air pollution has been linked to early pregnancy loss, with a 2021 Lancet article listing air pollution as a key environmental risk factor for miscarriage<sup>18,19</sup>. A systematic review has also implicated air pollution as a contributing factor to infertility<sup>20</sup>.

Most studies investigating the relationship between air pollution and adverse effects of pregnancy and fetal development have been undertaken in areas of very high pollution levels, including China and the United States<sup>21</sup>. Hence, one can identify a gap in the literature whereby countries of better air quality have not been studied. There are no studies looking at air pollution and pregnancy in Ireland.

In 2019, DPD Group and Pollutrack launched an air quality monitoring programme in cities around Europe, including Dublin. Pollutrack combines fixed sensors with mobile sensors (in this instance on DPD delivery vans) to provide validated measures of air pollution in real time. The Pollutrack sensors are based on the principle of a small optical particle counter, using a statistical approach to increase the accuracy of the measurements<sup>22</sup>. Pollutrack is designed to provide relative measures that will allow a cartography of the pollution heterogeneity across a city. Studies from the United Kingdom have demonstrated that the air around most hospitals exceeds air pollution limits<sup>23</sup>. The purpose of this study was to measure pollution levels in the immediate surroundings of the three Dublin maternity hospitals by measuring PM2.5.

## **Methods**

GPS coordinates were obtained for the three Dublin maternity hospitals: the Coombe Women and Infants' University Hospital (CWIUH), the Rotunda Hospital Dublin and the National Maternity Hospital (NMH). These GPS coordinates were provided to Pollutrack. Data pertaining to levels of PM2.5 in the areas of interest were obtained from Pollutrack's records for the time period 25/6/2021-2/12/2021. Measures were made by passing-by DPD vehicles equipped with Pollutrack sensors, following their normal parcel delivery routes during working hours including weekends and night deliveries. Average PM2.5 levels were calculated for various time periods. Results were compared to the 2021 WHO Air Quality Guidelines.

Traffic levels for the three sites were obtained from the Environment and Transportation Department of Dublin City Council for the time period 25/6/2021-2/12/2021. Traffic levels were measured via sensors embedded under the road surface in traffic lanes surrounding the hospitals. Traffic volume was reported as average number of vehicles passing per day.

## Results

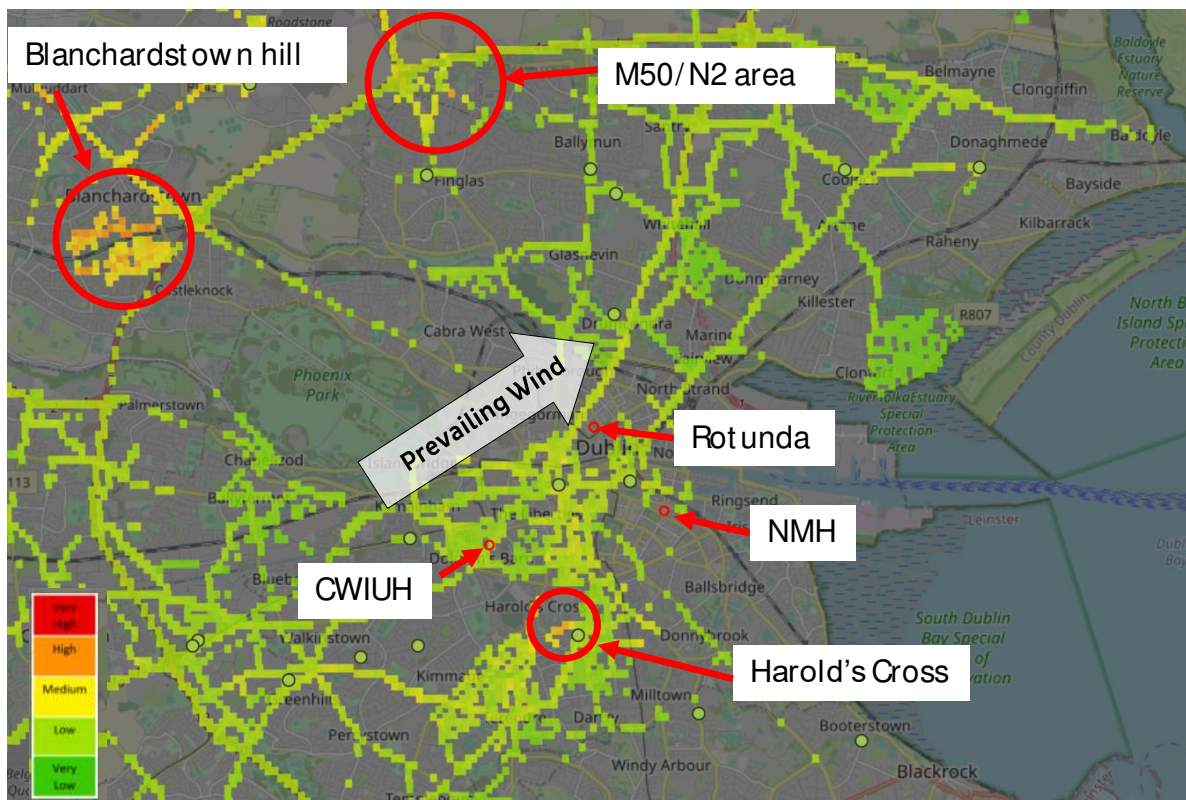
Table 1 shows the mean PM2.5 levels between 25/6/2021 and 2/12/2021 around the three hospitals and for Dublin city overall. WHO 2021 guidelines are provided for comparison in Table 2. The highest level of air pollution is seen at the Rotunda hospital, with an average PM2.5 of 13 $\mu\text{g}/\text{m}^3$ , while the lowest level is seen at NMH, with an average of 9  $\mu\text{g}/\text{m}^3$ . CWIUH matches the Dublin city average of 10  $\mu\text{g}/\text{m}^3$ . All three clinical sites and the city overall have a higher average reading than the WHO 2021 guideline level of 5  $\mu\text{g}/\text{m}^3$ . Number of data refers to the number of unique validated PM2.5 measures per 250mx250m area.

	Dublin	Rotunda (250mx250m)	NMH (250mx250m)	CWIUH (250mx250m)
<b>Full period</b>				
Number of data	5,772,097	538	236	492
Average PM2.5 ( $\mu\text{g}/\text{m}^3$ )	10	13	9	10
Range (min – max)		0 - 70	0 - 48	0 - 73
<b>Monday-Friday</b>				
Number of data	4,768,676	433	215	404
Average PM2.5 ( $\mu\text{g}/\text{m}^3$ )	10	14	10	10
Range (min – max)		0 - 70	0 - 48	0 - 73
<b>Saturday-Sunday</b>				
Number of data	-	105	21	88
Average PM2.5 ( $\mu\text{g}/\text{m}^3$ )	-	10	7	9
Range (min – max)		0 - 65	0 - 33	0 - 37
<b>08.00-20.00 (day)</b>				
Number of data	4,620,276	399	233	421
Average PM2.5 ( $\mu\text{g}/\text{m}^3$ )	10	14	9	10
Range (min – max)		0 - 70	0 - 48	0 - 62
<b>21.00-0700 (night)</b>				
Number of data	1,151,821	139	3	71
Average PM2.5 ( $\mu\text{g}/\text{m}^3$ )	14	11	-	14
Range (min – max)		0 - 64	-	0 - 73
<b>August 1st-31st</b>				
	<b>Dublin (500mx500m)</b>	<b>Rotunda (500mx500m)</b>	<b>NMH (500mx500m)</b>	<b>CWIUH (500mx500m)</b>
Number of data	737	105	52	218
Average PM2.5 ( $\mu\text{g}/\text{m}^3$ )	10	13	10	8
Range (min – max)	0 - 91	0 - 70	0 - 35	0 - 49
<b>December 1st-31st</b>				
Number of data	730	120	61	155
Average PM2.5 ( $\mu\text{g}/\text{m}^3$ )	15	18	13	13
Range (min – max)	0 - 97	0 - 67	1 - 38	0 - 82

**Table 1.** Average PM2.5 readings for 25/6/2021-2/12/2021.

Pollutant	Averaging time	WHO 2021 Air Quality Guideline
PM 2.5 (microg/m3)	Annual	5
	24 hour	15
PM 10 (microg/m3)	Annual	15
	24 hour	45
O3 (microg/m3)	Peak season	60
	8 hour	100
NO (microg/m3)	Annual	10
	24 hour	25
	1 hour	200
SO2 (microg/m3)	24 hour	40
	10 minute	500
CO (mg/m3)	24 hour	4
	8 hour	10
	1 hour	35
	10 minute	100

**Table 2.** WHO Air Quality Guidelines 2021<sup>1</sup>.



**Figure 1.** Prevailing wind direction in Dublin.

The average PM2.5 readings for midweek versus weekend days is also displayed in Table 1. All hospital sites have higher levels of air pollution between Monday-Friday than at the weekend, with the Rotunda and NMH showing more significant reductions at the weekends than CWIUH.

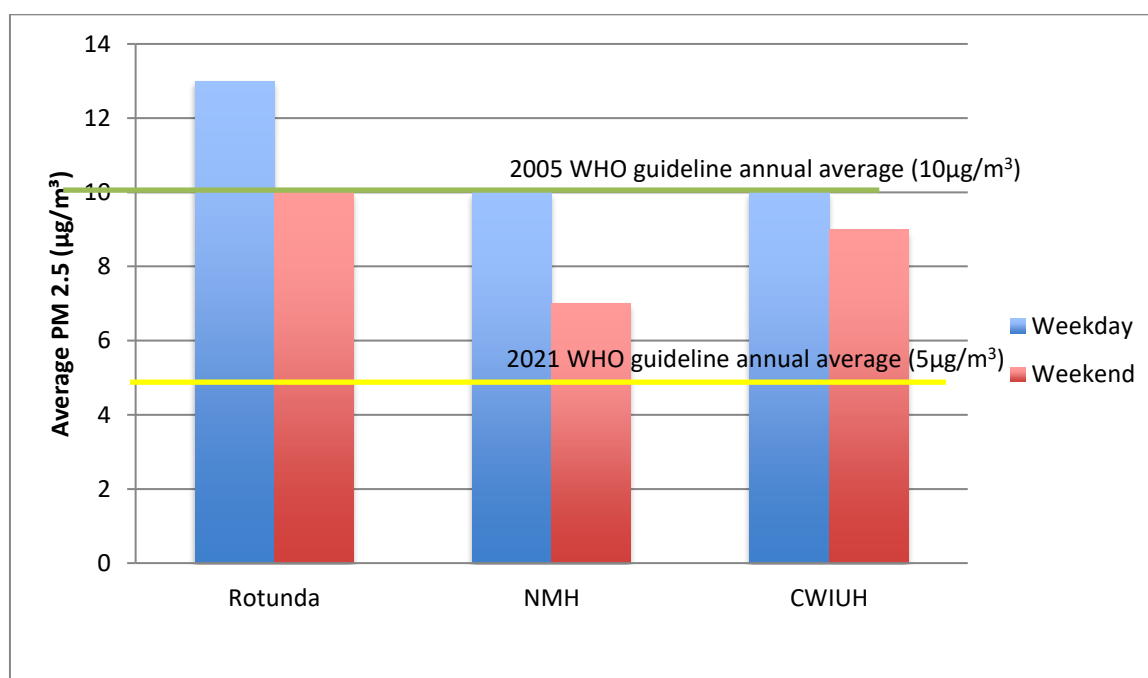
The lowest air pollution level is seen at the site of NMH on the weekend days, with an average PM<sub>2.5</sub> level of 7 µg/m<sup>3</sup>, however, only 21 readings were obtained at this site over weekend days. This level still exceeds the WHO guideline of 5 µg/m<sup>3</sup>.

With regard to traffic levels, this was studied as average number of vehicles passing per day during the time period in question 25/6/2021-2/12/2021. This was 16,022 for the Rotunda, 13,222 for NMH and 7,745 for CWIUH.

Table 1 also displays the differing air quality levels between the hours of 8am-8pm and 9pm-7am. Air pollution levels are higher outside the Rotunda Hospital during the daytime, while CWIUH has higher levels during nighttime hours. There was insufficient data from the NMH site to draw a nighttime average.

The average PM<sub>2.5</sub> levels outside each maternity hospital for the months of August and December 2021 was recorded per 500mx500m area. The highest levels of air pollution are seen at the site of the Rotunda Hospital, both in August and in December, with average levels reaching 18 µg/m<sup>3</sup> in December. Although NMH had the lowest average pollution level overall in the six month period, CWIUH had the lowest level of air pollution during the month of August. CWIUH and NMH both had a level of air pollution lower than the city average during the month of December. The average air pollution levels across the three sites increased from August to December. All readings from all sites are above the WHO 2021 guideline level of 5 µg/m<sup>3</sup>.

Figure 2 shows the average readings for the weekdays and weekends in comparison with the WHO 2021 and the previous WHO 2005 guidelines<sup>24</sup>. While the readings are good in comparison to the 2005 guidelines, they exceed the 2021 guidelines in all sites at all times.



**Figure 2.** Average PM<sub>2.5</sub> levels surrounding the three hospitals from 25/6/21-2/12/21 broken down by weekday and weekend and shown in comparison to WHO 2005 and 2021 guidelines.

## Discussion

In this study, we found that levels of PM<sub>2.5</sub> in the air surrounding all three of the capital's maternity units were above that recommended by the 2021 WHO guidelines on air quality. The levels were higher during the day, during weekdays and in winter months, but were consistently above recommended levels whenever measured. This is a concern given the large number of women in the country that choose to attend these three large city centre hospitals.

Solid fuel burning for home heating is the main source of PM<sub>2.5</sub> pollution in Ireland<sup>2</sup>. This may account for the rise in average PM<sub>2.5</sub> levels across sites seen between August and December. Another important source of PM<sub>2.5</sub> is road transport, which may explain the variation seen between midweek and weekend days, with less road traffic expected on weekend days.

Looking specifically at the sites of Dublin's three maternity hospitals, levels of air pollution similarly exceed the WHO guidelines. The Rotunda Hospital is close to a traffic hotspot within the city at Dorset Street, which may contribute to its less ideal air quality. However, traffic levels alone cannot explain the variation in measurements between the three hospitals - traffic levels are higher at NMH than CWIUH, but CWIUH has a higher average air pollution level. CWIUH's air pollution mostly comes from the Dolphin's Barn crossroads with South Circular Road. The prevailing wind direction, as demonstrated in Figure 1, pushes air pollution from this main crossroads in the direction of CWIUH. In the case of NMH, however, there is no such pollution hotspot upward in the direction of the wind, which results in better average air quality at the hospital. The lesser air quality at the Rotunda may also be impacted the direction of the prevailing winds. CWIUH and NMH may benefit due to their proximity to green spaces.

In their publication "Air pollution and pregnancy", the Royal Australian and New Zealand College of Obstetricians and Gynaecologists provides suggested methods of protection from outdoor air pollution, including use of High-Efficiency Particulate Air filters, wearing fitted respirator masks (e.g. N95), avoiding active transport along traffic routes during rush hours and maintaining healthy nutrition and exercise<sup>21</sup>.

In a joint statement published in September 2021, international medical, public health and scientific experts came together with patient representatives to describe the 2021 WHO guidelines as 'ambitious' but 'necessary'<sup>25</sup>. While Ireland has a relatively good air quality in comparison to other European countries, the authors specified a key message from the 2021 guidelines: that even in low pollution concentrations, 'every reduction in the outdoor concentration of key air pollutants brings health benefits to the surrounding population'. As such, it is imperative that efforts are made in Ireland to keep the level of air pollutants in line with the WHO guidelines. Possible solutions include clean public transport systems, expanding the electric vehicle network, supporting active transport and energy-efficient buildings, amongst others<sup>2</sup>.

Our findings highlight that further research is required to determine whether this poor air quality around our capital's maternity hospitals is causing any harm to mothers and their offspring, and how the quality can be improved to meet WHO recommendations.

**Disclosure:**

Mr. Gilles Delaunay is a staff member at Pollutrack SAS. No funding was received for this study.

**Corresponding Author:**

Dr. Sadhbh Lee

UCD Centre for Human Reproduction.

E-Mail: [Lees5@tcd.ie](mailto:Lees5@tcd.ie)

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