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Knowledge, attitudes, and perception of air pollution in Ireland

K.I. Quintyne [a,b,*], C. Kelly [a]

[a] Health Service Executive (HSE) Public Health, Area A, Dr Steeven's Hospital, Co Dublin, Ireland
[b] School of Public Health, University College Cork, Co Cork, Ireland

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ABSTRACT

Aim: Air pollution remains a major global public health challenge; and Ireland is no exception to the human health implications of exposure ambient air pollutants. Accurate and timely information can be critical to mitigate the harmful effects of air pollution. This study aimed to assess the knowledge, perceptions, and attitudes to poor air quality in Ireland to assist stakeholders in developing and implementing effective communication pieces and policies about the management of air pollution.
Study design: Cross-sectional population-based cohort.
Method: Quantitative data on knowledge, attitudes, and perceptions (KAP) were collected from respondents living across Ireland, and the results were analysed with SPSS (Version 28.0).
Results: Among the 1005 respondents included in this study, the mean [SD] age was 46.1 [15.3] years; 53% were female (n = 530); and 66% and 35% of respondents were aware of air pollution and its adverse effects on health at a national and local level respectively (n = 668 and n = 353 respectively). In addition, there were significant relationships between socio-demographic and air pollution awareness. There were correlation between respondent's age, gender, socio-economic group, and locality in Ireland.
Conclusion: This study demonstrates that environmental health literacy around air pollution in critically lacking among respondents. Given that air pollution is an increasingly important global priority, opportunities need to create to improve reach and impact of communication of air quality health risk and mitigation measures.

Additions to literature

- The majority of respondents are aware of air pollution as a major environmental issue.
- In terms of knowledge about air pollution, the survey found that the majority of the respondents were aware of the main causes of air pollution, including transport and industry emissions.
- However, there was a lack of understanding of the specific pollutants that contribute to poor air quality, with less than 50% people able to identify PM as a harmful pollutant.

Implications for policy and practice

- Development of policies around air pollution, should be as non-dsicrimtory as possible to allow for raising environmental literacy that will improve overall KAP and reduce poor health-related outcomes.
- Communication pieces within policy development work around air pollution should be aware of and take steps to address these deficits, as improving environmental literacy and increasing awareness of air quality issues is key in motivating individuals to make necessary behaviour changes.
- It is important that when developing any air pollution communication campaigns, that is critical to identify and promote integrated measures that will meet requirements for the widest audience, and also deliver on wider overall objectives of mitigation of poor air quality.

1. Introduction

Air pollution has been declared the leading environmental toxin, and responsible for an annual estimated 4.2 million premature deaths worldwide in 2016 (i.e. approximately 8% of all deaths globally) [1–3]. Some 91% of those premature deaths occurred predominantly in low- and middle-income countries. The World Health Organization (WHO)

* Corresponding author. HSE Public Health, Area A, Dr Steeven's Hospital, Co Dublin, Ireland.
E-mail address: keithi.quintyne@hse.ie (K.I. Quintyne).

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reported in 2016, almost 58% ambient air pollution-related premature deaths were due to ischaemic heart disease (IHD) and stroke, while 18% deaths were due to chronic obstructive airways disease (COAD) and acute lower respiratory respectively, and 6% of deaths were due to lung cancer [1].

There are numerous pollutants that can result in poor ambient air pollution. However, a select group have well-established human health impact as reported by WHO, and these include and are not exhaustive to particulate matter (PM), nitrogen dioxide (NO_2), and ground-level ozone (O_3) [1]. The European Environmental Agency (EEA) has published estimates on the potential burden of poor ambient air quality in Ireland, where it highlights that three major air pollutants (i.e. $PM_{2.5}$; NO_2, and O_3 cause at least 610 deaths annually in 2019) [4]. In addition, it reveals that poor ambient air quality has associated with morbidity for the major ambient air pollutants (i.e. $PM_{2.5}$, NO_2, and O_3) were 120, 12, and 18 years of life lost (YLL) per 100,000 inhabitants [4]. Overall, while Ireland's air quality is generally good, in comparison to other European countries, Ireland's average $PM_{2.5}$ concentration is relatively low [4]. However, Ireland's NO_2 levels are higher than the EU average, particularly in urban setting [4].

Irish research has reported that poor ambient air quality has resulted in increased short-term admissions for cardiovascular and respiratory illnesses [3]. These are in keeping with international evidence [5,6]. In addition, it has also been shown that poor air quality can increase mortality [7]. This research, in particular, was pivotal in supporting changes to national policy avoid protection persons resident in Ireland from anthropogenic sources of air pollution (i.e. the introduction of the 'smoky coal' ban).

Finding satisfactory and sustainable solutions to ambient air pollution is heavily reliant on good multisector engagement, which in turn should support improvement of population level environmental literacy. This mitigation strategy to tackle air pollution is therefore linked to good widespread knowledge, attitudes and perceptions (KAP) about impact of ambient air pollutants.

The above commentary illustrates that air pollution is a major public health problem in Ireland, and will continue to pose threats to health of its residents, unless sustainable counter-measures are not put in place promptly. According to a survey conducted by the Environmental Protection Agency (EPA) in Ireland in 2018, found that people in Ireland were generally aware of the impact of air pollution on health and are willing to take action to reduce it. However, it highlighted that there was a need for further education and awareness-raising around the specific pollutants that contribute to poor air quality and the actions that can be taken to reduce them. To date, there remains a paucity published Irish studies available to date, which means that it has not possible to fully quantify the KAP around the impact of ambient air pollution. This study was therefore designed to assess the KAP to poor air quality in Ireland. This will allow the authors of this study to add to the body of evidence around this area. It will also assist at obtaining information to aid stakeholders to develop and implement effective policies towards the management of air pollution and to ensure improvement in ambient air quality.

2. Methods

2.1. Study design

This study used a cross-sectional design to obtained quantitative data using questionnaires. The questionnaires were administered via telephone. Content and face validity of the questionnaire was determined by a panel of experts.

3. Sampling technique

The LIFE EMERALD project contracted Redline Carr Communications to undertaken population level engagement. The goal of the poll was to measure KAP about air pollution. The team surveyed a nationally representative sample of individuals aged 18 years or older. It utilised a targeted sampling technique to ensure adequate representation of the overall population. The cohort was recruited from a potential target group of over 50,000 possible respondents. Sampling weights were calculated by Redline Carr Communications to adjust for sample design aspects and for nonresponse bias arising from differential response rates across various demographic groups. This was to allow for quotas to be set across gender, age, region, and socioeconomic class, to ensure that the final sample was as representative as possible of the Irish population.

3.1. Data collection and analysis

The survey collection took place from 16th – 21st July 2021. The objectives of the research were met by employing a standardised structured questionnaire to assess KAP that was selected by the LIFE EMERALD project. LIFE EMERALD is part funded by the European Commission LIFE funding programme that will deliver an operational 3-day ambient air quality forecast for Ireland, near real-time mapping of the main air pollutants throughout the country and annual mapping of air pollutants across the country. The project will support Irish citizens in making decisions that positively benefit their health on a day-to-day basis.

The final survey instrument comprised of almost 80-item questionnaire in major areas around ambient air pollution: demographic information; attitudes; knowledge; support for policy options; and behaviour.

Face validity of the questionnaire had been established by basing the context of the survey on a comprehensive review of published research around air pollution; including specific reference to sociodemographic, and KAP. In addition, reliable items and subscales from previously published research was incorporated.

3.2. Respondents' consent and ethics considerations

Prior to data collection, respondents' consent was sought. They were informed that their participation was voluntary and refusal to participate would not have any impact on them in anyway. The study respondents were assured of their confidentiality. Personal identifiers were removed after data collection in the summary data to ensure confidentiality. This anonymised data was shared with Health Service Executive (HSE) following informed consent for analysis. This data used in this study was then controlled by the HSE in Ireland. The study authors are registered medical professionals. Legal duties, organisational policies, and good practices were observed in data handling and the data processing for the study was conducted for medical purposes by the authors to inform the statutory function of the HSE in Ireland to improve, promote, and protect the health and welfare of the public (Section 7, Health Act 2004), thus consistent with General Data Protection Regulations (GDPR) and their application in Ireland.

3.3. Data analysis

The data from the completed surveys were analysed using IBM SPSS for Windows version 28.0 (Armonk NY). We analysed the data by applying descriptive statistics. All results were considered significant at $p < 0.05$ (two-tailed). For correlation of metric variables, Spearman rank order (rho), and correlations of nominal variables, the chi-squared test, and for small sample sizes, the Fisher's exact test was used. All results of various statistical tests are of an explorative nature.

A non-conditional multiple logistic regression model was used to identify possible factors (i.e. age, marital status, gender, socioeconomic group, level of education, region of country, living arrangements, and working status) associated with respondents' KAP related to national and local air quality. The results were presented as an odds ratio (OR) value with a 95% confidence interval (95%CI). Spearman's Rank Correlation Coefficient was used to describe the strength and direction of

the relationship among KAP.

4. RESULTS

4.1. Demographics

A total of 1005 respondents were obtained from a network of 40,000. The demographic characteristics revealed: female preponderance of 52.7% (n = 530); the mean (standard deviation) of respondents was 46.0 (15.34) years; the age of the respondents ranged from <20 years of age to > 60 years of age, with the majority (23.0%) in the >60 years of age (n = 231); and female respondents were more than males in most age groups.

The largest socio-economic group responding to the questionnaire was C1 (i.e. lower middle class) at 34.0% (n = 342); with female respondents being greater than males in all groups. The biggest educational group of respondents was the higher secondary group (i.e. leaving certificate) 35% (n = 352); with males respondents being majority in most groups, other than third level post-graduate. The largest group of respondents (28.9%) were from Munster (i.e. Clare, Cork, Kerry, Limerick, Tipperary and Waterford) (n = 290).

4.2. Respondents' awareness

Respondents' awareness of air pollution and impact on human health at a national and local levels are presented in Table 1. Overall, they highlight that the respondents found air pollution to more a national problem than a local problem (i.e. 66.5% vs 35.1% respectively). It was observed that females (i.e. 57.0% and 58.1%) were more aware that air pollution at a national and local level respectively. The C1 (i.e. lower middle class) respondents (i.e. 34.4% and 36.3%) were most aware of air pollution at a national and local level respectively.

Association of Socio-demographic Characteristics on Air Pollution Awareness.

Table 2 shows the results of multiple logistic regression models for the association of socio-demographic characteristics on air pollution awareness. It was observed that males were half as likely to be aware of air pollution as females. The A (i.e. upper middle class) are more likely to be aware of air pollution (4.47) at a national level. In contrast, younger age groups (i.e. 30–39 years and 40–49 years) were more likely to be aware of air pollution (i.e. 1.75 and 1.63 respectively) at a local level. Respondents living in Dublin, Rest of Leinster, and Munster were aware (i.e. 2.62, 1.83 and 1.90 respectively) of air pollution at a local level.

4.3. Respondents' attitudes

Fig. 1 shows the attitudes of air quantity and related information around risks among respondents. The largest proportion of respondents at 52.4% (n = 485) identified climate change the leading pressing environmental issue facing Ireland; while only 8.2% (n = 76) identified air pollution as a pressing environmental issue. More than 70% of the respondents had already taken measures to air pollution and to improve the quality of the air in their local areas. Although over 80% agreed that air pollution posed a serious health risk to the public, 30% of respondents believe that air pollution is only a problem in and around cities.

With respect to particulate matter (PM), most of the respondents at 49.4% did not know this was one of the main air pollutants in Ireland. In addition, the most of them at 37.1% did not know that PM increased chances of unfavourable health outcomes; but largest proportion of them at 34.7% were aware that industry was a major source of PM in Ireland.

On the subject of nitrogen dioxide (NO_2), the majority of the respondents at 49.0% did know this was one of the main air pollutants in Ireland. Furthermore, the most of them at 33.1% did not know that NO_2

Table 1
Respondents' awareness of air pollution and impact on human health.

Variable (n = 1005)	Respondents' awareness of air pollution as a national problem			Significance level
	No N (%) (n = 337)	Yes N (%) (n = 668)	Total N (n = 1005)	
Age				$X^2 = 3.063$ p = 0.547 df = 4
≤ 30 years	47 (29.2)	114 (70.8)	161	
30–39 years	79 (35.4)	144 (64.6)	223	
40–49 years	75 (36.1)	133 (64.6)	208	
50–59 years	56 (30.8)	126 (69.2)	182	
≥ 60 years	80 (34.6)	151 (65.4)	231	
Marital status				$X^2 = 3.475$ p = 0.482 df = 4
Married	162 (34.4)	309 (65.6)	471	
Living as married/co-habiting	44 (29.5)	105 (70.5)	149	
Single	104 (35.9)	186 (64.1)	290	
Widowed/divorced/ separated	26 (28.0)	67 (72.0)	93	
Prefer not to say	1 (50.0)	1 (50.0)	2	
Gender				$X^2 = 14.775$ p < 0.001 df = 1
Male	188 (39.6)	287 (60.4)	475	
Female	149 (28.1)	381 (71.9)	530	
Socio-economic group				$X^2 = 6.306$ p = 0.390 df = 6
A	4 (14.8)	23 (85.2)	27	
B	46 (36.5)	80 (63.5)	126	
C1	112 (32.7)	230 (67.3)	342	
C2	80 (35.6)	145 (64.4)	225	
D	39 (30.5)	89 (69.5)	128	
E	48 (35.0)	89 (65.0)	137	
F	8 (40.0)	12 (60.0)	20	
What is the highest level of education				$X^2 = 10.690$ p = 0.220 df = 8
No education/only basic education	1 (100.0)	0 (0.0)	1	
Primary school level	3 (33.3)	6 (66.7)	9	
Lower secondary (Junior Certificate)	29 (31.2)	64 (68.8)	93	
Higher secondary (Leaving Certificate)	131 (37.2)	221 (62.8)	352	
Post Leaving Certificate (e.g. VEC)	30 (30.9)	67 (69.1)	97	
Third Level Non-Degree (e.g. Diploma)	53 (35.8)	95 (64.2)	148	
Third Level Degree	66 (31.3)	145 (68.7)	211	
Third Level Postgraduate (e.g. Master, PhD)	23 (24.7)	70 (75.3)	93	
Prefer not to say	1 (100.0)	0 (0.0)	1	
Region in Ireland				$X^2 = 2.580$ p = 0.461 df = 3
Dublin	93 (35.9)	166 (64.1)	259	
Rest of Leinster	87 (31.2)	192 (68.8)	279	
Munster	92 (31.7)	198 (68.3)	290	
Ulster/Connacht	65 (36.7)	112 (63.3)	177	
Current living arrangements				$X^2 = 2.767$ p = 0.837 df = 6
Living in private rented accommodation	85 (34.1)	164 (65.9)	249	

(continued on next page)

Table 1 (*continued*)

Variable (n = 1005)	Respondents' awareness of air pollution as a national problem			Significance level
	No N (%) (n = 337)	Yes N (%) (n = 668)	Total N (n = 1005)	
Living in council provided accommodation	23 (32.9)	47 (67.1)	70	
Living in own house with a mortgage	101 (36.7)	174 (63.3)	275	
Living in own house with no mortgage	87 (31.3)	191 (68.7)	278	
Living in parents'/ family home	39 (30.7)	88 (69.3)	127	
Other	1 (25.0)	3 (75.0)	4	
Prefer not to say	1 (50.0)	1 (50.0)	2	
Current working status				$X^2 = 2.359$ p = 0.884 df = 6
Working full time – working 30 h per week or more	163 (32.3)	342 (67.7)	505	
Working part time – working between 8 and 29 h per week	55 (33.3)	110 (66.7)	165	
Unemployed	17 (30.4)	39 (69.6)	56	
Homemaker	34 (36.6)	59 (63.4)	93	
Full time student	16 (38.1)	26 (61.9)	42	
Retired	49 (35.5)	89 (64.5)	138	
Prefer not to say	3 (50.0)	3 (50.0)	6	
Variable (n = 1005)	**Respondents' awareness of air pollution as a local problem**			Significance level
	No N (%) (n = 652)	Yes N (%) (n = 353)	Total N (n = 1005)	
Age				$X^2 = 19.071$ p < 0.001 df = 4
≤ 30 years	90 (55.9)	71 (44.1)	161	
30–39 years	131 (58.7)	92 (41.3)	223	
40–49 years	135 (64.9)	73 (35.1)	208	
50–59 years	136 (74.7)	46 (25.3)	182	
≥ 60 years	160 (69.3)	71 (30.7)	231	
Marital status				$X^2 = 4.089$ p = 0394 df = 4
Married	320 (67.9)	151 (32.1)	471	
Living as married/co-habiting	91 (61.1)	58 (38.9)	149	
Single	180 (62.1)	110 (37.9)	290	
Widowed/divorced/ separated	60 (64.5)	33 (35.5)	93	
Prefer not to say	1 (50.0)	1 (50.0)	2	
Gender				$X^2 = 6.219$ p = 0.013 df = 1
Male	327 (68.8)	148 ((31.2)	475	
Female	325 (61.3)	205 (38.7)	530	
Socio-economic group				$X^2 = 3.353$ p = 0.763 df = 6
A	19 (70.4)	8 (29.6)	27	
B	83 (65.9)	43 (34.1)	126	
C1	214 (62.6)	128 (37.4)	342	
C2	148 (65.8)	77 (34.2)	225	
D	84 (65.6)	44 (34.4)	128	
E	88 (64.2)	49 (35.8)	137	
F	16 (80.0)	4 (20.0)	20	
What is the highest level of education				$X^2 = 8.084$ p – 0.425 df = 8
No education/only basic education	1 (100.0)	0 (0.0)	1	
Primary school level	5 (55.6)	4 (44.4)	9	
Lower secondary (Junior Certificate)	59 (63.4)	34 (36.6)	93	
Higher secondary (Leaving Certificate)	244 (69.3)	108 (30.7)	352	
Post Leaving Certificate (e.g. VEC)	63 (64.9)	34 (35.1)	97	
Third Level Non-Degree (e.g. Diploma)	96 (64.9)	52 (35.1)	148	
Third Level Degree	130 (61.6)	81 (38.4)	211	
Third Level Postgraduate (e.g. Master, PhD)	53 (57.0)	40 (43.0)	93	
Prefer not to say	1 (100.0)	0 (0.0)	1	
Region in Ireland				$X^2 = 21.187$ p < 0.001 df = 3
Dublin	145 (56.0)	114 (44.0)	259	
Rest of Leinster	182 (65.2)	97 (34.8)	279	
Munster	188 (64.8)	102 (35.2)	290	
Ulster/Connacht	137 (77.4)	40 (22.6)	177	
Current living arrangements				$X^2 = 12.023$ p = 0.061 df = 6
Living in private rented accommodation	144 (57.8)	105 (42.2)	249	
Living in council provided accommodation	41 (58.6)	29 (41.1)	70	
Living in own house with a mortgage	189 (68.7)	86 (31.3)	275	
Living in own house with no mortgage	194 (69.8)	84 (30.2)	278	
Living in parents'/ family home	81 (63.8)	46 (36.2)	127	
Other	2 (50.0)	2 (50.0)	4	
Prefer not to say	1 (50.0)	1 (50.0)	2	
Current working status				$X^2 = 9.501$ p = 0.147 df = 6
Working full time – working 30 h per week or more	314 (62.2)	191 (37.8)	505	
Working part time – working between 8 and 29 h per week	122 (73.9)	43 (26.1)	165	
Unemployed	34 (60.7)	22 (39.3)	56	
Homemaker	61 (65.6)	32 (34.4)	93	
Full time student	24 (57.1)	18 (42.9)	42	
Retired	93 (67.4)	45 (32.6)	138	
Prefer not to say	4 (66.7)	2 (33.3)	6	

increased chances of medical problems; but the greatest group of them at 34.0% were not aware of major sources of NO_2 in Ireland.

It was also highlighted that the majority of the respondents 58.6% (589) did not know where to access information about ambient air quality.

5. Discussion

Exposure to poor air quality is a significant public health issue, having overtaken poor sanitation and lack of clean drinking water as the greatest environmental threat to health [2,4,6,8]. Previous research has found associations between air pollution and chronic respiratory diseases, cardiovascular disease, diabetes, dementia, and premature mortality. Improvements in air quality seen over recent decades have stalled, with the combustion of fossil fuels for road transport still a major contributor to air pollution in Europe [4,8].

There is general agreement that if society was better informed of the association between air pollution and ill health and were aware of

Table 2
Multiple logistic regression models on air pollution awareness.

Variable (n = 1005)	Respondents' awareness of air pollution as a national problem		Significance level	Respondents' awareness of air pollution as a local problem		Significance level
	OR	OR 95% CI		OR	OR 95% CI	
Age						
≤ 30 years	1.205	0.695–2.088	0.507	1.746	1.015–3.003	0.550
30–39 years	0.876	0.556–1.380	0.568	1.628	1.029–2.577	**0.044**
40–49 years	0.906	0.585–1.402	0.658	1.254	0.804–1.955	**0.037**
50–59 years	1.212	0.785–1.874	0.386	0.782	0.495–1.233	0.318
≥ 60 years	Reference	Reference		Reference	Reference	
Gender						
Male	0.617	0.467–0.815	**0.001**	0.765	0.579–1.010	0.059
Female	Reference	Reference		Reference	Reference	
Socio-economic group						
A	4.472	1.076–18.593	**0.039**	1.346	0.327–5.541	0.680
B	1.277	0.469–3.475	0.632	1.779	0.539–5.872	0.344
C1	1.561	0.603–4.039	0.359	2.008	0.638–6.324	0.233
C2	1.481	0.564–3.890	0.426	1.963	0.615–6.267	0.255
D	1.710	0.630–4.641	0.293	2.078	0.635–6.806	0.227
E	1.370	0.510–3.682	0.532	2.227	0.635–6.806	0.183
F	Reference	Reference		Reference	Reference	
Region in Ireland						
Dublin	0.993	0.651–1.515	0.975	2.621	1.672–4.110	**< 0.001**
Rest of Leinster	1.289	0.854–1.945	0.227	1.825	1.171–2.843	**0.008**
Munster	1.329	0.886–1.993	0.170	1.895	1.224–2.933	**0.004**
Ulster/Connacht	Reference	Reference		Reference	Reference	
What is the highest level of education						
No education/only basic education	5.143E-9	–	–	3.8943E-9	–	–
Primary school level	1.425	0.338–6.008	0.629	0.657	0.146–2.958	0.584
Lower secondary (Junior Certificate)	1.049	0.545–2.018	0.886	0.719	0.357–1.448	0.356
Higher secondary (Leaving Certificate)	0.736	0.443–1.226	0.239	0.557	0.321–0.968	**0.038**
Post Leaving Certificate (e.g. VEC)	0.868	0.460–1.636	0.661	0.699	0.355–1.378	0.302
Third Level Non-Degree (e.g. Diploma)	0.782	0.445–1.375	0.393	0.565	0.309–1.036	0.065
Third Level Degree	0.873	0.519–1.467	0.607	0.744	0.420–1.318	0.310
Third Level Postgraduate (e.g. Master, PhD)	Reference	Reference		Reference	Reference	

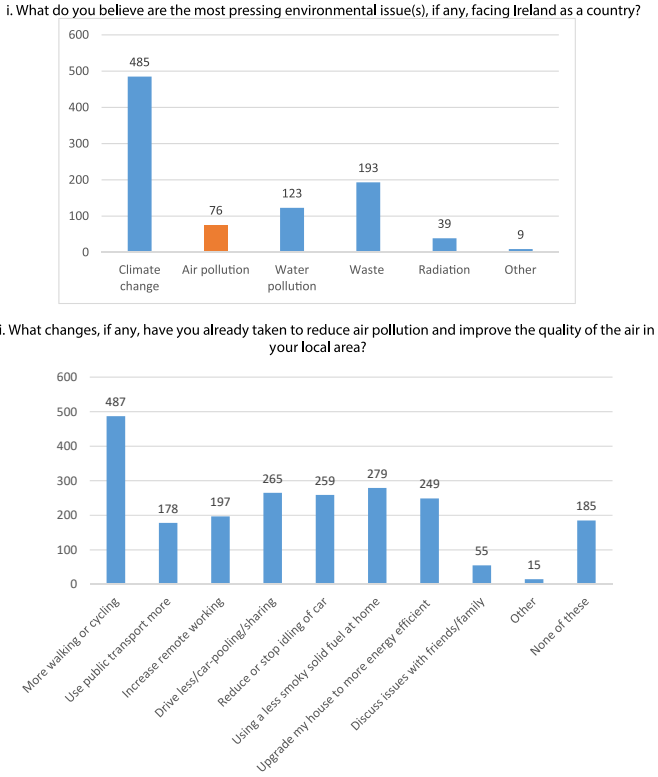

Fig. 1. Respondents' attitudes of air pollution and impact on human health.

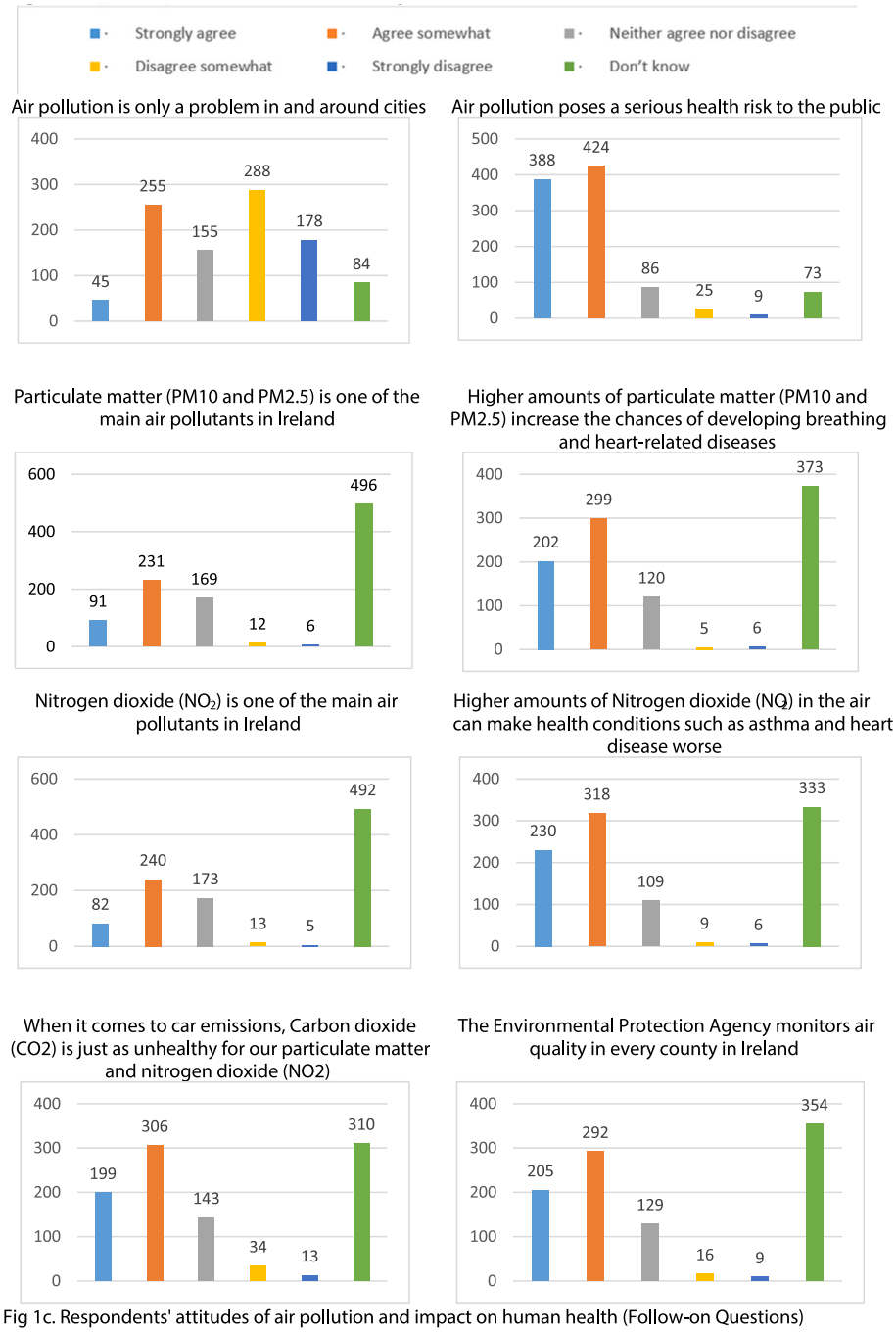

Fig 1c. Respondents' attitudes of air pollution and impact on human health (Follow-on Questions)

Fig. 1. (*continued*).

practical actions to reduce pollution, this could motivate change at a policy level and at an individual level [9,10]. Studies examining public awareness of air pollution and its effects on health have yielded mixed results. Some have demonstrated public concern over air pollution, an awareness of air quality alerts, and changes in activities following air quality alerts [11,12]. On the other hand, others have shown a lack of public awareness and understanding of air pollution, with air quality warnings not being received by the public [13].

This study has highlighted a knowledge gap in Ireland. Despite air pollution being an issue across the country, only 66.5% of survey participants identified it as a national issue and only 35.1% identified it as a local issue. Similar to other studies which have found females to be more concerned about environmental hazards, females were more likely to identify air pollution as both a local and national issue [14]. Younger age groups were more likely to identify air pollution as a local issue – in keeping with the idea of the "generation gap" in knowledge on environmental topics [15]. Those living in Dublin were also more likely to consider air pollution a local issue, perhaps reflecting previous findings that distance to industry has an association with air pollution awareness [16]. Although 81% of respondents agreed that air pollution poses serious health risks, there was a lack of specific knowledge, with only 49.9% agreeing that PM exposure increases ones risk of developing respiratory and cardiovascular diseases and only 54.5% agreeing that NO_2 worsens asthma and heart disease.

Only half of respondents were aware that the EPA monitors air quality in Ireland, and almost 60% of respondents did not know where to find information on air quality. The study did highlight positive measures taken by many to reduce air pollution, with almost half of

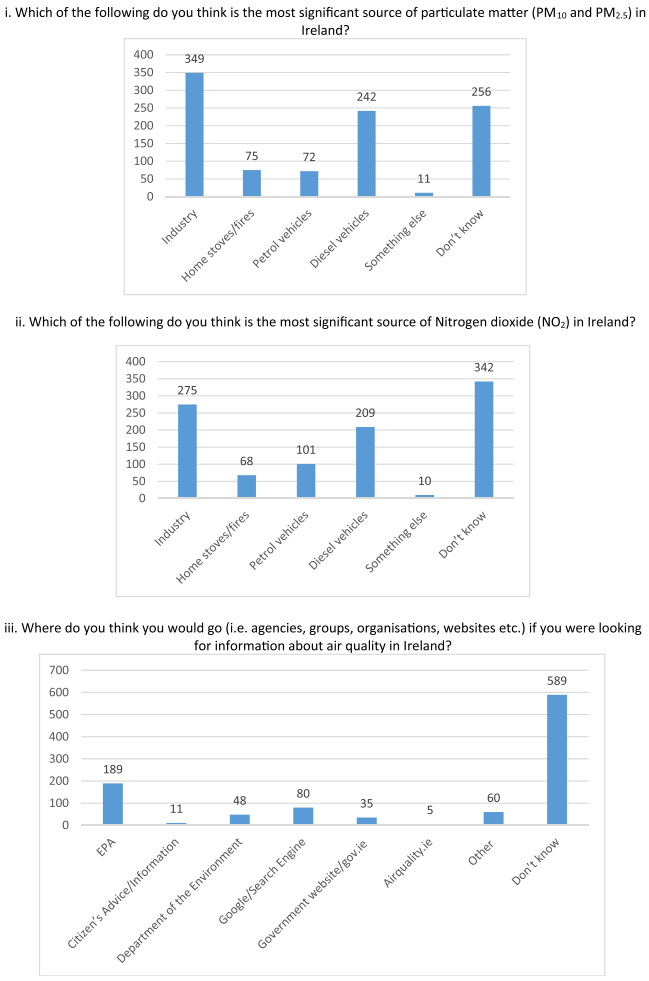

Fig. 1. (*continued*).

respondents walking or cycling more, almost 30% using less smoky solid fuel and almost 25% upgrading their houses to become more energy efficient. However, given the gaps in knowledge identified, it is not surprising that almost 1 in 5 respondents (18.4%) had made no changes to reduce air pollution.

Two overarching issues have emerged from this study, which need to be addressed. The first is in relation to the lack of awareness of air pollution as a problem in Ireland and the lack of understanding about the specific harms of air pollution. The second is in relation to the lack of knowledge about air quality monitoring, and where this information can be accessed. Both need to be addressed in order for individuals to be able to seek out information on air quality, and to be able to take mitigating steps in the event of air quality warnings (for vulnerable individuals this might mean avoiding outdoors exercising or taking additional reliever medication, and for the general population this might mean choosing means of transport with a lower impact on air quality).

In their piece on Environmental Health Literacy, Ramirez et al. recognise a number of challenges in air quality communication – describing issues with information quality as existing communication strategies lack crucial guidance on mitigation measures and long-term health effects, and with information reach as existing dissemination channels are failing to reach vulnerable populations [17]. The European Union Partnership on Air Quality has produced a "*Toolkit - Communicating on air quality and health*" to assist governments and organisations looking to address some of these challenges.

Citizen science has been identified as a tool to engage communities and stakeholders, and in doing so, improve public understanding of air pollution [18]. In Ireland, the Clean Air Together initiative is doing just this, getting members of the public in Dublin and Cork involved in NO_2 monitoring – however, care needs to be taken to ensure that initiatives like this one do not inadvertently provide false reassurance to localities not included.

If the public are well informed about air pollution and its risks, they can utilise the Air Quality Index, and newer technology, like wearable air quality monitors and real-time apps, to make educated decisions which can impact their own, and others' health [8]. However, in communicating air pollution risks, a balance needs to be achieved to ensure precautions taken are measured and does not result in over-medication or unnecessary avoidance of physical activity [9].

Based on the current air pollution situation in Ireland and findings of this work, there are some policy and practice implications that can be considered to improve air quality and reduce negative health impacts associated with air pollution. Here are some potential implications: raising public awareness of health impacts of air pollution and promoting behaviours that reduce emissions can help improve air quality; encouraging the use of cleaner modes of transportation, such as cycling, walking, and electric vehicles, can help reduce emissions and improve air quality; shifting towards renewable energy sources and improving energy efficiency ca help reduce emissions from residential heating and other sources; and strengthen and enforce existing regulations.

6. Conclusion

This study has revealed that the majority of respondents to this survey are aware that air pollution is a major environmental issue. In terms of knowledge about air pollution, the survey found that the

majority of the respondents were aware of the main causes of air pollution, including transport and industry emissions. However, there was a lack of understanding of the specific pollutants that contribute to poor air quality, with less than 50% people able to identify PM as a harmful pollutant. Furthermore, awareness of air pollution was high in: females; respondents in higher socio-economic groups; and respondents aged 30–49 years of age. Therefore, non-discriminatory policies should be formed towards raising environmental literacy around air pollution to improve KAP and related health outcomes. Stakeholders involved in creating communication pieces, and involved in policy development should be aware of and take steps to address these deficits, as improving environmental literacy and increasing awareness of air quality issues is key in motivating individuals to make necessary behaviour changes.

Ethical approval

This anonymised data was shared with Health Service Executive (HSE) following informed consent for analysis. This data used in this study was then controlled by the HSE in Ireland. The study authors are registered medical professionals. Legal duties, organisational policies, and good practices were observed in data handling and the data processing for the study was conducted for medical purposes by the authors to inform the statutory function of the HSE in Ireland to improve, promote, and protect the health and welfare of the public (Section 7, Health Act 2004), thus consistent with General Data Protection Regulations (GDPR) and their application in Ireland.

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Declaration of competing interest

The authors declare no conflict of interest.

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