

## Air Quality and Its Association with Cardiovascular and Respiratory Hospital Admissions in Ireland

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### Abstract

#### **Aim**

Cardiovascular (CVD) and respiratory (RSD) diseases are leading causes of morbidity and mortality in Ireland. Clear links have been demonstrated in the literature between poor air quality and these diseases. This study aimed to use routinely available data to examine the relationship between air quality index for health (AQIH) (Available URL: <http://www.epa.ie/air/quality/index/>) and hospital admissions due to CVD and RSD in Dublin City and County between 2014 and 2018.

#### **Methods**

Admission data were collected from the HSE Hospital In-Patient Enquiry (HIPE). Daily count of hospital admissions with Dublin city and county address with a primary diagnosis of CVS and RSD was performed. The daily AQIH were obtained from the EPA for Dublin.

#### **Results**

Overall, AQIH distribution was: Good: 96% (1,575/1,642); Fair: 3% (52/1,642); and Poor: 1% (11/1,642). There were significant rises in admissions with change in AQIH (i.e. from good to very poor) for asthma, chronic obstructive airways disease and heart failure. There were also varying significant changes in short-term admission rates (i.e. up to 72 hours) following change in AQIH.

#### **Conclusions**

This study, using routinely gathered data, suggests that in Dublin city, where the AQ is predominantly good, that change in ambient AQ appears to impact admissions with CVD and RSD.

### Introduction

The detrimental effects of poor air quality (AQ) on human health came to international public prominence in the early-1990s, as a result of numerous high profile pollution episodes in several countries.<sup>1-4</sup> The situation in Ireland was associated with increased morbidity and mortality, and served as the catalyst for the introducing the legislation for the 'smoky coal ban'.<sup>5-7</sup>

A large number of studies have investigated the health risks of poor AQ, and found consistent association between components of ambient air pollution and measures of ill-health.<sup>3, 5</sup> The literature has shown that poor AQ is linked with up to 7 million global premature deaths annually, with an even larger number of hospital admissions.<sup>8</sup>

Published reports have also demonstrated that ambient air pollution contributes to various health problems including cardiovascular system (CVS), and respiratory system (RS) diseases.<sup>3, 9</sup>

The Air Quality Index for Health (AQIH) (Available URL: <http://www.epa.ie/air/quality/index/>) reported by the Environmental Protection Agency (EPA) provides information on short-term health risks associated with ambient AQ.<sup>8, 10, 11</sup>

The aim of this study was to explore the relationship between the AQIH and acute hospitalisations for specific diseases among residents of Dublin city and county between 2014 and 2018. This would allow the authors to add to the body of evidence about the effects of ambient AQ on health in Ireland. This study focusses on CVS and RS diseases as the health outcomes, because they are the leading causes of death and ill-health in Ireland, and are also clinical and public health priorities for the Health Service Executive (HSE).

## Methods

This study used routinely gathered hospitalisation data collected from the HSE Hospital In-Patient Enquiry (HIPE) system. Daily counts of hospital admissions for residents (all ages) with an address in Dublin city and county admitted on same day, 24 hours later, 48 hours later, and 72 hours later were examined. These admissions were for individuals with primary diagnoses of atrial fibrillation (ICD 10AM code I48), heart failure (ICD 10AM code I50), myocardial infarction (ICD 10AM codes I21, I22), asthma (ICD 10AM codes J45, J46), and chronic obstructive pulmonary disease (COPD) (ICD 10AM codes J43, J44) for January 2014 to July 2018. The daily AQIH was obtained from the EPA for Dublin city and county, the less favourable of two results for each day was used as a proxy AQIH for the day. Data were analysed using Excel (Microsoft 2010).

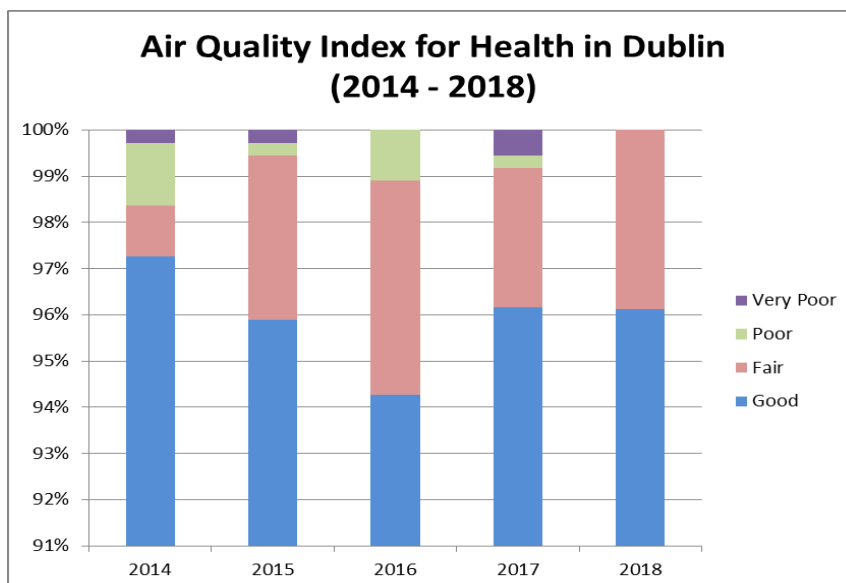
Finally, as this research uses routinely collected data at the population level rather than the individual level, it conforms to the Helsinki Declaration, and does not require approval from an ethics committee.

## Results

The daily hospital in-patient admission data and corresponding AQIH are displayed in Error! Reference source not found. [\(Click to view\)](#), which shows the overall number of admissions over the four-year period. There were no specific patterns observed for CVS diseases, this was not the same for RS diseases, which showed seasonal variations, which corresponded to episodes of poor AQ.

Overall, the AQIH distribution for 2014 to 2018 was: Good: 96% (1,575/1,642); Fair: 3% (52/1,642); Poor: 1% (11/1,642); and Very poor: < 1% (4/1,642). There was a non-significant trend for reduction in the proportion of episodes with poor and very poor AQIH during the interval under investigation ( $p = 0.134$ ) (see **Figure 1**).

**Figure 1: Air Quality Index for Health results in Dublin (2014 - 2018)**



The impact of the AQIH on hospital admission stratified by time is shown in **(Next Page)**. It highlighted that change ambient AQIH had varying impact on cardiovascular and respiratory hospital admissions in Dublin. It showed that asthma-related admissions were significantly impacted for up to 48 hours, while COAD-related admissions were only significantly impacted only 24 hours following any change. It also revealed that heart failure-related admissions were significantly impacted for up to 24 hours following change in AQIH.

**Table 1: Hospital admissions for residents in Dublin stratified by time (2014 - 2018)**

DISEASE CATEGORY		Mean Number of Daily Admissions by AQIH				$\chi^2$ TEST
		GOOD	FAIR	POOR	VERY	
RESPIRATORY DISEASES	<b>ASTHMA</b>					
	Admissions: Same Day	2.68	3.04	4.55	3.25	<b>0.003</b>
	Admissions: 24 hours later	2.67	3.04	4.18	5.75	<b>&lt;0.001</b>
	Admissions: 48 hours later	2.68	3.19	4.09	2.70	<b>0.009</b>
	Admissions: 72 hours later	2.69	3.13	3.00	2.25	0.312
	<b>CHRONIC OBSTRUCTIVE AIRWAYS DISEASE</b>					
	Admissions: Same Day	10.57	11.29	10.82	10.75	0.696
	Admissions: 24 hours later	10.53	12.25	11.91	12.00	<b>0.023</b>
Admissions: 48 hours later	10.54	11.90	11.55	11.75	0.114	
Admissions: 72 hours later	10.58	11.15	9.82	9.75	0.703	
CARDIOVASCULAR DISEASES	<b>ATRIAL FIBRILLATION</b>					
	Admissions: Same Day	3.88	3.73	4.55	2.25	0.425
	Admissions: 24 hours later	3.87	3.96	4.09	3.00	0.881
	Admissions: 48 hours later	3.87	3.88	4.64	6.00	0.249
	Admissions: 72 hours later	3.88	3.77	4.09	4.50	0.931
	<b>HEART FAILURE</b>					
	Admissions: Same Day	3.64	3.58	5.45	2.75	<b>0.038</b>
	Admissions: 24 hours later	3.64	3.69	4.27	5.00	<b>0.047</b>
	Admissions: 48 hours later	3.65	3.81	3.64	3.75	0.961
	Admissions: 72 hours later	3.66	3.58	3.00	2.75	0.619
	<b>MYOCARDIAL INFARCTION</b>					
	Admissions: Same Day	3.25	3.37	3.27	1.75	0.431
Admissions: 24 hours later	3.26	2.98	3.64	1.75	0.248	
Admissions: 48 hours later	3.25	3.33	3.00	2.75	0.904	
Admissions: 72 hours later	3.27	2.98	2.36	3.25	0.303	

The impact of the AQIH on hospital admission stratified by age is shown in Error! Not a valid bookmark self-reference. **(Next Page)**. It revealed that asthma-related admissions were significantly impacted among the 0 – 17 years and 18 – 64 years age groups. It also highlighted that heart-failure admissions were significantly impacted among the 18 – 64 years age group.

**Table 2: Hospital admissions for residents in Dublin stratified by age (2014 - 2018)**

DISEASE CATEGORY		Mean Number of Daily Admissions by AQIH				$\chi^2$ TEST
		GOOD	FAIR	POOR	VERY POOR	
RESPIRATORY DISEASES	<b>ASTHMA</b>					
	Admissions: Same Day – All ages	2.68	3.04	4.55	3.25	<b>0.003</b>
	Admissions: Same Day – 0 – 17 years	1.80	1.72	2.89	1.33	<b>0.021</b>
	Admissions: Same Day – 18 – 64 years	1.74	1.97	1.78	3.50	<b>0.029</b>
	Admissions: Same Day – 65+ years	1.24	1.39	1.33	1.00	0.528
	<b>CHRONIC OBSTRUCTIVE AIRWAYS DISEASE</b>					
	Admissions: Same Day – All ages	10.57	11.29	10.82	10.75	0.696
	Admissions: Same Day – 0 – 17 years	N/A	N/A	N/A	N/A	N/A
	Admissions: Same Day – 18 – 64 years	3.36	8.06	3.20	2.67	0.917
	Admissions: Same Day – 65+ years	7.32	8.06	7.91	8.75	0.342
CARDIOVASCULAR DISEASES	<b>ATRIAL FIBRILLATION</b>					
	Admissions: Same Day – All ages	3.88	3.73	4.55	2.25	0.425
	Admissions: Same Day – 0 – 17 years	N/A	N/A	N/A	N/A	N/A
	Admissions: Same Day – 18 – 64 years	1.30	1.17	1.91	1.00	0.104
	Admissions: Same Day – 65+ years	2.92	2.89	3.22	2.00	0.695
	<b>HEART FAILURE</b>					
	Admissions: Same Day – All ages	3.64	3.58	5.45	2.75	<b>0.038</b>
	Admissions: Same Day – 0 – 17 years	1.00	1.00	N/A	N/A	N/A
	Admissions: Same Day – 18 – 64 years	1.26	1.52	1.67	1.00	<b>0.032</b>
	Admissions: Same Day – 65+ years	3.41	3.28	4.55	2.50	0.164
	<b>MYOCARDIAL INFARCTION</b>					
	Admissions: Same Day – All ages	3.25	3.37	3.27	1.75	0.431
	Admissions: Same Day – 0 – 17 years	N/A	N/A	N/A	N/A	N/A
	Admissions: Same Day – 18 – 64 years	1.96	1.90	2.13	1.50	0.889
Admissions: Same Day – 65+ years	2.17	2.26	2.38	2.00	0.919	

**Abbreviations: N/A: No data available.**

## Discussion

The main findings of this study using routinely gathered information was that there was likelihood of increased hospital admissions for asthma, COAD, and heart failure between 2014 and 2018 with changes in short-term ambient AQIH. These changes were prolonged to varying degrees for both asthma and heart failure. These results were consistent with published reports.<sup>1, 2, 9</sup> These increases also coincided with the influenza season; and each season can vary in

severity depending on the prevailing strain of influenza and the level of vaccination coverage year. These factors were not controlled for in this preliminary study, given that a differential fraction would need to be attributed to each year, depending on the severity of the influenza season, but of note none of the admission years reviewed had a major pandemic like in 2009/2010 season. Furthermore, the annual rates of admission were consistent each year without controlling for changes in severity of seasonal influenza which might suggest that these findings are independent of the season. However, in turn it raises questions on why there were no associations found with the other CVS and RS diseases. It also highlighted age-specific admission patterns, which is not unexpected the respective diseases have specific demographic profiles.

Based on these results, it is fair to say that the AQIH does not have the same detrimental impact on all CVS and RS diseases equally. This might be related to the fact that the AQIH is a composite of different air quality measures (i.e. PM<sub>2.5</sub> particles; PM<sub>10</sub> particles; nitrogen dioxide gas; ozone gas; and sulphur dioxide gas).<sup>10,11</sup> These individual components have different degrees of impact on human health. These have been well documented within the literature.<sup>1,9</sup> However, the AQIH has been shown to be an effective health protection tool for the general population.<sup>5, 10, 11</sup>

A second explanation for the findings might be that the AQIH monitoring network in Dublin may not have been sufficient to accurately characterise the spatial pattern for AQIH around Dublin city and county. This potentially can lead to errors in the daily exposure estimates. These errors may occur because the ambient AQIH network measured concentrations from a small number of monitors, some of which were located next to busy roads. A number of statistical approaches have been reported to alleviate this short-coming, including using modelling and forecasting software.<sup>8,12,13</sup> However, these approaches are not a substitute for improved data collection, and the EPA is currently and continually upgrading and expanding the ambient AQ network and the AQIH towards a station-based index to overcome this issue. Additionally as a reference, monitoring network had 14 stations at the start of 2014 and this was expanded to 18 stations by the end of 2018.

The lack of impact on short-term hospital admission rates (i.e. up to 72 hours following a change in the ambient AQIH) might also be related to the lack of sustained fair, poor, and very poor AQ episodes to generate a sustained impact on human health. This is not a change that would be desirable for long-term human health.

There are a series of limitations associated with this work. The first limitation is that there are low levels of day-to-day variation in ambient AQIH, which might lend to lack of statistical power to establish impact on human health. Given that there are national strategies in place to improve ambient AQ, it is unlikely and undesirable to see deterioration in the levels of air pollutants. The second limitation is related to the lack of individual level information on medical co-morbidities and smoking status. This might have to further quantify the level of impact on persons at high-risk for impact of poor AQ. Access to this level of information would be useful and relevant, but would require ethical approval, which was not necessary to undertake this current piece of work. And the third limitation noted, was that some diseases included might have impact from poor AQ episodes which do not result in hospital admissions. Ambulatory care in general practice, out-patient settings, emergency room visits that do not conclude in hospital admission, and pharmacy attendances are not traditionally captured by the HIPE system. Given that there is no consistent and equitable way to gather any of the aforementioned healthcare interactions, the hospital admissions is the best surrogate for capturing morbidity related to poor AQ for this piece of work

This study suggests that in Dublin city and county, where the AQ is relatively good, that when the AQIH is not good, there is an impact of hospital admissions for individuals with asthma, chronic obstructive airways disease and heart failure. Also that this routinely gathered information is not sufficient to detect impact on certain CVS and RS states, but it is still a suitable measure for providing/raising awareness for the high-risk groups (i.e. persons with CVS and RS diseases; children; and the elderly) and the general population.

**Declaration of Conflicts of Interest:**

The authors declare no conflict of interest.

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