Report No. 487



Research on the Environment, Health, Consumer Behaviour and the Economy: ESRI Environment Research Programme 2022–2024

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Environmental Protection Agency

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- Provide the Secretariat to the Climate Change Advisory Council and support to the National Dialogue on Climate Action;
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- Promote radon testing in homes and workplaces and encourage remediation where necessary.

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- 1. Office of Environmental Sustainability
- 2. Office of Environmental Enforcement
- 3. Office of Evidence and Assessment
- 4. Office of Radiation Protection and Environmental Monitoring
- 5. Office of Communications and Corporate Services

The EPA is assisted by advisory committees who meet regularly to discuss issues of concern and provide advice to the Board.

EPA RESEARCH PROGRAMME 2021–2030

Research on the Environment, Health, Consumer Behaviour and the Economy: ESRI Environment Research Programme 2022–2024

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Prepared for the Environmental Protection Agency

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This report is based on research carried out/data from August 2022 to July 2024. More recent data may have become available since the research was completed.

The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

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Executive Summary

Continuing the collaboration established between the Economic and Social Research Institute and the Environmental Protection Agency (EPA) in phases I (2016–2018), II (2018–2020) and III (2020–2022) of the research programme on environment economics, this report summarises the findings from phase IV of the programme (2022–2024). A diverse set of research topics was examined, broadly grouped under four thematic areas.

Environment and Health

Four projects, using data from a variety of survey and administrative sources, were carried out to examine the impact of participation in the Clean Air Together (CAT) citizen science project in Dublin on attitudes, awareness and behaviour in relation to air pollution; the healthcare costs associated with poor air and water quality; and equity in environmental exposures.

Evaluation of CAT. Prior to participation in CAT, CAT Dublin participants were more aware of nitrogen dioxide (NO_2) (and other environmental risks) than the general Dublin population aged 18+ years, and more likely to correctly identify the main source of NO_2 pollution. However, nearly one-quarter of CAT Dublin participants did not know the most significant source of NO_2 pollution, and a further one-quarter answered this question incorrectly. While awareness of NO_2 -related issues improved with CAT Dublin participation, there was limited evidence of significant changes in behaviour as a result of participation in CAT.

Healthcare costs of poor air quality. Using administrative and survey data on emergency inpatient hospitalisations, general practitioner visits and prescribed medications dispensed in community pharmacies, the research described a methodology that can be used to assess the healthcare costs associated with healthcare conditions linked to poor air quality. While direct comparisons between the three types of healthcare utilisation could not be made due to differences in data and methodologies, the results highlight that although the overall contact with general practitioner and community pharmaceutical services was far greater than that with emergency inpatient hospitalisations, the much higher unit costs of emergency inpatient care were reflected in much higher overall costs.

Healthcare costs of water-related diseases (WRDs). Much of the existing evidence on the healthcare costs of WRDs is based on localised outbreaks. Examining the national healthcare burden of WRDs in Ireland using a mixture of survey and administrative data and published research, this project estimated that WRDs resulted in healthcare expenditure reaching as much as €20 million in Ireland over the period 2015–2018.

Equity in environmental exposures. An examination of inequalities in average annual concentrations of fine particulate matter ($PM_{2.5}$) and NO_2 air pollution across Census Small Areas in Ireland revealed large differences between urban and rural areas. While there was little evidence of demographic and socioeconomic inequalities across small areas in annual concentrations of $PM_{2.5}$ air pollution, those living in small areas characterised by larger shares of ethnic minorities and rented accommodation had higher annual concentrations of NO_2 air pollution.

Behavioural Science

Six projects employed techniques from behavioural science to provide evidence on more effective communications, the barriers to behaviour change and public perceptions of key environmental issues, while a further study used survey data to examine the intention–behaviour gap in climate behaviour.

Randomised controlled trial of radon test kit uptake. The results of the study showed that using behaviourally informed communications resulted in an almost 50 per cent (11 percentage-point) increase in radon test kit uptake in high-radon areas. Compared with the standard letter, a redesigned letter in the standard envelope generated the largest increase in requests for radon test kits.

Public perceptions of environmental risks. The findings showed that public concern about electromagnetic fields is appropriately low in Ireland. However, when prompted to think about electromagnetic fields, many people reported misconceptions that they cause harm. Intention-behaviour gap in climate policy. Using a "stage of change" approach to investigate the intention-behaviour gap with regard to transport and dietary behaviours, most participants mentioned transport (64 per cent) and home energy use (56 per cent) as daily behaviours that mattered most for their carbon footprint, with very few (4 per cent) mentioning whether they ate or avoided meat. Almost 40 per cent reported having made some change to their transport behaviour to reduce their carbon footprint, with fewer participants reporting changing their diet (26 per cent).

Effect of greenwashing on consumer choice. When presented with three greenwashed and three genuine advertisements, participants in the treatment condition reported greater suspicion of two of the three greenwashed advertisements compared with participants in the control condition. However, they were also more likely to rate two of the three genuine advertisements as greenwashed. Similar patterns were observed on trust in each of the brands and on willingness to purchase from the brand. The research showed that interventions to educate consumers about greenwashing may increase scepticism about environmental claims in general.

Pre-testing of effective eco-labels. The results of the research demonstrated that binary eco-labels can have a positive effect on shifting consumers towards more sustainable clothing products. However, the graded label, inspired by evidence from food choice research, had much stronger effects, i.e. it led to more purchases of more sustainable products.

Interaction between climate attitudes and actions. Using survey data from the 2021 Eurobarometer, the research found significant variation in the size of attitude–behaviour gaps across the EU. Females and those from more advantaged social classes had a smaller attitude–behaviour gap, and a feeling of greater responsibility to act to mitigate climate change was also correlated with a smaller attitude–behaviour gap.

Climate Change

The two projects under the climate change theme aimed to create a better understanding of the emissions embedded in our consumption, using improved data and international comparisons.

Irish consumption-based emissions. Using comprehensive trade flow data for 2017, the research found that consumption-based accounting (CBA) emissions were larger than production-based accounting (PBA) emissions in Ireland. Most of the imported emissions were embedded in the fuel, chemical products and animal agriculture sectors. Exported emissions were concentrated in air transport and animal-related commodities.

Comparing Irish consumption-based emissions. In an international comparison, Ireland had relatively low total PBA and CBA emissions compared with EU and Organisation for Economic Co-operation and Development averages due to its relatively smaller population. However, on a per capita basis, Ireland had higher PBA and CBA emissions. In contrast to other European countries, more than half of Ireland's emissions embedded in fuel were generated from imports from the UK and USA.

Regulation and Enforcement

A final project used detailed EPA data on licensed facilities to examine the effect of enforcement tools on behaviour and emissions.

Prevention and control of pollution in Ireland. Using comprehensive EPA data on licensed facilities' inspections, this research found evidence that escalation of enforcement led to more scrutiny in the form of inspections across all types of facilities. While less frequent violators responded promptly to enforcement pressures, repeat violators showed a persistent offender profile. Moreover, there was no sign of improvement in emission reductions, suggesting that enforcement measures did not trigger investment in pollution abatement technologies.

1 Introduction

The Environmental Protection Agency (EPA)/Economic and Social Research Institute (ESRI) Environment Research Programme brings together a diverse set of research topics with the objective of assessing the ways in which the environment interacts with economic and social conditions and policies. The programme has at its core the ambition to produce fast and focused empirical analysis that employs publicly available data in new ways to generate evidence for policy. Lyons (2019), Ahrens et al. (2020) and Andersson et al. (2023) provide detailed summaries of the topics examined in the first (2016-2018), second (2018-2020) and third (2020-2022) phases of the programme. In this report we synthesise the results from the fourth phase of the programme, which comprised 13 studies, carried out between 2022 and 2024. These studies can be grouped as follows:

- environment and health;
- behavioural science;
- climate change;
- regulation and enforcement.

The research topics for phase IV were selected through a process of dialogue with the EPA and other stakeholders (e.g. the Department of the Environment, Climate and Communications and the Health Service Executive) and are closely related to EPA research themes as set out in the EPA Research Strategy, annual research action plans and thematic research assessments. In some cases, e.g. on the climate theme, the work further developed the research carried out in earlier phases. Other themes, e.g. research on regulation and enforcement, involved new research, using new data sources and methods. Throughout, as in earlier programmes, the EPA and ESRI sought to identify research questions and themes that offered policy relevance and scope for robust empirical analysis.

It is worth summarising the diversity of data and methodological approaches used in the research programme, as it highlights the uses of different approaches for policy analysis and development. First, the research team made extensive use of administrative data in this phase of the programme, building on exploratory analyses in earlier phases. For example, data from the Health Protection Surveillance Centre (HPSC) and Hospital In-Patient Enquiry (HIPE) databases were used to provide estimates of the healthcare costs of water-related diseases (WRDs), while new sources of trade data were used to refine estimates of consumption-based emissions for Ireland, and EPA data on licensed facilities were used to assess the impact of environmental enforcement and inspection on compliance.

Second, data from survey datasets were used to provide additional insights. For example, data from Healthy Ireland and Growing Up in Ireland were used to inform the analysis of the impact of poor air quality on healthcare utilisation. Data from the Eurobarometer survey were used to quantify European citizens' attitudes and actions regarding climate change.

Finally, the use of behavioural science techniques, such as laboratory experiments and field trials, which involves the collection of new data, offers an opportunity to influence the design of policy interventions. In this phase of the programme, six topics used these techniques, providing evidence on topics such as the most effective communication methods to increase the uptake of radon testing, and the particular barriers that underlie the intention–action gap in consumer behaviours with regard to transport and diet.

Much of the research carried out in this phase of the programme has either been published as peerreviewed ESRI reports or has been submitted for publication in peer-reviewed journal articles, with a number of articles already published. In these cases, we summarise the research in this report; additional material can be found in the full publications, which are referenced in each section. ESRI research bulletins, which are shorter, non-technical summaries of published journal articles, have also been produced. In other cases, research has only recently been completed and is awaiting publication, and so this report contains a more detailed account of the work. Full references are provided in the text describing each project.

2 Environment and Health

Research by Aislinn Hoy, Gretta Mohan, Frank Moriarty (Royal College of Surgeons in Ireland), Anne Nolan and Brendan Walsh.

2.1 Introduction

The natural and built environment is an important component of the "social determinants of health", i.e. the non-medical factors that determine our health and well-being throughout the life course. Building on an extensive body of research carried out in phases I, II and III of the EPA research programme, in phase IV we focused on the following three broad themes:

- examining the impact of participation in the Clean Air Together (CAT) citizen science project in Dublin on awareness, attitudes and behaviour in relation to air quality (section 2.2);
- calculating the healthcare costs of poor air and water quality (sections 2.3 and 2.4);
- investigating equity in environmental exposures (section 2.5).

2.2 Evaluation of Clean Air Together

Research by Aislinn Hoy and Anne Nolan.

2.2.1 Background

CAT is a citizen science project where people voluntarily sign up to measure levels of nitrogen dioxide (NO₂) pollution in their local area. The main source of NO₂ is road transport, which emits NO₂ close to the ground, mostly in densely populated areas (European Environment Agency, 2022). NO₂ leads to respiratory disease and mortality, and there is evidence that children and older people are at increased risk (WHO, 2021). In the first phase of CAT, conducted in 2021 and 2022, approximately 1000 participants in Dublin recorded NO₂ levels in their local area. Subsequent phases have been conducted in Cork (2022), Galway (2023) and Limerick (2024). In this study, we assessed the impact of participation in CAT Dublin on the awareness, attitudes and behaviours of participants in relation to air quality.

2.2.2 Data and methods

Selected participants (and those who signed up for the study but who were ultimately not selected to engage in NO₂ measurement, referred to as non-selected participants) were invited to complete three online surveys at various points in 2021 and 2022. These survey responses were used to evaluate the impact of CAT participation on participants' awareness, attitudes and behaviour in relation to air quality. Survey attrition (i.e. dropout) was a problem, with fewer participants answering survey questions in each of the three waves, as demonstrated in Table 2.1.

2.2.3 Results

While the analysis was hindered by small samples, the research identified a number of key findings. Compared with the general Dublin population aged 18+ years, CAT participants were more concentrated in the middle age groups (aged 35–64 years), and nearly half had postgraduate-level educational qualifications.

The baseline survey was conducted in October 2021, at the start of the CAT project and before participants participated in NO₂ measurement or received infographics and further information on NO₂. It revealed that CAT participants were more aware of NO₂ (and other environmental risks) than the general Dublin population aged 18+ years, and more likely to correctly identify the main source of NO₂ pollution. However, nearly one-quarter of CAT participants did not know the most significant source

Table 2.1. Number of participants and responserates (%)

Survey	Selected participants	Non-selected participants
Baseline sample	1186	1064
Survey 1 (October 2021)	721 (60.8)	181 (17.0)
Survey 2 (March 2022)	371 (31.3)	162 (15.2)
Survey 3 (September 2022)	196 (16.5)	84 (7.9)

Response rate (% of baseline sample) is presented in parentheses.

of NO_2 pollution, and a further one-quarter answered this question incorrectly. Analysis of CAT participants who responded to the first (October 2021) and second (March 2022) surveys showed that awareness of NO_2 related issues improved. For example, the proportion who correctly identified the most significant source of NO_2 increased from just over 50 per cent to nearly 70 per cent, with an additional large decline in the proportion of participants who reported that they did not know the most significant source of NO_2 pollution. The surveys also collected information on individual behaviours (focusing on transport mode choice and working from home), but there was limited evidence of significant changes in behaviour as a result of participation in CAT.

2.2.4 Conclusions and policy implications

In terms of lessons for future environmental citizen science projects, including further CAT projects, a number of key points can be made. First, the socioeconomic profile of CAT participants highlights a real challenge for those designing environmental citizen science projects and who seek to ensure greater diversity in participation. Effective strategies to encourage greater diversity in the profile of environmental citizen scientists include the use of alternative recruitment strategies (e.g. recruitment via schools, sports clubs, community organisations), recognition of the barriers to participation for certain groups (e.g. time commitments on the part of individuals with paid work and caring responsibilities) and the co-designing of citizen science projects, all of which can be effective tools for widening participation.

Second, in terms of maximising response rates in future CAT surveys, consideration could be given to sending dedicated reminders to those who have not yet completed surveys. Insights from behavioural science interventions to increase survey response rates (e.g. using personalised communications) may be useful in future CAT projects.

Finally, in order to achieve lower levels of air pollution, individual-level behaviour change will need to be accompanied by targeted public policies. Overall, survey participants exhibited high levels of agreement with various policy options designed to reduce NO_2 air pollution. However, policy options that required increased investment on the part of the state (e.g. increased investment in public transport) were

favoured over those options that involved restrictions or curbs on individual behaviour (e.g. implementing congestion charges in cities). Further research would be required to understand if these findings are replicated for other forms of air pollution, such as fine particulate matter (PM_{2.5}), and associated policy responses.

The findings of the study have been published as an ESRI Survey and Statistical Series Report (Nolan and Hoy, 2023).

2.3 The Healthcare Costs of Poor Air Quality in Ireland

Research by Aislinn Hoy, Frank Moriarty (Royal College of Surgeons in Ireland) and Anne Nolan.

2.3.1 Background

Air pollution is well recognised as a major risk factor for disease and premature mortality worldwide (European Environment Agency, 2022; Murray *et al.*, 2020; Vos *et al.*, 2020). Global assessments of ambient (outdoor) air pollution suggest that between 4 million and 9 million deaths annually and hundreds of millions of lost years of healthy life can be attributed to ambient air pollution (WHO, 2021). As a result, air pollution is now recognised as the single largest environmental threat to public health (WHO, 2021). In Ireland, $PM_{2.5}$, which originates largely from burning solid fuel for heating, and NO_2 , derived from road transport, in particular from diesel engines, are the main sources contributing to poor air quality (EPA, 2024).

In addition to the mortality and morbidity burden, air pollution also imposes a significant economic burden, in terms of healthcare costs, lost productivity, impact on agricultural crops and damage to buildings and infrastructure (OECD, 2020; WHO, 2021). In this project, we focused on the costs of poor air quality for three types of healthcare: emergency inpatient hospitalisations, general practitioner (GP) care and prescribed medications dispensed in community pharmacies (i.e. community pharmacy services).

2.3.2 Data and methods

The absence of a national disease register, and the limited roll-out of a unique health identifier, create





challenges for the assessment of the healthcare costs of poor air quality in Ireland. Figure 2.1 provides an overview of the methodological approach. In all cases, a number of pieces of information are required. First, it was necessary to identify the healthcare conditions that are linked to poor air quality. Second, the healthcare utilisation and costs associated with these healthcare conditions needed to be quantified and scaled up to the population level. Finally, an estimate of the proportion of cases (or utilisation) of a particular disease or condition that can be attributed to poor air quality needed to be obtained. Evidence from the international literature was used to identify health conditions with causal links to poor air quality (and estimates of the proportion of diagnoses attributable to poor air quality), while a variety of administrative and survey data sources and published literature were used to gather information on healthcare utilisation, costs and population prevalence.

Data on health conditions with causal links to air pollution

Research from the European Environment Agency (EEA) was used to identify health conditions associated with poor air quality. The EEA research estimated the morbidity-related health burden associated with exposure to key air pollutants, $PM_{2.5}$, NO_2 and ozone, for 41 European countries in 2019 (Kienzler *et al.*, 2022). The identification of the risk–outcome pairs was derived by considering published epidemiological evidence on the links between risk and outcome for each risk–outcome pair, with a further assessment of the quality of the evidence base (i.e. only studies for which causal evidence of

associations was strong were included). In this project, we focused on six of the risk–outcome pairs that relate to long-term impacts of $PM_{2.5}$ and NO_2 on circulatory and respiratory diseases (see Table 2.2). Circulatory and respiratory disease are also the health outcomes for which the broader evidence base on the links between air pollution and health is most developed (Anderson *et al.*, 2003; Brook *et al.*, 2010; Murray *et al.*, 2020; OECD, 2020).

Data on utilisation and costs of emergency inpatient hospitalisations, GP services and prescription medications

A mixture of administrative, survey and treatment guideline data were used to quantify healthcare

Table 2.2. Risk-outcome pairs for circulatory andrespiratory diseases related to air pollution

Risk–outcome pair	ICD-10-AM code
PM _{2.5}	J45 and J46
Asthma (age 0–14 years)	
PM _{2.5}	J40–J44; J47
Chronic obstructive pulmonary disease (age 25+ years)	
PM _{2.5}	120–125
Ischaemic heart disease (age 25+ years)	
PM _{2.5}	160–169
Stroke (age 25+ years)	
NO ₂	160–169
Stroke (age 25+ years)	
NO ₂	J45 and J46
Asthma (age 15+ years)	

ICD-10-AM, International and Statistical Classification of Disease and Related Health Problems.

utilisation and costs for each type of care. The data on emergency inpatient hospital utilisation and costs were sourced from the HIPE and Activity-Based Funding databases; data on GP service utilisation and costs were sourced from the Growing Up in Ireland and Healthy Ireland surveys, and published data on unit costs of care for non-acute services in Ireland (Smith *et al.*, 2021); and data on community pharmaceutical utilisation were sourced from published treatment guidelines for each of the relevant risk–outcome pairs and cost data from the Primary Care Reimbursement Service.

Identification of disease burden attributable to poor air quality

Finally, an estimate of the proportion of cases (or utilisation) of a particular disease or condition that can be attributed to poor air quality was obtained. Evidence from the EEA was used to provide estimates of the proportion of particular health conditions attributable to poor air quality, i.e. the population-attributable fraction (PAF). The PAFs ranged from 1.1 per cent for the $PM_{2.5}$ -ischaemic heart disease risk-outcome pair to 7.9 per cent for the $PM_{2.5}$ -chronic obstructive pulmonary disease risk-outcome pair (Nolan, 2023).

2.3.3 Results

Table 2.3 presents the results of the analysis of the annual costs (expressed in 2023 prices) of emergency inpatient care, GP care and community pharmaceuticals. Across all three types of healthcare, the most resource-intensive risk–outcome pair related to PM_{2.5} and chronic obstructive pulmonary disease in adults aged 25+ years, accounting for €8.4 million, €1.8 million and €4.4 million in annual expenditure on emergency inpatient hospitalisations, GP services and community pharmaceutical services, respectively.

2.3.4 Conclusions and policy implications

For this project, a mixture of administrative and survey data on healthcare utilisation and costs, supplemented with data on the burden of ill health attributed to air pollution for specific conditions with causal links to air pollution (e.g. asthma), was used to assess the healthcare utilisation and costs associated with treating conditions that are linked with poor air quality in Ireland. While direct comparisons between the three types of healthcare utilisation examined in this project could not be made due to differences in data and methodologies, a number of key findings can be identified. First, for emergency inpatient hospital care, PM₂₅ and chronic obstructive pulmonary disease was the most resource-intensive risk-outcome pair, reflecting a relatively high PAF, a large number of emergency hospital discharges and a high cost complexity. The same was true for GP and community pharmacy services, and, while overall contact with GP and community pharmacy services was far greater than that for emergency inpatient hospitalisations, the much higher unit costs of emergency inpatient care were reflected in much higher overall costs.

Risk–outcome pair	Emergency inpatient care	GP care	Community pharmaceuticals	
PM _{2.5}	407,151	613,417	1,441,897	
Asthma (age 0–14 years)				
PM _{2.5}	8,393,987	1,752,542	4,390,951	
Chronic obstructive pulmonary disease (age 25+ years)				
PM _{2.5}	1,067,859	297,631	939,974	
Ischaemic heart disease (age 25+ years)				
PM _{2.5}	5,746,361	473,494	803,906	
Stroke (age 25+ years)				
NO ₂	2,697,271	222,252	377,344	
Stroke (age 25+ years)				
NO ₂	416,469	1,365,431	4,360,280	
Asthma (age 15+ years)				

Table 2.3. Annual cost (€) of healthcare conditions associated with poor air quality in emergency inpatient care, GP care and community pharmaceuticals

The data and methodological approach used in this report, while incomplete, provide a framework that can be used to inform future data collection and research studies on this issue. Future work could expand the analysis to include other types of healthcare utilisation (e.g. practice nurse visits) and other risk–outcome pairs (e.g. PM_{2.5} air pollution and lung cancer), assess the sensitivity of the findings to alternative assumptions about PAFs, population prevalence and healthcare utilisation, and incorporate cost–benefit analyses of policy measures aimed at reducing air pollution levels.

The findings of the first phase of this project (on the emergency inpatient hospitalisation costs of poor air quality in Ireland) have been published as an ESRI Working Paper (Nolan, 2023), while the findings from the second phase (on GP and prescription medicine costs) are currently being finalised for publication as an ESRI Survey and Statistical Series Report.

2.4 The Healthcare Costs of Water-related Diseases in Ireland

Research by Aislinn Hoy and Brendan Walsh.

2.4.1 Background

Infectious intestinal diseases (IIDs), or gastroenteritis, represent a significant public health concern due to their high incidence rate and the burden they place on individuals and healthcare systems. Many IIDs are caused by WRDs. At the individual level, such WRDs can result in minor short-term inconveniences for those infected. However, for more vulnerable population groups such as children and people with frailty, more severe outcomes such as hospital admission and longer-term morbidities may occur. More severe WRD health outcomes can then potentially increase healthcare costs for different services within healthcare systems (Bartsch *et al.*, 2020; Lakhan *et al.*, 2023; Schmutz *et al.*, 2017).

Most of the evidence on the incidence of and the healthcare burden attributed to WRDs internationally is based on specific WRD outbreaks. In the only large study on the healthcare burden posed by WRDs undertaken in Ireland to date, Chyzheuskaya *et al.* (2017) examined the societal cost of a large *Cryptosporidium* outbreak that occurred in the west of Ireland in 2007. This focus on localised outbreaks creates challenges in understanding WRD-related healthcare costs on a national level. In addition, the burden of WRDs on a healthcare system is difficult to estimate due to the challenges in measuring WRDs. This study attempted to circumvent these issues by adopting a framework used in England (Tam *et al.*, 2012), Australia (Barker *et al.*, 2018) and the USA (Collier *et al.*, 2021), which used a mixture of administrative data and cohort studies to develop ratios of "true" prevalence of WRDs in Ireland, and their associated healthcare costs from 2015 to 2018.

2.4.2 Data and methods

The primary data source for incidence data was the 2015–2018 annual infectious disease statistics published by the HPSC. We used these data on a subset of IIDs to help estimate changes in notified IIDs over time, as the base number against which to measure IIDs and subsequently WRDs in Ireland between 2015 and 2018. In this study, we adopted a broad WRD definition to ensure inclusion of all potential WRDs in the analyses. Information from each chosen WRD was available in the HPSC data. The main WRDs chosen included cryptosporidiosis, campylobacteriosis, rotavirus, verocytotoxin (shiga toxin)-producing Escherichia coli (E. coli), giardiasis, salmonellosis and norovirus. We also examined other IIDs that are less likely to be caused by WRDs, including adenovirus, E. coli, hepatitis A, shigellosis and typhoid. The HPSC captures notified illness incidences for a range of IIDs. However, it is well understood that under-reporting of IIDs is a problem. We identified a study (Tam et al., 2012) that compared notified IIDs with the likely incidence of individual IIDs in England. The authors' methodology produced a number of underestimation ratios/scalers for individual diseases. We applied these to Irish HPSC data. In addition, not all IIDs are caused by water pollutants. Therefore, in this study, we further incorporated information on the likely proportion of IIDs that are WRDs, sourced from the World Health Organization (WHO) (WHO, 2016).

We used a number of data sources and studies to inform WRD healthcare utilisation and costs. A key utilisation and cost source was the HIPE dataset from 2015 to 2018. HIPE is a comprehensive administrative dataset that records all acute public hospital day patient and inpatient activity in Ireland. It includes patient-level demographic details, age, admission information, and principal and secondary diagnoses based on the International and Statistical Classification of Disease and Related Health Problems. As hospital admission for an IID is typically unscheduled (emergency), we considered only emergency inpatients who attended one of the large adult or children's hospitals in Ireland. We examined healthcare utilisation for WRDs using a mixture of empirical analysis and evidence from Ireland and internationally. We examined the four key healthcare services: community pharmacy care, GP care, emergency department care and acute public hospital emergency inpatient care.

2.4.3 Results

We estimated that from 2015 to 2018 there were almost 100,000 WRD cases in Ireland. Overall, we estimated that the total healthcare burden from WRDs in Ireland during this period was \in 20 million. While only a small number of WRD cases resulted in an acute hospital admission, \in 14.5 million was attributed to hospital care due to its high cost (Table 2.4). WRDs led to approximately \in 2 million in pharmacy costs and \in 1.3 million in GP costs.

2.4.4 Conclusions and policy implications

This study was the first study to examine the national healthcare burden of WRDs in Ireland. The results indicated a significant burden imposed by WRDs

on healthcare resources. Cost estimations for the period of 2015–2018 suggested that WRDs resulted in expenditure reaching as much as \in 20 million. These findings are consistent with previous Irish (Chyzheuskaya *et al.*, 2017) and international studies examining the healthcare costs of WRDs, which have primarily focused on localised outbreaks (Larsson *et al.*, 2014).

A draft of this paper has been completed and is currently being finalised for submission to a peerreviewed journal.

2.5 Equity in Environmental Exposures

Research by Aislinn Hoy, Gretta Mohan and Anne Nolan.

2.5.1 Background

This research was concerned with mapping the distribution of air pollution¹ as measured by $PM_{2.5}$ and NO_2 concentrations, to examine whether there are demographic and socioeconomic inequalities in exposures to environmental pollutants in Ireland. The investigation was motivated by a concern that more socially and economically marginalised groups may be more exposed to environmental hazards, and that these more vulnerable groups may encounter a double health jeopardy, where they may already experience greater health inequalities and health risks, for

Disease	Pharmacy	GP	ED	Hospital
Campylobacteriosis	€236,604	€214,405	€521,762	€1,931,813
Cryptosporidiosis	€55,426	€101,772	€172,602	€611,186
VTEC	€12,195	€3476	€8940	€58,092
Salmonellosis	€2896	€5645	€23,745	€105,666
Giardiasis	€32,907	€23,070	€32,184	€99,091
Rotavirus	€835,438	€586,137	€968,095	€1,975,961
Norovirus	€774,640	€215,189	€25,104	€108,635
Other IIDs	€175,023	€104,968	€159,728	€485,277
Gastroenteritis (unspecified)				€9,153,894
Total	€2,095,257	€1,256,151	€1,912,158	€14,525,984

Table 2.4. Estimated healthcare WRD costs

ED, emergency department; VTEC, verocytotoxin-producing Escherichia coli.

¹ Exploratory analysis of the EPA noise mapping data was also undertaken with a view to incorporating these data in future research.

instance due to higher baseline disease rates and/or poorer access to healthcare.

2.5.2 Data and methods

For the two environmental hazards examined, different datasets of pollutant records for varying years were available. Data on annual average concentrations of $PM_{2.5}$ and NO_2 were accessed from the Gateway to Global Aging Environmental Exposome database.²

Maps of average annual concentrations were linked to relevant Census of Population data at the level of Census Small Area.³ The census data included a composite index of deprivation (the Pobal HP Deprivation Index) and a variety of indicators on the demographic and socioeconomic characteristics of small areas, e.g. educational attainment, ethnic composition, skills levels and housing status. For the two environmental hazards examined, the temporal dimensions of the datasets were:

- annual PM_{2.5} concentrations for 2011 and 2016 linked to the 2016 Census of Population;
- annual NO₂ concentrations for 2020 linked to the 2022 Census of Population.

2.5.3 Results

The findings from the inequalities in exposure analysis concerning the two air pollution measures, PM_{2.5} and NO₂, differed, and are described in turn. First, the mapping of PM25 concentrations across small areas in Ireland showed heavier concentrations of PM₂₅ in urban areas, with an overall decline in mean concentrations between 2011 and 2016 (see Figure 2.2). Despite the observed decline, in 2016 almost all small areas in Ireland exceeded the WHO PM₂₅ annual air quality guideline level of 5 µg/m³. In terms of the inequalities analysis, overall, the statistical modelling did not find substantial evidence of demographic or socioeconomic inequalities in PM₂₅ concentrations across Census Small Areas. However, where socioeconomic indicators were examined separately for urban and rural areas, some small differentials in PM225 concentrations were observed. In general, those living in more disadvantaged small areas in rural Ireland had higher levels of PM_{2.5} air pollution than those living in more advantaged small areas in rural Ireland.

Turning to the analysis of NO₂ air pollution, the data revealed that Ireland experienced relatively low levels of NO₂ exposure – the average annual concentration was approximately $6.1 \,\mu\text{g/m}^3$ in 2020, below the WHO annual guideline level of $10 \,\mu\text{g/m}^3$. However, urban



Figure 2.2. Average annual PM_{2.5} concentrations by Census Small Area, 2011 and 2016.

² https://exposome.g2aging.org/ (accessed 28 April 2025).

³ Small areas are the lowest level of geography for the dissemination of statistics and generally comprise either complete or part of townlands or neighbourhoods. Small areas generally comprise between 80 and 120 dwellings. See https://www.cso.ie/en/census/ census2022/census2022smallareapopulationstatistics/ for further details (accessed 28 April 2025).



Figure 2.3. Average annual NO₂ concentrations by Census Small Area, 2022.

areas had approximately twice the average annual level of NO₂ than rural areas (see Figure 2.3). The environmental inequalities in exposure to NO₂ analysis found evidence of higher levels of NO₂ air pollution in areas composed of greater shares of non-white populations and non-owner-occupied housing. The stratified urban-rural analysis demonstrated that these issues pertained in particular in urban jurisdictions. A U-shaped pattern between NO₂ air pollution and levels of deprivation, educational attainment and skills categorisation was also observed. This may be cause for concern because, although more disadvantaged populations encounter relatively similar levels of pollution to the most advantaged group, more disadvantaged people may be at a greater risk of health-damaging effects from NO₂ as they may have poorer quality housing, poorer access to healthcare services or existing underlying conditions.

2.5.4 Conclusions and policy implications

This research project found stronger evidence for potential health-related environmental inequalities from NO_2 pollution than from $PM_{2.5}$ pollution in Ireland. This work highlights that the association

between environmental pollutants and socioeconomic characteristics is complex, and that interpretation of findings depends on the choice of pollutant measures and socioeconomic indicators. The results generated from this project provide policymakers with a greater understanding of links between NO, and PM_{2.5} concentrations and the composition of small spatial geographies. The recent Clean Air Strategy for Ireland contains a commitment to achieve the WHO's annual guideline limits by 2040, and the strategy outlines efforts to monitor NO₂ levels in high-traffic roads in Dublin (Department of the Environment, Climate and Communications, 2023). Achieving air pollution targets will require further efforts to reduce air pollution, particularly from transport, as well as industry and agriculture, and to decarbonise home heating.

The PM_{2.5} paper has been published in a peerreviewed journal (Hoy *et al.*, 2024), and an accompanying non-technical ESRI research bulletin is also available at https://www.esri.ie/system/files/ publications/RB202414.pdf.

The findings from the NO_2 analysis are currently being finalised for submission to a peer-reviewed journal.

3 Behavioural Science

Research by Ylva Andersson, Clare Kelly (Trinity College Dublin), Maria Lee, Pete Lunn, Alexandros Papadopoulos, Olga Poluektova, Adam Shier, Shane Timmons and Ava Whelan (Trinity College Dublin).

3.1 Introduction

The aim of this component of the programme was to employ theory and methods from behavioural science to a range of environmental issues, including radon testing (section 3.2), perceptions of environmental hazards (section 3.3), climate change mitigation attitudes and behaviours (section 3.4), advertising of environmental claims (section 3.5) and sustainable clothing consumption (section 3.6). A final project that uses survey data to examine the intention behaviour gap in climate mitigation behaviours is also summarised (section 3.7). In each section, we summarise the main findings, with more detail available in the respective publications.

3.2 Encouraging Radon Test Uptake

Research by Shane Timmons and Pete Lunn.

3.2.1 Background

Radon is a leading cause of lung cancer, but the rate at which homeowners test for exposure is low, even when kits are offered freely (Cholowsky *et al.*, 2021; Dempsey *et al.*, 2018). Building on previous EPA-funded research (Timmons and Lunn, 2023a), we used a randomised controlled trial to test whether using behavioural science to inform communications with households in high-risk areas can increase test kit uptake.

3.2.2 Methods

We selected a random sample of 3500 households from areas predicted to be at high risk of radon exposure. Householders were randomised to receive one of four communications: (i) a "control" letter adapted from typical test encouragement communications; (ii) a simplified "behaviourally informed" letter that employed multiple behavioural levers to encourage testing, such as using natural frequencies to convey risk (e.g. "one in five homes has high levels of radon gas"); (iii) a behaviourally informed letter in an envelope designed to attract attention, via a sticky note with the writing "household selected for a free radon test kit"; or (iv) a behaviourally informed letter in a redesigned envelope with a printout of a hazard map for the household's county, depicting the risk levels in different areas.

Letters were issued on 9 and 10 March 2023, with requests for test kits recorded until 12 April 2023. The design and analysis plan were pre-registered on the Open Science Framework.

3.2.3 Results

The test kit response rate among those with successfully delivered letters (n=3035) was 27.5 per cent. The response rate was highest among those who received the behaviourally informed letter in the standard envelope (32.6 per cent), followed by the behaviourally informed letter in the redesigned envelope (29.9 per cent) and the behaviourally informed letter with the map (25.7 per cent). The control group had the lowest response rate (21.9 per cent), similar to previous trials run by the EPA. A logistic regression model showed that the behaviourally informed letter led to a significantly higher uptake rate than the control letter, but there was no additional benefit of the redesigned envelope, and including the map led to a marginally weaker effect. Additional analyses suggested that although the map generated faster responses initially, these were quicker to plateau below the level reached by issuing the behaviourally informed letter in the standard envelope (Figure 3.1).

3.2.4 Conclusions and policy implications

Using behaviourally informed communications generated a relatively large effect. Compared with an average "nudge" effect size of 8 per cent (DellaVigna and Linos, 2022), we observed an almost 50 per cent (11 percentage-point) increase in test kit uptake. This trial is the first test of direct householder



Figure 3.1. Cumulative responses by treatment condition over time. Note that the *x*-axis includes only business days, as responses were not recorded on weekends or public holidays. BI, behaviourally informed; Env., redesigned envelope.

communications to generate radon testing rates above 20 per cent. More broadly, our results demonstrate the benefit of using the psychology of risk perception and behavioural science to inform radon communications with householders. The trial's most effective letter is now used to inform communications in the EPA's National Radon Survey.

The findings of the research have been published in a peer-reviewed journal (Timmons and Lunn, 2023b).

3.3 Public Perceptions of Environmental Risks

Research by Shane Timmons, Alexandros Papadopoulos and Pete Lunn.

3.3.1 Background

Measuring public perceptions of risk is not straightforward. Multiple psychological studies show that seemingly innocuous features of surveys, such as the order in which questions are asked, can bias attitudes and beliefs (Bruine de Bruin, 2011). As such, surveys showing apparent high levels of concern about electromagnetic fields (EMFs), i.e. generally harmless areas of invisible energy associated with the use of electricity, may overstate real concern (European Commission, 2007). In this study, we sought to measure public perceptions of EMFs using methods from behavioural science. Our approach provided additional insights into public perceptions of other environmental hazards.

3.3.2 Methods

A nationally representative sample of 800 adults were recruited by a market research agency to complete the online study in September 2023. Participants completed a series of tasks, including an open-text task about environmental health risks; a series of rating scales about EMFs, various environmental hazards and a fictitious hazard; and a quiz about EMFs. The study also featured an experiment, in which participants were randomised to see instructions that stated the study focus as (i) EMFs, (ii) an alternative risk (carbon monoxide) or (iii) environmental hazards in general. The study design and analysis plan was pre-registered on the Open Science Framework.

3.3.3 Results

The open-text task showed that few people spontaneously thought about EMFs when thinking about environmental health risks (2.7 per cent; Figure 3.2). Instead, far more people mentioned outdoor air quality (59.7 per cent), cars and traffic (29.8 per cent), or weather issues or climate change (22.8 per cent).

Participants rated their perceived risk from EMFs towards the midpoint of the 7-point rating scales,



"Please list here any environmental factors that you are aware of that can impact your health"

Figure 3.2. Responses to the open-text task about environmental hazards. Source: Timmons *et al.* (2024a); licensed under CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/).

implying moderate perceptions of risk, but the same pattern was observed for the fictitious risk. Carbon monoxide, lead in drinking water and *E. coli* received much higher ratings of perceived risk. Interestingly, the experimental test of survey instructions made a difference. Participants who read that the focus of the study was EMFs were more worried about EMFs than participants who read that the focus of the study was carbon monoxide or environmental risks in general.

Despite the low levels of concern about EMFs, responses to the quiz demonstrated misconceptions, with a bias towards perceived harm. The majority (>58 per cent) of participants erroneously answered that EMFs can damage human cells, exposure in urban areas in Ireland is above suggested limits and new technologies such as 5G have increased exposure in public spaces. Holding misconceptions about EMFs was associated with greater perceived risk reported in prior tasks.

3.3.4 Conclusions and policy implications

The findings suggest that public concern about EMFs is appropriately low. Previous surveys may have produced overestimates of concern, due to a precautionary tendency for survey participants to rate unfamiliar risks towards the midpoint of commonly used scales and a bias induced by the stated focus of the study. However, when prompted to think about EMFs, many people report misconceptions that they cause harm. Therefore, accurate, evidence-based information should be made easily accessible for the public, without drawing unnecessary attention to the benign hazard.

Descriptive results from the open-text question and rating scales have been published as an ESRI Survey and Statistical Report (Timmons *et al.*, 2024a). Results from the experiment have been published in a peer-reviewed journal article (Timmons *et al.*, 2024b), accompanied by a non-technical ESRI research bulletin, available at https://www.esri.ie/pubs/ RB202420.pdf.

3.4 Intention–Behaviour Gap in Climate Policy

Research by Shane Timmons, Ylva Andersson, Maria Lee and Pete Lunn.

3.4.1 Background

Mitigating climate change requires rapid societal change. In addition to policy implementation and changes to industry practices, consumer behaviour change is vital. Everyday behaviour, however, appears to contradict the high levels of concern about climate change widely documented in surveys (e.g. the EPA's Climate Change in the Irish Mind).⁴ In this study, we sought to investigate this "intention–action" gap, focusing on transport and diet. We took a "stage of change" approach (Bamberg, 2013) and first aimed to measure awareness of climate-mitigative behaviours before recording self-reported stage of change and a battery of psychological variables informed by psychological theory.

3.4.2 Methods

A nationally representative sample of 1200 adults completed the online study in September 2023. Participants first completed a diary task about the previous day, after which they were asked to identify the actions that mattered most for their carbon footprint. They then completed a series of survey questions, including on their daily behaviour and their stage of change (i.e. had they changed their diet or transport behaviours, were they considering a change), and a series of psychology-related questions (e.g. on identity, perceived social norms). Participants who reported wanting to change their behaviour but not doing so were asked about impediments. The study design and analysis plan were pre-registered on the Open Science Framework.

3.4.3 Results

When asked to identify parts of their day that mattered most for their carbon footprint, most participants mentioned transport (64 per cent) and home energy use (56 per cent). Very few mentioned whether they ate or avoided meat (4 per cent). Turning to stage of change, almost 40 per cent reported having made some change to their transport behaviour to reduce their carbon footprint, with the remainder split between those who would like to change but feel they cannot and those who see no need to change (Figure 3.3). Participants with intentions to change that they had not enacted cited public transport availability and cost as the main challenges. Fewer participants reported changing their diet (26 per cent), with the largest group seeing no need to change (47 per cent). Reported impediments to changing food behaviours were perceived cost and not knowing what to eat.

Statistical models testing the association between psychological variables and stage of change showed that, for both transport and diet, participants who reported intentions to change also reported worrying more about climate change and feeling more morally responsible to act, while acting on intentions was associated with a stronger environmental identity.



Figure 3.3. "Stage of change" for transport and diet behaviours among the public (%). Source: Andersson *et al.* (2024).

⁴ https://www.epa.ie/environment-and-you/climate-change/what-is-epa-doing/national-dialogue-on-climate-action/climate-change-inthe-irish-mind/ (accessed 28 April 2025).

Other psychological variables often cited in the literature had little association with change, including social norms and belief in individual responsibility.

3.4.4 Conclusions and policy implications

Given the widespread awareness of transport emissions, the findings imply that the largest gains from a behavioural change perspective are likely to be achieved by increasing the supply (and reliability) of accessible public transport, particularly outside Dublin, supporting the aim of the Climate Action Plan for transport. For food, there is clear scope to improve awareness of the link between type of food consumed and greenhouse gas emissions. Results from the statistical models further imply that intentions to change can be motivated by emphasising the risks of climate change. Efforts to foster green identities, e.g. through neighbourhood or community initiatives, may be beneficial.

Descriptive results from the open-text questions have been published as an ESRI Research Series Report (Timmons *et al.*, 2024c). Results from the statistical models of stage of change have been published as an ESRI Working Paper (Andersson *et al.*, 2024), which has been submitted to an international journal for peer review.

3.5 Effect of Greenwashing on Consumer Choice

Research by Shane Timmons, Ava Whelan (Trinity College Dublin) and Clare Kelly (Trinity College Dublin).

3.5.1 Background

Products and services are increasingly advertised in ways that highlight their environmental credentials, using phrases like "eco-friendly". Evaluating the truthfulness of such claims is difficult, creating potential for businesses to mislead consumers about their environmental performance. We conducted an experimental test of whether "inoculating" consumers against greenwashing tactics can boost their ability to distinguish greenwashed from genuine environmental claims on real advertisements.

3.5.2 Data and methods

A nationally representative sample of 2000 adults were recruited by a market research agency to take part in the online experiment in August 2022. Participants were randomly assigned to a treatment group or control group. The treatment group read a series of infographics about greenwashing and completed a short multiple-choice quiz with feedback to test their ability to identify different forms of greenwashing. The control group read an opinion piece about climate change. For the main task, all participants were shown a series of six real advertisements and asked to rate whether they believed it was an example of greenwashing, whether they trusted the brand's environmental claims and their willingness to purchase from the brand, on scales from 1 (not at all) to 7 (very much). The design and analysis plan were preregistered on the Open Science Framework.

3.5.3 Results

Participants in the treatment condition reported greater suspicion of two of the three greenwashed advertisements than participants in the control condition (Figure 3.4). However, they also were more likely to rate two of the three genuine advertisements as greenwashed. Similar patterns were observed on trust in each of the brands and on willingness to purchase from the brand.

3.5.4 Conclusions and policy implications

The findings suggest that interventions to educate consumers about greenwashing may increase scepticism about environmental claims in general. Therefore, genuinely sustainable brands that are not already familiar to consumers may struggle to convey their authentic message. Systems-level regulations, such as some of the measures under the proposed EU Green Claims Directive, are likely to be more effective than individual-level measures at preventing consumers from being misled.

This paper has been published in a peer-reviewed international journal (Timmons *et al.*, 2024d) and is accompanied by a non-technical ESRI research bulletin: https://www.esri.ie/system/files/publications/RB202407.pdf.



Figure 3.4. Percentage of participants who suspected each advertisement of having been greenwashed. Source: Timmons *et al.* (2024d); licensed under CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/).

3.6 Pre-testing of Effective Eco-labels

Research by Shane Timmons, Adam Shier, Olga Poluektova and Pete Lunn.

3.6.1 Background

"Fast fashion" describes low-cost, low-durability clothing that is produced at mass. Producing fast fashion generates substantial environmental damage, but this harm is not evident to consumers at the point of purchase. Previous studies, including EPAfunded research (Ní Choisdealbha and Lunn, 2020), have shown that eco-labelling influences consumer choice of food and groceries, but little research to date has tested its effects on clothing choice. This study tested two eco-labelling systems for clothing: a binary system, informed by existing policy, and a graded system, informed by evidence from research on communicating nutritional information about food (Robertson *et al.*, 2023).

3.6.2 Data and methods

A representative sample of 1200 consumers were recruited by a market research agency to use a simulated online clothing store. Participants were assigned at random to see (i) a binary label, informed by existing policy, applied to the most sustainable products; (ii) a colour-coded graded "eco-score" applied to all products; or (iii) no label (Figure 3.5). They were given a hypothetical budget to choose clothing, with some participants selected at random to receive items they bought. Data were collected in July 2024. The design and analysis plan were preregistered on the Open Science Framework.





3.6.3 Results

Figure 3.6 shows a violin plot of the proportion of sustainable purchases by eco-label condition. Results from statistical models showed that, relative to the control condition, the binary label increased the proportion of "some" sustainable purchases by 10 per cent (4 percentage points), whereas the eco-score label did so by 20 per cent (7 percentage points). The binary label effect on "all" sustainable purchases was, in fact, negative (-28 per cent; -2 percentage points), while the eco-score more than doubled the likelihood of a participant only choosing from the most sustainable brands (114 per cent; 8 percentage points). Although just marginally significant in the model, the reduction on "no" sustainable purchases in the eco-score condition was moderate (23 per cent; 6 percentage points).

The results were robust to multiple checks, including excluding participants who suspected the study's focus was on the environmental impact of clothing. Further exploratory analyses revealed that the effects were primarily driven by participants who reported high levels of concern about the environmental impact of clothing but that the labels functioned similarly for "high frequency" shoppers.

3.6.4 Conclusions and policy implications

Binary textile labels have tended to be favoured by policy; all but one textile label listed on ecolabel.eu is binary. Our results suggest that binary labels can have a positive effect on shifting consumers towards more sustainable products. However, the graded label, inspired by evidence from food choice research, had much stronger effects. These clothing eco-labels appear to enable consumers to make choices that better align with their preferences and may assist more expensive but less environmentally harmful brands in competing with producers of fast fashion.

This paper is available as an ESRI Working Paper (Timmons *et al.*, 2024e) and has been submitted for publication in an international journal.

3.7 Interaction Between Climate Attitudes and Actions

Research by Miguel Tovar Reaños and Constantine Spandagos.

3.7.1 Background

The environmental attitude–behaviour gap is characterised by the inconsistency between an



Figure 3.6. Violin plot showing distributions of the proportion of sustainable ("A/B") products chosen by participants by condition. Note that box plots show the interquartile range, with white dots representing the median. Source: Timmons *et al.* (2024e).

individual's stated environmental concerns and their actual behaviours. This gap can be seen as a separation or discrepancy between environmental values and actions. This study contributes to the literature in a number of ways. First, we measured the magnitude of the attitude-behaviour gap using various pro-environmental behaviours and identified patterns among socio-demographic groups in 26 European countries. We used a composite index to summarise attitudes and behaviours separately and jointly. Second, we analysed the influence of factors such as feeling responsible for climate change and social media exposure, providing practical insights for policymakers and individuals interested in sustainability. These insights empower policymakers with actionable strategies to reduce the gap between environmental attitudes and behaviours.

ElHaffar *et al.* (2020) comprehensively overview the environmental attitude–behaviour gap. One of the most notable approaches they discuss is modelling the gap by examining various variables that might cause deviations between green attitudes and behaviours. ElHaffar *et al.* (2020) emphasise that internal and contextual determinants significantly influence environmental behaviour. Building on this comprehensive overview, our study provided a robust analysis of the environmental attitude–behaviour gap.

Regarding the literature on the effects of exposure to social media on pro-environmental behaviours, Awan et al. (2022) employed a general survey of the Chinese population to find evidence that individuals with higher media exposure have a higher disposition for pro-environmental behaviour. These findings are also confirmed by Shen et al. (2023). Shao and Yu (2023) focused on the young population and found that while exposure to media can trigger donations to environmental organisations it does not necessarily increase pro-environmental behaviours. Feeling responsible for climate change is a complex issue. Social and individual values shape our moral boundaries when making choices and have direct social, economic and environmental consequences (Enke, 2024). Interesting research shows that feeling responsible for one's actions is a strong predictor of correcting the externalities caused by one's actions (Jakob et al., 2017).

3.7.2 Data and methods

The European Parliament's spring 2021 Eurobarometer survey gathered data on European citizens' attitudes and actions regarding climate change and their perceptions of the COVID-19 pandemic's impact on their income. This survey was chosen for its up-to-date information on citizens' views and behaviours related to various policy options for de-carbonising European economies. It was used to define the dependent variables in the analysis. Additionally, the survey included data on citizens' attitudes and habits concerning socio-political dimensions and the use of social media for receiving and sharing information, which were used to shape the predictor variables in the analysis.

The analysis included pro-environmental behaviours such as considering the carbon footprint of food and travel choices, eating less meat and purchasing organic food. It also examined attitudes towards climate change and clean energy. Our analysis proceeded as follows. We used a probabilistic model that allows for separately analysing the drivers of attitudes and behaviour and measures the correlation between these two dimensions. After this, we used factor analysis to create a composite index of attitudes and behaviours (one for attitudes and one for behaviours).⁵ We then created a combined index for attitudes and behaviours. This was our measure of the intention-action gap; the larger the index, the smaller the gap. We used statistical models to analyse the personal and country characteristics that drive the gap. Finally, we identified clusters of respondents with different gap levels. We used latent class models. A latent class model identifies a subgroup within a population with specific and common characteristics, but this subgroup is not directly observed (Goodman, 2002).

Following the literature, we used exposure to social media and feeling responsible for climate change to examine whether the clusters with the smallest gap indeed had a high proportion of members selfreporting using social media and feeling responsible for climate change. The primary goal of the project was therefore to investigate if there is a correlation between the intention–action gap and (i) self-reporting

⁵ This statistical technique explains the variability among observed, correlated variables by identifying fewer underlying and unobserved factors (Bravo and Farjam, 2022).

using social media and (ii) feeling responsible for climate change.

3.7.3 Results

The sign of the estimates provided in Table 3.1 shows that positive attitudes were more likely among couples with children, employed individuals and females. Pro-environmental behaviours were more common

Table 3.1. Bivariate probit regression model

Variable	Attitudes	Behaviour
Age	-0.005*** (0.002)	-0.002 (0.002)
Couple with children	0.136** (0.066)	-0.004 (0.035)
Single parent	0.113 (0.091)	0.192** (0.091)
Employed	0.165** (0.077)	-0.010 (0.044)
Working class	0.057 (0.210)	-0.094 (0.162)
Lower middle class	-0.059 (0.214)	0.011 (0.193)
Middle class	-0.025 (0.211)	0.149 (0.194)
Upper middle class	0.090 (0.201)	0.539** (0.212)
Higher class	0.086 (0.206)	0.623** (0.291)
Female	0.514*** (0.071)	0.277*** (0.050)
Observations	26,669	26,669
Correlation of attitudes and behaviour (ρ)	0.283*** (0.0403)	

Dependent variables: respondent has a positive attitude towards a concept and respondent performs a behaviour. Robust standard errors in parentheses.

***p<0.01, **p<0.05, *p<0.1.

among more socioeconomically advantaged citizens and females. It is observed that ρ – the coefficient that correlates attitudes and behaviours – is positively and statistically significant, indicating that those with more pro-environmental attitudes also report more proenvironmental behaviours.

Figure 3.7 highlights the mean value of the composite index for attitudes and behaviours, where a larger index indicates a smaller gap. The index is a continuous number computed using factor analysis. The countries with the largest gaps, represented by the smallest bars in the figure, are the Czech Republic, Estonia, Latvia and Romania. This suggests that these countries exhibit the greatest disparities in attitudes and behaviours. Ireland is one of the countries with the smallest gaps. Our regression analysis showed that being part of a middle or more advantaged social class and being female contributed to an increase in the index (i.e. reduction of the gap). Regarding countryspecific factors, a higher gross domestic product was associated with a greater index value.

Using this composite index and other controls, we created clusters of participants. Table 3.2 provides the mean proportion of the members in each group. Group 1 had a smaller gap (i.e. less discrepancy between environmental values and actions) than group 2. Group 1's members are, on average, younger than those of group 2, with a mean age of 36 years compared with a mean age of 52 years for group 2.



Figure 3.7. Composite index of attitudes and behaviours.

	Group 1: with a small gap		Group 2: with a large gap	
Variable	Mean	Standard error	Mean	Standard error
Age	36.376	0.857	52.153	0.758
Female	0.555	0.010	0.404	0.025
Rural	0.274	0.021	0.356	0.024
Dependent children	0.124	0.010	0.063	0.005
Climate responsibility personal	0.422	0.022	0.172	0.019
Use of media	0.741	0.012	0.496	0.034

Table 3.2. Latent class marginal means

Group 1 also had a higher proportion of females, a larger proportion of families with dependent children and more members who feel responsible for climate change and use social media.

We also estimated the probability of citizens belonging to group 2, which had the largest gap. Figure 3.8 displays the distribution across countries of this probability. Finland, the Czech Republic, Estonia and Latvia had the largest probability, while Ireland had a relatively small probability, indicating that improvements are still needed to increase pro-environmental behaviours.

3.7.4 Conclusions and policy implications

The study highlights the significant environmental attitude–behaviour gaps across the EU. Females and those from more advantaged social classes had a smaller attitude–behaviour gap. Compared with

the group with the larger attitude-behaviour gap, the group with a smaller discrepancy also had a more significant proportion of members who feel a greater responsibility to act to mitigate climate change. While encouraging more pro-environmental behaviours is complex and challenging (van Valkengoed et al., 2022), the study's approach provides valuable insights into the personal and contextual factors affecting the attitude-behaviour gap in a cross-country context. Future research should continue exploring this phenomenon in a broader geographical context to develop more effective strategies for promoting sustainable behaviours globally. Our findings also identify respondent characteristics that can be used to tailor information campaigns using social media or similar platforms to increase pro-environmental behaviours.

A draft of this paper has been submitted to a peerreviewed journal.



Figure 3.8. Probability of belonging to the group with the largest gap.

4 Climate Change

Research by Kelly de Bruin, Çağaçan Değer and Aykut Mert Yakut.

4.1 Introduction

In this chapter, we summarise the results of two studies that were undertaken to calculate consumption-based emissions for Ireland, using enhanced trade flow data (section 4.2) and comparing Irish consumption-based emissions with those of a group of comparator countries (section 4.3).

4.2 Irish Consumption-based Emissions

4.2.1 Background

The level of emissions generated within a country is the most frequently employed indicator for environment policy-related discussions. Established approaches to emission accounting assign emissions to the country where they are emitted, i.e. the country of production. This is referred to as production-based accounting (PBA) of emissions. An alternative approach builds on the idea that the consumer, rather than the producer, is responsible for the emissions. If one country imports a commodity, the importer should be held responsible for the emissions embedded in the imported commodity, i.e. what is emitted to produce that commodity. This leads to the concept of consumption-based accounting (CBA) of emissions. CBA has been gaining traction in the policy arena, where a major concern is that production is being outsourced from countries with relatively strict environmental legislation to countries with less strict regulations. This would mean that global environmental targets may not be met. This concern about outsourcing emissions has led to some movement in the policy space with, for example, the design of mechanisms such as the Carbon Border Adjustment Mechanism (CBAM).

Therefore, it is important to develop mechanisms to measure CBA emissions to ensure that we do not overcontribute to global emissions through our consumption. Inspired by such necessities, this study focuses on the calculation of PBA and CBA emissions for Ireland using an international database.

4.2.2 Data and methods

This analysis employed the GTAP (Global Trade Analysis Project) 11 database. The GTAP database originated in the 1990s and was initially created as a database for the GTAP computable general equilibrium model. Initial research using the GTAP database focused on the analysis of trade-related issues. The database was later extended to include environment-related indicators. In its latest version, the GTAP 11 database represents 141 countries and 65 production sectors.

The analysis processed the GTAP 11 database to generate PBA and CBA emissions for Ireland in 2017. For the PBA emissions, production-related emissions and combustion emissions related to the consumption of fuels were compiled. In order to obtain CBA emissions, the PBA emissions were corrected for international trade embedded emissions. Specifically, emissions embedded in imported goods were added to the PBA emissions and the emissions embedded in exported goods were subtracted. The processing of the database also necessitated improvements to better account for emissions embedded in the electricity and cattle sectors and their implications for internationally traded emissions.

4.2.3 Results

The obtained PBA and CBA emissions for 2017, in $MtCO_2$ eq (million tonnes carbon dioxide equivalent) units, are presented in Table 4.1. The calculated figures show that the PBA emissions of Ireland in 2017 were concentrated in the agriculture, fuels and transport sectors. CBA emissions of Ireland were 7.9 per cent higher than PBA-based emissions. That is, in net terms, Ireland was an emissions importer. The imported emissions were concentrated in fuels. Exported emissions were concentrated in the exports of animal-related agricultural and manufacturing industry sectors.

Table 4.1. PBA and CBA emissions of Ireland (2017), $MtCO_2eq$

Source	PBA emissions	CBA emissions
Agriculture, plant	2.98	3.47
Agriculture, animal	22.75	15.34
Other extraction	0.49	0.49
Fuels	12.51	19.82
Food, beverage, tobacco	1.44	0.66
Chemical products	0.90	2.85
Basic pharmaceuticals	0.40	0.35
Metal and mineral products	5.00	6.27
Machinery manufacturing	1.24	1.07
Other manufacturing	0.58	1.32
Electricity	0.42	0.41
Water and waste management	1.28	1.29
Construction	0.37	0.37
Air transport	2.83	3.79
Other transport	11.33	10.92
Other services	4.86	6.48
Sum	69.38	74.90
CBA/PBA (%)	107.92	

The analysis also considered the geographical distribution of imported emissions. Figure 4.1 visually presents the sources of imported emissions for Ireland. The highest sources of imported emissions were the USA and the UK, with fuels being the main commodity. Other major sources of imported emissions were Germany, China, Russia, the Netherlands and India.

The emissions imported from these countries were concentrated in fuels and manufactured goods.

4.2.4 Conclusions and policy implications

This work laid the methodological foundation for the calculation of PBA and CBA emissions using the GTAP 11 database. We found that most of the imported emissions were embedded in the fuel, chemical products and animal agriculture sectors. Exported emissions were concentrated in air transport and animal-related commodities. The procedure adopted in this study can be replicated for other countries represented in the GTAP 11 database.

This research has been published as an ESRI Working Paper (De Bruin *et al.*, 2024).

4.3 Comparing Irish Consumptionbased Emissions

4.3.1 Background

As noted above, the policy targets and debates on emissions reduction policy are often focused on the PBA emissions of countries. The established approach assigns emissions to the location of production. However, the pollution of production could also be assigned to the users of the produced good. This lays the foundation for CBA of emissions. CBA emissions





assign emissions to the country where the output is used or consumed.

CBA emissions are based on PBA emissions and require accounting for emissions embedded in international trade. If countries import commodities rather than produce them, the global emissions targets may be missed. Thus, there are attempts to reduce import-embedded emissions through policy mechanisms such as the CBAM. Evaluation of the impact of such mechanisms will require accounting for emissions embedded in international trade. Hence, calculation and comparison of CBA emissions in addition to PBA emissions is important.

This study calculated PBA and CBA emissions for Ireland and a group of selected countries. A comparison between Ireland and these countries was made to compare their relative carbon footprints.

4.3.2 Data and methods

The analysis was based on the GTAP 11 database. The GTAP 11 database covers 141 countries and 65 production sectors. It includes economic- and environment-related data for these countries and sectors. As the data are gathered and processed consistently across all the countries and sectors, they are suitable for multicountry comparisons.

The calculations are based on the method employed by De Bruin *et al.* (2024). First, PBA emissions were calculated, after which CBA emissions of a country were calculated by adding the emissions embedded in imports and subtracting the emissions embedded in exports. With a database like the GTAP 11, where multiple countries and commodities are represented, it was then possible to adopt a common method and present internationally comparable PBA and CBA emission values. We selected several countries to compare with Ireland, namely a subsample of European countries and New Zealand. The choice of the countries depended on the interaction of a number of criteria. A similarity index, similar to that of Krugman (1991), was calculated to determine the similarity of production patterns across countries. This was supplemented by other criteria. For example, a rich country and a poor country may have similar production patterns, but may not actually be comparable due to their size dissimilarity, i.e. in per capita terms.

4.3.3 Results

The analysis focused on identifying similarities between Ireland and the sample countries. An initial finding was that Ireland had relatively low total PBA and CBA emissions compared with the EU and Organisation for Economic Co-operation and Development averages. This was due to its small population, as in per capita terms Ireland appeared to have high PBA and CBA emissions.

The sources of emissions embedded in fuels was also examined. European countries were observed to generate imported emissions sourced from Russia, the Middle East (Iran and Iraq), Africa (especially Algeria and Nigeria) and Norway. Ireland diverged by sourcing more than half its emissions embedded in fuel from imports from the UK and USA.

4.3.4 Conclusions and policy implications

The analysis revealed the unique conditions each country has regarding PBA and CBA emissions. The findings so far imply that blanket policy actions require careful consideration, given the varied circumstances of countries.

The findings from the study are being prepared for publication.

5 Regulation and Enforcement

Research by Marta Alvaro-Taus and John Curtis.

5.1 Background

Environmental regulation, enforcement and monitoring are at the core of environmental policy in industrialised economies. In Ireland, industrial and waste facilities need an environmental licence to be able to operate.⁶ These licences establish industrial emission limits and other operational and administrative conditions that aim to protect and improve the environment and human health.

The EPA is responsible for ensuring that regulated facilities implement and comply with these licence conditions, making its environmental enforcement activity important for accomplishing sound environmental policy, enhancing citizens' well-being and promoting sustainable growth. This research examined the impact of the EPA's enforcement actions on the behaviour of licensed industrial facilities in order to assess their effectiveness at improving environmental behaviours.

5.2 Data and Methods

We used data extracted from the EPA's Licensing, Enforcement, Monitoring and Assessment (LEMA) system for the years 2016 to 2019. LEMA is the system used by EPA inspectors to conduct all enforcement and administrative reporting. The system has been in place since 2013, and it was created with the aim of automating licensing and enforcement processes. All communications with integrated pollution control, industrial emissions and waste licensees are processed via LEMA, which is integrated with the interface used by licensees themselves.

Our dataset consisted of a panel dataset that included facility-level information on non-compliances, inspections, complaints from the public, incidents reported by facilities, compliance investigations and National Priority Site (NPS) lists. Data on other attributes of each facility, such as the enforcement default category, enforcement region and industry, were also available.

The empirical analysis was split into three parts. First, it provided evidence of the implementation of dynamic enforcement. It estimated the response of the environmental authority to facilities' past enforcement actions, compliance history, complaints from the public and incident notifications. Second, a model was estimated to establish the relationship between lagged inspections and facilities' non-compliance behaviour in the following periods. Finally, the last empirical exercise was aimed at drawing further understanding of NPSs' response to the escalation of enforcement measures.

5.3 Results

The empirical strategy hinged on the varying compliance behaviours observed among facilities. We categorised facilities into two groups: "conformists" and "repeat violators". As Figure 5.1 shows, facilities in the former group were highly compliant (i.e. they tended to conform with their licence conditions), while facilities in the latter group presented a significantly higher average number of violations per quarter in all periods of our sample. Based on this, the empirical analysis tried to disentangle the implications for enforcement policy of the sites' response to enforcement authorities.

5.3.1 Drivers of environmental monitoring

We found evidence that past compliance behaviour played a prominent role in determining the amount of monitoring resources deployed to inspect not only facilities with associated elevated environmental risk (i.e. repeat violators), but also facilities with modest or minimal environmental risk (i.e. conformists). While the escalation of enforcement led to more scrutiny in the form of inspections across all types of facilities, the regulator response to a facility's past compliance history was different for each facility type. In relative terms, the regulator response to past compliance

⁶ These licences are for industrial emissions, industrial pollution control and waste.



Figure 5.1. Non-compliance and inspection histories for conformist and repeat violator facilities. Note that the repeat violators sample consists of facilities included in the NPS list at some point (composed of 31 facilities in total). The red line marks the commencement of the NPS list quarterly publication. Both non-compliances and inspections are higher for the repeat violators group. This group consistently exhibits worse environmental behaviour, showing that these facilities pose higher risks to the environment. The higher rates of quarterly inspections indicate that these facilities are subject to increased scrutiny, suggesting that dynamic enforcement is in effect.

behaviour was lower for repeat violators. One potential explanation for the lower response, compared with conformists, is that the EPA was already aware of these facilities' environmental performance. New offences would not necessarily provide additional information to heighten its already established significant concerns about these facilities. However, an additional violation by mostly compliant facilities might present information on new ongoing risks.

In turn, we found signs that the recurrent publication of the NPS list is instrumental in optimising the allocation of enforcement resources on a rolling basis. The NPS "designation" is the result of a combination of enforcement actions and associated risks to the environment, i.e. it collates many factors taken into consideration in the enforcement decision-making process. Thus, facilities included in the NPS list are those that are potentially posing the highest risk to the environment and thus deserve more attention. We explore further the implications of becoming an NPS below.

5.3.2 The impact of inspections on violations

We found a strong correlation suggesting that inspections served to uncover new violations (i.e. a consequence of dynamic enforcement), and that facilities' speed of adjustment to enforcement pressures depended on the facility type. Most facilities sought to conform with licence conditions and guickly rectified any detected non-compliances. This has been previously attributed in the literature to a reminder effect of enforcement "to check on the reliability of existing compliance routines" (Thornton et al., 2005). A small minority of facilities had persistent negative behaviours, with repeated violations detected. For these repeat violators, there was a lack of evidence of a reversal in behaviour after exposure to inspections. Overall, if we took conformist facilities as those with potentially lower abatement costs and repeat violators as those with higher abatement costs, then these results could align with the results reported by Hanna and Oliva (2010), who found that industries that typically have low abatement costs respond more

strongly to an inspection than industries with high abatement costs.

5.3.3 Effects of becoming a National Priority Site on compliance

To dig further into the behaviour of repeat violators, we looked at the effect of inclusion in the NPS list. The results showed an improvement in compliance behaviour from the first period after being included in the NPS list, and this improvement was long-lasting. However, we found that the effects were not sufficient for repeat violators to bridge the gap to reach the compliance standards observed among conformist facilities (Figure 5.2).

More importantly, we did not find clear evidence of reductions in violations of emission limit values. Given that a reduction in emissions generally requires some type of abatement technology investment (or output curtailment), this result suggests that the escalation of a facility to the NPS list (and associated increase in scrutiny) does not yield sufficient investment in abatement technologies to reduce emission levels. As shown in Figure 5.3, most of the compliance improvement took place via the amendment of administrative and operational processes (e.g. incremental attention to training, maintenance and operations), as seen by a reduction in violations of these types, which do not require large expenditures (as discussed by Shimshack and Ward (2022)).

5.4 Conclusions and Policy Implications

Using unique data on environmental enforcement activities for Ireland, this study disentangled the dynamic response of enforcement authorities to facilities' environmental behaviour, and the impact of enforcement actions on facilities' compliance behaviour. The research found evidence of a



Figure 5.2. Effects of becoming an NPS on non-compliance. Note that this figure shows the effects of inclusion in the NPS list from the estimation of an event study. The event study compares NPS facilities against all others. The figure illustrates that non-compliances start declining in the first period of inclusion in the NPS list, which represents a sharp reversal in the pre-treatment trend. The upwards trend in the lead periods exposes the worsening environmental behaviour of treated facilities relative to non-treated facilities ahead of being included in the NPS list. In turn, the post-treatment effects are significant and long-lasting, which suggests that inclusion in the NPS list has permanent effects on the behaviour of targeted sites. The point estimates of the post-NPS long-term effects (grey dot at time ≥ 6) are somewhat lower than the pre-treatment long-term non-compliance average (grey dot at time ≤ -4), suggesting that the behaviour of these facilities does not converge towards the other type, i.e. at best, the gap returns to the initial levels. CI, confidence interval.



Figure 5.3. Effects of becoming an NPS on non-compliance by violation type. Note that this figure shows the effects of inclusion in the NPS list on the different types of non-compliance from the estimation of an event study. The top left hand-side chart shows that the effects on emission limit values breaches are insignificant throughout the post-treatment period. Likewise, the effects on nuisance violations are insignificant (top right). The coefficients for administrative and operational procedure violations, the bottom two charts, are significant and decreasing, which suggests that most of the compliance improvement takes place via corrections of administrative and operational procedures. CI, confidence interval.

well-defined dynamic escalation mechanism of enforcement. The escalation of enforcement led to more scrutiny in the form of inspections across all types of facilities. While less frequent violators responded promptly to enforcement pressures, repeat violators showed a persistent offender profile. Despite efforts from the regulator to target repeat violators with an information disclosure programme (i.e. the NPS), we found that these facilities failed to achieve the compliance behaviour of less frequent violators. Moreover, there was no sign of improvement in reductions of emission limit values violations, suggesting that the addition of non-traditional measures, such as the NPS, to traditional actions (e.g. inspections, fines) did not necessarily yield the required incentives to trigger investment in pollutionabatement technologies.

These results prompted the discussion of two broad policy considerations. On the one hand, the findings suggest that the threat of fines and prosecution might not be large enough to trigger a change in the inherent polluting behaviour of serious violators. This could be related to the way fines are implemented in Ireland. The EPA initiates prosecutions in the district court, and penalties are imposed by a judge if a facility is convicted. This process is lengthy and might prove more costly than administrative penalties used in other jurisdictions. For instance, the Clean Water Act in the USA has clear guidelines on how to issue fines based on environmental harm, facilities' expected financial gain from the associated violation, compliance history and ability to pay, without the need to take a facility to a court. There is evidence that this works in curtailing violations, while penal sanctions may have little effect (Shimshack and Ward, 2022). Thus, this suggests that

the results found in this research project are cases in which the threat of sanctions have "small teeth" and therefore have little effect on the compliance decisions of some large industrial facilities. If this is the case, more discretion on when and how to issue penalties could benefit enforcement authorities.

On the other hand, the irresponsiveness of repeat violators to enforcement pressures found in our study bolsters the new wave of thinking, supporting the use of voluntary approaches to enforcement. Voluntary programmes designed to encourage innovation and investment in green technologies can support traditional measures (e.g. inspections, fines) to bring the required change in the greening of these facilities. The literature on the deterrence effects of sanctions substantiates this perspective, given that, at some point, the increase in enforcement resources needed to deal with repeat violators might not be efficient at maximising compliance (i.e. the cost of enforcing penalties among this group is significantly higher than among facilities that conform with their licence conditions).⁷ The call for voluntary programmes has also gained traction due to declining enforcement budgets in different jurisdictions. Therefore, further enhancing the co-operative enforcement environment, particularly with regard to information and technical and financial support to encourage the adaptation of green technologies, could have substantial benefits in complementing the allocation of enforcement resources.

A draft of this paper has been finalised and submitted to a peer-reviewed journal.

⁷ For example, Blundell et al. (2020) and Shimshack and Ward (2022).

6 **Recommendations**

While the knowledge base on the links between environmental conditions and population health is increasing, gaps remain in our understanding of issues such as awareness, attitudes and behaviours in relation to air quality, the healthcare costs of poor air (and water) quality, and inequalities in exposures to poor air quality. A deeper understanding is vital for the design of appropriate policy interventions. We present here a number of recommendations.

- 1. While participants in the CAT Dublin citizen science project improved their awareness of NO₂ air pollution during their participation in the project, the socioeconomic profile of CAT participants highlights a real challenge for those designing environmental citizen science projects and who seek to ensure greater diversity in participation in citizen science. Strategies to encourage greater diversity in the profile of environmental citizen scientists include the use of alternative recruitment strategies, recognition of the barriers to participation for certain groups (e.g. time commitments on the part of individuals with paid work and caring responsibilities) and the co-designing of citizen science projects, all of which can be effective tools for widening participation.
- 2. The absence of a national disease register, and the limited roll-out of a unique health identifier, creates challenges for the assessment of the healthcare costs of poor air and water quality in Ireland. However, the data and methodological approaches used in this research, while incomplete, provide a framework that can be used to inform future data collection and research studies on this issue. In the context of poor air quality, future work could expand the analysis to include other types of healthcare utilisation (e.g. practice nurse visits) and other risk-outcome pairs (e.g. PM₂₅ air pollution and lung cancer), and assess the sensitivity of the findings to alternative assumptions about PAFs, population prevalence and healthcare utilisation.
- The finding that inequalities in exposure to air pollution across small areas in Ireland depended

on the type of pollutant examined, i.e. PM_{2.5} or NO₂, highlights that the association between environmental pollutants and socioeconomic characteristics is complex. Therefore, the interpretation of findings should consider issues such as the choice of pollutant measure, socioeconomic indicators, time period and level of spatial disaggregation.

The way information is presented affects the extent to which people attend to that information as well as the choices they make. Using insights from behavioural science, the research provided evidence for policymakers tasked with communicating with the public about (i) radon testing, (ii) environmental risks, (iii) climate mitigation actions, (iv) greenwashing and (v) sustainable clothing choices.

- 4. The results from the radon testing trial showed that using behaviourally informed communications generated a large uptake in radon test kits. This demonstrates the benefit of using the psychology of risk perception and behavioural science to inform radon communications with householders. The trial's most effective letter is now used to inform communications in the EPA's National Radon Survey.
- 5. While the findings from the research suggest that public concern about EMFs is appropriately low, when prompted to think about EMFs, many people reported misconceptions that they cause harm. Therefore, previous surveys may have produced overestimates of concern, due to a precautionary tendency for survey participants to rate unfamiliar risks towards the midpoint of commonly used scales and a bias induced by the stated focus of the study. Therefore, accurate, evidence-based information should be made easily accessible for the public without drawing unnecessary attention to the benign hazard.
- Given the widespread awareness of transport emissions, the findings from the research on the "stage of change" with respect to transport and dietary behaviours imply that the largest gains from a behavioural change perspective are

likely to be achieved by increasing the supply (and reliability) of accessible public transport, particularly outside Dublin. For food, there is clear scope to improve awareness of the link between the type of food consumed and greenhouse gas emissions. Results also showed that intentions to change can be motivated by emphasising the risks of climate change. Efforts to foster green identities, e.g. through neighbourhood or community initiatives, may be beneficial.

- 7. The research suggests that interventions to educate consumers about greenwashing may increase scepticism about environmental claims in general. Therefore, genuinely sustainable brands that are not already familiar to consumers may struggle to convey their authentic message. Systems-level regulations, such as some of the measures under the proposed EU Green Claims Directive, are likely to be more effective than individual-level measures at preventing consumers from being misled.
- 8. In the context of sustainable clothing choices, the results suggest that binary labels (which are favoured by policy) can have a positive effect on shifting consumers towards more sustainable products. However, the graded label, inspired by evidence from food choice research, had much stronger effects. These clothing eco-labels appear to enable consumers to make choices that better align with their preferences and may assist more expensive but less environmentally harmful brands in competing with producers of fast fashion.
- 9. When comparing Ireland with other EU countries, a significant environmental attitude-behaviour gap was apparent across the EU. While encouraging more pro-environmental behaviours is complex and challenging, the study's comprehensive approach provides valuable insights into the internal personal and contextual factors affecting the attitude-behaviour gap in a cross-country context.

The level of greenhouse gases we emit is determined by our consumption patterns. While governments introduce taxes and incentives to deter emissions contributing to climate change, these policies focus on reducing the national (production) emissions and not the global level of emissions. The two projects under the climate change theme aimed to create a better understanding of the emissions embedded in our consumption.

- 10. Most of the imported emissions in Ireland were embedded in the fuel, chemical products and animal agriculture sectors. Exported emissions were concentrated in air transport and animalrelated commodities. For a country such as Ireland, understanding both PBA and CBA emissions can help inform policymakers, in particular in the context of policy measures such as the CBAM.
- The analysis revealed the unique conditions each country has regarding PBA and CBA emissions. The findings imply that blanket policy actions require careful consideration, given the varied circumstances of countries.

Finally, the research assessed the impact of the EPA's enforcement actions on the behaviour of licensed industrial facilities in order to assess their effectiveness at improving environmental behaviours. In Ireland, industrial facilities need an environmental licence to be able to operate. These licences establish industrial emission limits and other operational and administrative conditions that aim to protect and improve the environment and human health.

12. On the one hand, the findings suggest that the threat of fines and prosecution might not be large enough to trigger a change in the inherent polluting behaviour of serious violators. This could be related to the way fines are implemented in Ireland. The EPA initiates prosecutions in the district court, and penalties are imposed by a judge if a facility is convicted. This process is lengthy and might prove more costly than administrative penalties used in other jurisdictions. On the other hand, the irresponsiveness of repeat violators to enforcement pressures bolsters the new wave of thinking, supporting the use of voluntary approaches to enforcement, particularly those encouraging the adoption of green technologies and practices. Voluntary programmes designed to encourage innovation and investment in green technologies combined with traditional measures (e.g. inspections, fines) could bring about the required change in the greening of these facilities.

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Abbreviations

CAT	Clean Air Together
СВА	Consumption-based accounting
CBAM	Carbon Border Adjustment Mechanism
EEA	European Environment Agency
EMF	Electromagnetic field
EPA	Environmental Protection Agency
ESRI	Economic and Social Research Institute
GP	General practitioner
GTAP	Global Trade Analysis Project
HIPE	Hospital In-Patient Enquiry
HPSC	Health Protection Surveillance Centre
IID	Infectious intestinal disease
LEMA	Licensing, Enforcement, Monitoring and Assessment
NPS	National Priority Site
PAF	Population-attributable fraction
PBA	Production-based accounting
PM _{2.5}	Fine particulate matter
WHO	World Health Organization
WRD	Water-related disease

An Ghníomhaireacht Um Chaomhnú Comhshaoil

Tá an GCC freagrach as an gcomhshaol a chosaint agus a fheabhsú, mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ar thionchar díobhálach na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialáil: Rialáil agus córais chomhlíonta comhshaoil éifeachtacha a chur i bhfeidhm, chun dea-thorthaí comhshaoil a bhaint amach agus díriú orthu siúd nach mbíonn ag cloí leo.

Eolas: Sonraí, eolas agus measúnú ardchaighdeáin, spriocdhírithe agus tráthúil a chur ar fáil i leith an chomhshaoil chun bonn eolais a chur faoin gcinnteoireacht.

Abhcóideacht: Ag obair le daoine eile ar son timpeallachta glaine, táirgiúla agus dea-chosanta agus ar son cleachtas inbhuanaithe i dtaobh an chomhshaoil.

I measc ár gcuid freagrachtaí tá:

Ceadúnú

- > Gníomhaíochtaí tionscail, dramhaíola agus stórála peitril ar scála mór;
- Sceitheadh fuíolluisce uirbigh;
- Úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe;
- Foinsí radaíochta ianúcháin;
- Astaíochtaí gás ceaptha teasa ó thionscal agus ón eitlíocht trí Scéim an AE um Thrádáil Astaíochtaí.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- > Iniúchadh agus cigireacht ar shaoráidí a bhfuil ceadúnas acu ón GCC;
- Cur i bhfeidhm an dea-chleachtais a stiúradh i ngníomhaíochtaí agus i saoráidí rialáilte;
- Maoirseacht a dhéanamh ar fhreagrachtaí an údaráis áitiúil as cosaint an chomhshaoil;
- > Caighdeán an uisce óil phoiblí a rialáil agus údaruithe um sceitheadh fuíolluisce uirbigh a fhorfheidhmiú
- Caighdeán an uisce óil phoiblí agus phríobháidigh a mheasúnú agus tuairisciú air;
- Comhordú a dhéanamh ar líonra d'eagraíochtaí seirbhíse poiblí chun tacú le gníomhú i gcoinne coireachta comhshaoil;
- > An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Dramhaíola agus Ceimiceáin sa Chomhshaol

- > Rialacháin dramhaíola a chur i bhfeidhm agus a fhorfheidhmiú lena n-áirítear saincheisteanna forfheidhmithe náisiúnta;
- Staitisticí dramhaíola náisiúnta a ullmhú agus a fhoilsiú chomh maith leis an bPlean Náisiúnta um Bainistíocht Dramhaíola Guaisí;
- An Clár Náisiúnta um Chosc Dramhaíola a fhorbairt agus a chur i bhfeidhm;
- > Reachtaíocht ar rialú ceimiceán sa timpeallacht a chur i bhfeidhm agus tuairisciú ar an reachtaíocht sin.

Bainistíocht Uisce

- Plé le struchtúir náisiúnta agus réigiúnacha rialachais agus oibriúcháin chun an Chreat-treoir Uisce a chur i bhfeidhm;
- > Monatóireacht, measúnú agus tuairisciú a dhéanamh ar chaighdeán aibhneacha, lochanna, uiscí idirchreasa agus cósta, uiscí snámha agus screamhuisce chomh maith le tomhas ar leibhéil uisce agus sreabhadh abhann.

Eolaíocht Aeráide & Athrú Aeráide

- Fardail agus réamh-mheastacháin a fhoilsiú um astaíochtaí gás ceaptha teasa na hÉireann;
- Rúnaíocht a chur ar fáil don Chomhairle Chomhairleach ar Athrú Aeráide agus tacaíocht a thabhairt don Idirphlé Náisiúnta ar Ghníomhú ar son na hAeráide;

 Tacú le gníomhaíochtaí forbartha Náisiúnta, AE agus NA um Eolaíocht agus Beartas Aeráide.

Monatóireacht & Measúnú ar an gComhshaol

- Córais náisiúnta um monatóireacht an chomhshaoil a cheapadh agus a chur i bhfeidhm: teicneolaíocht, bainistíocht sonraí, anailís agus réamhaisnéisiú;
- Tuairiscí ar Staid Thimpeallacht na hÉireann agus ar Tháscairí a chur ar fáil;
- Monatóireacht a dhéanamh ar chaighdeán an aeir agus Treoir an AE i leith Aeir Ghlain don Eoraip a chur i bhfeidhm chomh maith leis an gCoinbhinsiún ar Aerthruailliú Fadraoin Trasteorann, agus an Treoir i leith na Teorann Náisiúnta Astaíochtaí;
- Maoirseacht a dhéanamh ar chur i bhfeidhm na Treorach i leith Torainn Timpeallachta;
- Measúnú a dhéanamh ar thionchar pleananna agus clár beartaithe ar chomhshaol na hÉireann.

Taighde agus Forbairt Comhshaoil

- Comhordú a dhéanamh ar ghníomhaíochtaí taighde comhshaoil agus iad a mhaoiniú chun brú a aithint, bonn eolais a chur faoin mbeartas agus réitigh a chur ar fáil;
- Comhoibriú le gníomhaíocht náisiúnta agus AE um thaighde comhshaoil.

Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéil radaíochta agus nochtadh an phobail do radaíocht ianúcháin agus do réimsí leictreamaighnéadacha a mheas;
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha;
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta;
- Sainseirbhísí um chosaint ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Ardú Feasachta agus Faisnéis Inrochtana

- > Tuairisciú, comhairle agus treoir neamhspleách, fianaisebhunaithe a chur ar fáil don Rialtas, don tionscal agus don phobal ar ábhair maidir le cosaint comhshaoil agus raideolaíoch;
- > An nasc idir sláinte agus folláine, an geilleagar agus timpeallacht ghlan a chur chun cinn;
- Feasacht comhshaoil a chur chun cinn lena n-áirítear tacú le hiompraíocht um éifeachtúlacht acmhainní agus aistriú aeráide;
- > Tástáil radóin a chur chun cinn i dtithe agus in ionaid oibre agus feabhsúchán a mholadh áit is gá.

Comhpháirtíocht agus Líonrú

> Oibriú le gníomhaireachtaí idirnáisiúnta agus náisiúnta, údaráis réigiúnacha agus áitiúla, eagraíochtaí neamhrialtais, comhlachtaí ionadaíocha agus ranna rialtais chun cosaint chomhshaoil agus raideolaíoch a chur ar fáil, chomh maith le taighde, comhordú agus cinnteoireacht bunaithe ar an eolaíocht.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an GCC á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóir. Déantar an obair ar fud cúig cinn d'Oifigí:

- 1. An Oifig um Inbhunaitheacht i leith Cúrsaí Comhshaoil
- 2. An Oifig Forfheidhmithe i leith Cúrsaí Comhshaoil
- 3. An Oifig um Fhianaise agus Measúnú
- 4. An Oifig um Chosaint ar Radaíocht agus Monatóireacht Comhshaoil
- 5. An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tugann coistí comhairleacha cabhair don Ghníomhaireacht agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.



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