RESEARCH SERIES NUMBER 187
JULY 2024

COVID-19 INFECTION RATES AND SOCIAL DISADVANTAGE IN IRELAND: AN AREA-LEVEL ANALYSIS

ANNE DEVLIN, ADELE WHELAN AND SEAMUS MCGUINNESS

AN INSTITIÚID UM THAIGHDE EACNAMAÍOCHTA AGUS SÓISIALTA
ESRI ECONOMIC & SOCIAL RESEARCH INSTITUTE

COVID-19 INFECTION RATES AND SOCIAL DISADVANTAGE IN IRELAND: AN AREA-LEVEL ANALYSIS

Anne Devlin

Adele Whelan

Seamus McGuinness

July 2024

RESEARCH SERIES

NUMBER 187

Available to download from www.esri.ie.

https://doi.org/10.26504/rs187

ABOUT THE ESRI

The Economic and Social Research Institute (ESRI) advances evidence-based policymaking that supports economic sustainability and social progress in Ireland. ESRI researchers apply the highest standards of academic excellence to challenges facing policymakers, focusing on ten areas of critical importance to 21st Century Ireland.

The Institute was founded in 1960 by a group of senior civil servants led by Dr T.K. Whitaker, who identified the need for independent and in-depth research analysis. Since then, the Institute has remained committed to independent research and its work is free of any expressed ideology or political position. The Institute publishes all research reaching the appropriate academic standard, irrespective of its findings or who funds the research.

The ESRI is a company limited by guarantee, answerable to its members and governed by a Council, comprising up to 14 representatives drawn from a cross-section of ESRI members from academia, civil services, state agencies, businesses and civil society. Funding for the ESRI comes from research programmes supported by government departments and agencies, public bodies, competitive research programmes, membership fees, and an annual grant-in-aid from the Department of Public Expenditure NDP Delivery and Reform.

Further information is available at www.esri.ie.

THE AUTHORS

Anne Devlin is a Research Officer at the Economic and Social Research Institute (ESRI) and an Adjunct Assistant Professor at Trinity College Dublin (TCD). Adele Whelan is a Senior Research Officer at the ESRI and Adjunct Associate Professor at TCD. Seamus McGuinness is a Research Professor at the ESRI and an Adjunct Professor at TCD.

ACKNOWLEDGEMENTS

The work carried out in this report was funded by Pobal as part of the Research Programme on Community Development and Social Inclusion. We would like to thank all the individuals within Pobal who provided assistance during the project, particularly Ela Hogan and Martin Quigley. Valuable contributions were made by members of the Research Programme Steering Committee: Delma Byrne, John Curtis, Paul Geraghty, Deirdre Kelly, Helen Russell, Alana Ryan, and Roshin Sen. We are extremely grateful to the members of the Research Programme Steering Committee for their ongoing support and feedback on the research.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

CSO	Central Statistics Office
ED	Electoral Division
ICU	Intensive Care Unit
NI	Northern Ireland

EXECUTIVE SUMMARY

Existing research has shown that deprived areas were impacted to a greater extent by the COVID-19 pandemic in a multitude of ways but particularly in terms of the health impact. This research examines the health impact of the pandemic on people living in disadvantaged areas in Ireland. Health impacts are measured in terms of COVID-19 infection rates and ICU admission rates. The analysis is conducted by using area-level COVID-19 infection rate data at the Electoral Division (ED) level for Ireland and ED-level measures of deprivation based on the Pobal Haase Pratschke Relative Deprivation Index (Pobal HP Deprivation Index). Additional area-level information from the Census is also utilised. This work builds on previous work that examined the economic impact of COVID-19 on disadvantaged areas in Ireland in terms of pandemic-related unemployment.

Descriptive analysis suggests that the average COVID-19 infection rate in the most deprived areas was significantly higher than the average in more affluent areas. More specifically, the average infection rate was over 50 per cent higher in the most deprived areas. The average infection rate in the most deprived areas was 5.6% compared to 3.7% in more affluent areas.

The results of formal modelling show that infection rates were highest in the most deprived areas even when controlling for ethnic make-up, age structure at the area level and the presence of communal establishments. More precisely, when these area-level factors are controlled for, we find that the most deprived areas had infection rates more than a third higher than more affluent areas. Areas with higher shares of ethnic minorities as well as areas with communal establishments also had higher infection rates.

Infection rates were also higher in non-deprived areas located in border counties. This latter finding in particular has significant policy ramifications given the porous border between Ireland and Northern Ireland.

In terms of ICU admission, deprivation is not correlated directly with high ICU admission rates due to COVID-19; however, it appears to be having an indirect impact through other area-level characteristics. High ICU admission rates are more likely to manifest in areas with communal establishments as well as areas with higher proportions of people with underlying health conditions. Areas with higher proportions of racial/ethnic minorities were also more likely to have high ICU admission rates. These factors are highly correlated with area-level deprivation so while deprivation does not have a direct impact on ICU admission rates at the area level, it appears to be mediated through these other area-level factors, e.g. ethnicity, age and health.

From a policy perspective, this research suggests that the underlying markers of deprivation which differ spatially across Ireland influence the prevalence and severity of COVID-19. Therefore, there are important lessons to be learned about

health inequalities during a pandemic as well as the impact of other pre-existing inequalities which may impact the prevalence of COVID-19.

CHAPTER 1

Introduction

The COVID-19 pandemic is well-documented internationally to have had a disproportionate impact on disadvantaged communities (Gullón et al., 2022; Rohleder et al., 2022; Manz et al., 2022; Meurisse et al., 2022; Moissl et al., 2022; Clouston et al., 2021; Green et al., 2021; Morrissey et al. 2021; KC et al., 2020; Lewis et al., 2020). The literature finds that areas of high deprivation have been impacted to a greater extent in terms of both health (infection rate, ICU admission rates, mortality) and the economy (pandemic-related employment disruption). People living in areas of high deprivation are more likely to work in lower-paid jobs that are not suitable for remote working or have had higher exposure to the virus (e.g. healthcare assistants, and essential retail workers). Individuals in areas of deprivation are also more likely to live in more crowded housing and to rely on public transport, which elevates their exposure to the virus. This report exploits geographically disaggregated (Electoral Division (ED)) data to answer the following research question: were areas of higher deprivation associated with higher rates of 1) COVID-19 infections and/or 2) Intensive Care Unit (ICU) admissions during the COVID-19 pandemic in Ireland?

Existing international studies suggest a positive correlation between higher levels of deprivation and COVID-19 infection rates, as well as higher hospitalisation and ICU admission rates. However, the strength of this positive association varies across studies. Through our analysis, we seek to provide insights into the magnitude and nuances of these associations within the context of the ED-level spatial distribution of COVID-19 in Ireland.

The primary data sources utilised in our analysis include data obtained from the Central Statistics Office (CSO), which contain the COVID-19 infection rate and ICU admissions data, and the 2022 Pobal HP Deprivation Index.[1][2] During the period from March 2020 to April 2021, the average COVID-19 infection rate at the Electoral Division (ED) level was 3.9 per cent, with substantial variations observed. Similarly, the ICU admission rate as a proportion of the infected was recorded at 0.62 per cent at the ED level during this period.

Our research reveals that higher COVID-19 infection rates are found in the most deprived areas, as well as in both deprived and less deprived areas situated in border counties. This suggests a complex interplay between deprivation and geographic factors in influencing COVID-19 infection rates. Higher rates of COVID-

[1] In this report, the term HP Index and deprivation index refer to the HP Relative Deprivation Index unless explicitly stated otherwise.

[2] For more info on the Pobal HP deprivation index see www.pobal.ie/pobal-hp-deprivation-index.

19 infection are also found in areas with higher shares of some minority groups and in areas with communal establishments.

In contrast, our multivariate analysis does not yield significant evidence of a relationship between area-level deprivation and ICU admissions. However, we observe that areas with larger proportions of individuals infected with underlying clinical conditions, with higher proportions of ethnic minorities, and areas with communal establishments exhibit higher rates of ICU admissions. These factors, particularly ethnicity and health, are positively correlated with area-level deprivation which suggests they are playing a mediating role between deprivation and ICU admission. That is to say that while deprivation does not directly impact ICU admission rates, it does correlate with the ethnic/racial make-up of an area and the overall health levels of an area, which do impact ICU admission rates. This highlights the importance of considering additional factors beyond deprivation alone when examining patterns of ICU utilisation in response to COVID-19.

CHAPTER 2

Literature

2.1 OVERVIEW OF RELEVANT LITERATURE

There is extensive literature on the impact of pandemics from across the spectrum of academic disciplines, which covers a number of pandemics, albeit primarily the Great Influenza Pandemic 1918–1920 (Doran et al., 2024). A systematic review of the broader pandemic literature by Doran et al. (2024) finds that the majority of studies on pandemics focus on investigating determinants of mortality and economic outcomes, with fewer studies focusing on health outcomes other than mortality (e.g. infection and recovery). Of this subset of studies, some have examined how socio-economic status impacts morbidity. Mamelund (2018) examines socio-economic status and morbidity during the Great Influenza Pandemic (1918–1920). The study finds that poorer people were more vulnerable to the infection, perhaps due to increased exposure, and suggests that they should be prioritised in vaccination programmes in the case of future pandemics. The more recent literature on the COVID-19 pandemic, while still growing, focuses primarily on morbidity as well as economic impacts.

The existing COVID-19 studies examine a range of outcomes at international, national, and local levels. Publications analysing the relationship between deprivation and COVID-19 health impacts utilise a variety of outcome measures. In general, outcome measures capture one or more of: (i) COVID-19 infection rate, (ii) hospitalisations, (iii) Intensive Care Unit (ICU) admissions and, (iv) mortality due to COVID-19. These are measured either as a proportion of the population or a proportion of the infected in the case of the latter three. This variation in outcomes within the literature is largely due to an asymmetry of available COVID-19 data between countries. While these outcome measures are strongly related, they are distinct from one another, and associated findings will have substantially different implications for policy.

2.2 DEPRIVATION AND COVID-19 INCIDENCE

Numerous studies find that residence in deprived areas is positively associated with increased risk of COVID-19 infection (Fortunato et al., 2023; Gullón et al., 2022; Rohleder et al., 2022; Manz et al., 2022; Meurisse et al., 2022; Moissl et al., 2022; Clouston et al., 2021; Green et al., 2021; Morrissey et al., 2021; KC et al., 2020; Lewis et al., 2020). However, the magnitude of this positive association differs between studies. For example, KC et al. (2020) report that residents in the most deprived neighbourhoods in Louisiana (US) had a 40 per cent higher risk of COVID-19 infection relative to the least deprived neighbourhoods, which is robust to the inclusion of an urban/rural control. Gullón et al. (2022) find a 17 per cent higher risk of infection for the most deprived areas in Madrid (Spain) relative to the least deprived areas. Both studies use deprivation indices developed from their respective census.

The magnitude of findings differs between studies. The finding from KC et al. (2020) is one of the higher estimates when comparing the most deprived and least deprived areas per our review of the literature, though is not the highest. Lewis et al. (2020) find that residents living in areas of high deprivation were up to three times as likely to become infected with COVID-19 when compared to residents of areas of low deprivation in Utah, USA. The finding from Gullón et al. (2022) is among some of the lowest estimates. Other studies in the review publish estimates (albeit with methodological variation) between these figures.

However, this relationship is not found in all studies. For example, Gaubert et al. (2023) found that in France, deprivation was linked to the COVID-19 severity in terms of hospitalisation rate but was not linked to a higher infection rate.

Furthermore, some studies find that the variation in infection rates between areas was dependent on the outbreak. Meurisse et al. (2022) find that more deprived areas in Belgium were more at risk of infection during the latter stages of the pandemic, during which time COVID-19 circulation and severity was most intense. Similar results were found by Mateo-Urdiales et al. (2021) in Italy, Gullón et al. (2022) in Barcelona, Spain and Manz et al. (2022) in Germany. These findings highlight the importance of the temporal dimension of the relationship between deprivation and COVID-19 health outcomes.

2.3 DEPRIVATION, HOSPITALISATION, ICU ADMISSION AND MORTALITY

International evidence suggests that higher levels of deprivation are positively linked to higher hospital admissions (Patel et al., 2020; Lewis et al., 2020). Studies have also suggested that heterogenous hospitalisation rates may have been driven by specific factors that are associated with socio-economic status. One study conducted in Minnesota, USA found evidence that increased hospital admission rates were more prevalent among minority ethnic groups, while deprivation in and of itself was not directly associated with increased hospital admission (Ingraham et al., 2021). Ingraham et al. (2021) used the Area Deprivation Index from Singh (2003) to operationalise deprivation, which is constructed using demographic variables, education levels, income, property value, poverty indicators and others.

Studies of ICU admissions and mortality also provide evidence of a positive relationship with area-level deprivation (Lone et al., 2021; Kim and Bostwick, 2020; Chen and Krieger, 2021; Brandily et al., 2021). McGowan and Bambra (2022) synthesise the available literature on area-based inequalities and COVID-19 mortality rates and find of 95 papers, 86 find mortality rates higher in deprived areas relative to affluent areas. While Lone et al. (2021) find that patients with COVID-19 from more deprived areas in Scotland were admitted to ICU more than those from less deprived areas and exhibited a significantly higher rate of 30-day mortality post-admission. Using logit regression analysis, the study controlled for intrinsic health characteristics (comorbidity, physiology) and demographic variables (ethnicity, age, sex) to determine the influence of deprivation on ICU admission and mortality. Ingraham et al. (2021), Lone et al. (2021), Kim and Bostwick (2020) and Patel et al. (2020) all control for comorbidities in their studies.

In addition, other studies examine the underlying pathways associated with deprivation that may influence COVID-19 mortality. Albani et al. (2022) examine inequalities in various key pathways between areas that influence the prevalence of COVID-19. They categorise these pathways as: (i) transmission (overcrowding, high area occupancy, etc.); (ii) vulnerability (prevalence of health issues such as diabetes or hypertension); (iii) susceptibility (poverty, inequality, homelessness, etc.): and (iv) exposure (industrial composition of the area). The authors find that inequalities in transmission and vulnerability were key drivers of COVID-19 mortality in England in early 2020. This research therefore suggests that the underlying markers of deprivation which differ across areas spatially fundamentally influence the prevalence and severity of COVID-19.

It is worth noting that indicators of ICU admission rates and mortality rates differ between studies. Some authors, for example, Lone et al. (2021), conduct their analysis at the individual level and examine COVID-19 case outcomes (e.g. whether specific cases of COVID-19 result in ICU admission or death). They then stratify their results by deprivation quintiles to highlight differences in health outcomes.

Others examine COVID-19 outcomes at the area level. Kim and Bostwick (2020) examine the relationship between their own calculated Social Vulnerability Index and the number of COVID-19-related deaths at the Chicago Community Area (CCA) level; notably, they do not account for population size in this study, which may be due to low population variation between small areas (CCAs), though the authors don't explicitly address this in their paper. Brandily et al. (2021) use their own measure of excess mortality, calculated from death rates from previous years (2019 and 2020) as a baseline. They calculate excess deaths per capita at the municipality level in France in 2020 based on the assumption that short-term death trends would not have been affected by factors other than the COVID-19 pandemic. These differences in measurement are largely due to differences in data availability between countries.

2.4 RACE, ETHNICITY AND COVID-19

In Sections 2.2 and 2.3 we examine the international literature on area-level deprivation and COVID-19 infection rates and health outcomes. We find that there is a growing body of work which finds higher rates of infection in deprived areas as well as poorer health outcomes. We also find that other characteristics, both at the area level and the individual level, are correlated with COVID-19 infection rates and health outcomes. In this section, we examine in more detail why these other area-level and individual characteristics may impact COVID-19 transmission and outcomes.

Ethnicity has emerged as a key predictor of COVID-19 transmission and severity. Pan et al. (2020) early in the pandemic published a systematic review of the relationship between ethnicity and reporting of COVID-19 as well as clinical outcomes. They find that at that early stage of the pandemic, data on ethnicity was not widely included in the published medical literature, but was present in the emerging literature (grey literature and preprint material), which suggested that Black, Asian and Ethnic minorities did have an increased risk of being infected with COVID-19 as well as poorer health outcomes. Mackey et al. (2020) also conducted a systematic review of studies in the US and found that African American/Black and Hispanic populations all had higher rates of COVID-19 infection and higher rates of mortality (but only due to the higher infection rate). Asian populations had outcomes similar to non-Hispanic white populations. They attributed these differences to access to healthcare and differences in exposure to the virus rather than to any differences in comorbidities.

In a study of the state of California, Reitsma et al. (2021) found the Latino population[3] had higher rates of infection as well as higher mortality rates, which they attribute to higher exposure risk. Higher exposure risk exists amongst those who live in households with more people than rooms and with at least one member of the household employed in an essential role. Wilkinson et al. (2022) also find that ethnic minorities were more likely to have severe COVID-19, which they also attribute to minorities being more likely to work in essential roles and more likely to live in larger households. Similarly, Sze et al. (2020) also attribute ethnic disparities to overcrowded housing and working in essential jobs or in jobs which aren't conducive to remote working. In another US study, McLaughlin et al. (2020) examine county-level characteristics and COVID-19 rates and find that counties which are more urban, have more crowded housing, higher levels of air pollution, higher shares of women, more people aged between 20 and 49, higher shares of racial/ethnic minorities, higher levels of residential segregation, more income inequality, more people with no health insurance, a higher prevalence of diabetes, or more people who couldn't shelter in place during the pandemic, had higher rates of COVID-19 infection and mortalities.

In the UK, Prats-Uribe et al. (2020) find COVID-19 rates to be higher in BAME (Black, Asian, or Minority Ethnic) communities, in deprived areas, amongst obese patients, and patients with previous comorbidities (specifically, hypertension, chronic obstructive pulmonary disease (COPD), asthma, and renal disease). Mathur et al. (2021) find that some minority ethnic populations in England were more likely to test for COVID-19, more likely to test positive for the infection and had poorer outcomes relative to the white population; these results were over and above socio-demographic, household and clinical measures. Nafilyan et al. (2021) attribute the higher mortality rate from COVID-19 amongst some ethnic minority

[3] Hispanic/Latino of all races.

groups in England to the increased likelihood of living in multi-generational households. More specifically, elderly adults who live with dependent children are at increased risk of COVID-19 mortality even after controlling for their pre-pandemic health status. That rates of COVID-19 transmission are higher and health outcomes poorer amongst ethnic minorities is particularly interesting given there is a significant literature on the uptake of protective behaviours during pandemics, which shows that non-white ethnicities and ethnic minorities are more likely to undertake health-protecting behaviours than those who are white (Smith et al., 2022; Bish and Michie, 2010; Rubin et al., 2009[4]). Furthermore, Barrett and Cheung (2021), in a study of UK students, found that those of non-white ethnicities were more likely to carry out hygiene behaviours that protect against COVID-19 transmission. Atchison et al. (2021), on the other hand, find that ethnic minorities during the COVID-19 pandemic were less able to work from home or self-isolate.

2.5 COVID-19 IN IRELAND

McKeown et al. (2023) examine the relationship between deprivation and hospital admissions, ICU admissions and mortality between March 2020 and May 2021 in Ireland. The authors use the HP Index (Haase et al., 2014) to categorise small areas by deprivation and employ backwards stepwise regression to determine the associative relationship between deprivation and COVID-19 health outcomes. The study was based on individual data, also from the COVID-19 infection rate data sourced from the national Computerised Infectious Diseases Reporting (CIDR) system managed by the Health Protection Surveillance Centre as is used in this study, with a control included for location in a deprived area; they find that area-level deprivation was associated with increased individual risk of hospital admission due to COVID-19, relative to those from less deprived areas. However, they find that deprivation was not associated with the individual risk of ICU admission, nor was it associated with elevated individual risk of mortality as a result of COVID-19 for the time period studied. Instead, they find that comorbidity, age, and outbreak-associated infection at the individual level were the strongest predictors of both ICU admission and COVID-19-associated mortality. This suggests that while deprivation has an impact on infections, it is also related to the health characteristics intrinsic to the individual driving variation in terms of severity and mortality in Ireland, rather than deprivation. It should be noted that McKeown et al. (2023) measured the role of area-level deprivation in elevating individual-level COVID-19 exposure, which is distinct from the current study which assesses the extent to which COVID-19 infection and ICU admittance rates were higher in deprived areas controlling for other area-level characteristics. Furthermore, a key finding of this work is the relationship between ethnicity and COVID-19 health outcomes, which McKeown et al. (2023) does not examine.

---

[4] This literature predates the COVID-19 pandemic, with studies examining ethnic disparities in protective behaviours in response to the H1N1 virus and others.

Some evidence that area-level deprivation influenced COVID-19 infection rates in Ireland is offered by Madden et al. (2021). Using a hierarchical Bayesian spatio-temporal model, they find an association between the most deprived areas in Ireland and elevated COVID-19 infection rates between March 2020 and February 2021. The authors recommend that socially deprived areas should be prioritised in public health interventions (i.e. vaccination) because they are more at risk of comorbidities, and therefore more at risk of severe COVID-19 infection. While the study is limited to examining infection rates (i.e. not hospitalisations, ICU admissions or mortality), it does offer tentative evidence that deprivation has a role to play in determining COVID-19 outcomes in Ireland.

Given Ireland is one of two jurisdictions on a small island with a porous land border, the effect of the border on COVID-19 outcomes has been examined. Kennelly et al. (2020) argued that Ireland's land border with Northern Ireland (NI) 'deserves close attention during this health emergency' as counties along the border had the highest rates of infection and deaths per person. They argued that cross-border mobility between areas with differing public health strategies and testing strategies was a particular source of worry, especially as NI utilised community testing to a much lesser degree.

There are also two qualitative studies which consider the border and the varying government responses across the island. Nolan et al. (2021) explore public health policies in NI and Ireland in the first wave of the pandemic (February 2020–June 2020) using the Oxford COVID-19 Government Response Tracker (OxCGRT). They find that, at least early in the pandemic, there was alignment between the jurisdictions. However, it is unclear whether the findings would hold for other waves. O'Connor et al. (2021) explore the perspective of laypeople in the border region during the COVID-19 pandemic and find that public opinion was that the pandemic response was divergent and politicised, which led to undermining public belief in the response. They found that there was wide support amongst those in border areas to an all-island response to the pandemic.

2.6 DEPRIVATION IN IRELAND

The Irish economy has been performing strongly in recent years, even when considering the COVID-19 pandemic period (Department of Finance, 2023). Unemployment is currently at low levels and labour force participation, particularly amongst women, is high. However, a growing economy does not equate to improved economic fortunes for all. In fact, recent economic policy in Ireland has moved away from the outdated notion of focusing on income as a sole indicator for economic success to a more holistic approach which looks at various aspects of social inclusion, such as housing, healthcare, and childcare (Whelan et al., 2023a).

Using comparable data across the EU, Ireland has a lower than average at risk of poverty rate (Eurostat, 2024). However, there is significant regional variation with the at risk of poverty rate in 2023 19.8%, 15.2% and 11.1% for the Northern and Western region, the Southern region, and the Eastern and Midland region respectively (Eurostat, 2024). This suggests that while overall the Irish economy is performing well, the economic prosperity may not be equally distributed across the country.

The HP relative deprivation index is used as the main measure of spatial differences in terms of disadvantage in Ireland. The most recent version of this index was built using Census 2022 data. While this new set of deprivation measures saw overall improvements on a national basis, the gap between the most disadvantaged areas and the national average increased (Pobal, 2023). Disadvantage is disproportionately experienced in small pockets within Dublin city centre, the north and west suburbs of Dublin, the outskirts of Cork, Waterford, Limerick and some small rural towns (Pobal, 2023).

Deprivation, poverty, and social exclusion are also more common amongst particular groups in Ireland. Lone parents, people with disabilities, Roma and Travellers, people in the international protection system, and refugees are all more likely to be experiencing deprivation or poverty. Lone parents and people with disabilities are more likely to face deprivation than their peers (CSO, 2024). Ethnic minorities in Ireland, particularly those mentioned above, face particular barriers to social and economic inclusion (McGuinness et al., 2018). Forty per cent of Travellers live in households that have great difficulty in making ends meet, which is significantly higher than the State average (8%) (European Union Agency for Fundamental Rights, 2019).

Examining COVID-19 through a spatial lens is particularly important in Ireland given these pre-existing spatial and minority inequalities. Furthermore, previous research found there to be significant spatial differences in terms of the economic impact of the pandemic in Ireland (Whelan et al., 2023b).

CHAPTER 3

Data and methods

3.1 COVID-19 DATA

The COVID-19 infection rate data used in this study was accessed via the Central Statistics Office (CSO) COVID-19 Data Hub. Approval was sought and received from the ESRI Ethics Committee, the Health Research Consent Declaration Committee, the CSO and the Research Data Governance Board. COVID-19 cases in Ireland were collected on the Computerised Infectious Diseases Reporting (CIDR) system; confirmed cases notified on CIDR must meet the Health Protection Surveillance Centre's case definition, which requires detection of SARS-CoV-2 nucleic acid (via a PCR test) or antigen in a clinical specimen[5]. Positive tests through a self-administered rapid antigen test are not considered a confirmed case.

The data covers the period from March 2020 (the beginning of the pandemic) to April 2021 (when data was applied for)[6]. There are a total of 238,907 observations in the COVID-19 infection rate data, with each observation representing a recorded infection. The dataset contains information on individual characteristics such as age, gender, ethnicity, country of birth, occupation, whether or not individuals were healthcare workers, and possible source of transmission of the virus. However, these variables, with the exception of age and gender, are not well populated. Health information is also recorded for a minority of individuals and includes whether the infected person had a BMI over 40, smoker status, and the presence of certain medical conditions (chronic respiratory disease, diabetes, and any other underlying chronic condition). Again, these fields were not well populated, with some variables being recorded for approximately 10 per cent of the sample. The coverage of these health variables is shown in Table A.1 in an appendix. The area of residence at the Electoral Division (ED) level is also recorded for each individual.

This COVID-19 infection rate data is used to generate area-level infection rates. An overall infection rate is calculated by dividing the number of observations in the dataset, which represent a confirmed infection of COVID-19 from March 2020 to April 2021 in an ED, by the population of that ED. ED is coded from each individual's address using the Health and Safety Executive's Health Atlas tool[7].

---

[5] See www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/casedefinitions/covid-19interimcasedefinitionforireland for more information on the definition of a confirmed case of COVID-19.

[6] This period is before the vaccination rollout in Ireland, see https://covid-19.geohive.ie/pages/vaccinations.

[7] For more information on the Health Atlas tool, see www.healthatlasireland.ie.

3.2 OTHER DATA SOURCES USED

The HP Deprivation Index[8] is the key explanatory variable in our analyses, as we aim to quantify the relationship between area-level COVID-19 health impacts and area-level deprivation. The index is constructed by Pobal using data from the 2022 Census for Ireland at the ED level on a range of indicators for demographic profile, social class composition and labour market situation. In total, ten measures from the Census under these three categories are used to generate the index. The measures used are displayed in Figure A.1 in the appendix. Table 3.1 shows the distribution of the relative deprivation across categories which are frequently used by researchers; the index score ranges from approximately -40 (most deprived) to +20 (least deprived). Table 3.1 also shows the labels frequently used to describe EDs. The least deprived EDs may be described as 'affluent', while those with the highest levels of relative deprivation are described as 'extremely disadvantaged'. In all, there are six categories which vary considerably in size; in fact, there are only two EDs described as 'extremely disadvantaged'. The 2016 HP Relative Deprivation Index described one ED as 'very affluent' but there are no such EDs in the 2022 index and 'affluent' is the highest designated category. For the purposes of modelling, we combine these small groups to generate three categories of deprivation, which are shown in the final column on Table 3.1.

[8] For more information on the Pobal HP Deprivation Index, see www.pobal.ie/pobal-hp-deprivation-index.

TABLE 3.1 CLASSIFICATION OF HP RELATIVE INDEX SCORES AT ED LEVEL IN IRELAND, 2022

Relative Index Score	Label	Number of EDs in 2022	Percentage of EDs in 2022	*Our Classification (1–3)*
10 to 20	Affluent	129	3.81%	*3*
0 to 10	Marginally above average	1538	45.41%	*3*
0 to -10	Marginally below average	1481	43.73%	*2*
-10 to -20	Disadvantaged	214	6.32%	*1*
-20 to -30	Very disadvantaged	23	0.68%	*1*
Below -30	Extremely disadvantaged	2	0.06%	*1*
Total		3387	100%	

Notes: *This is restricted to the EDs used for the analysis going forward.*

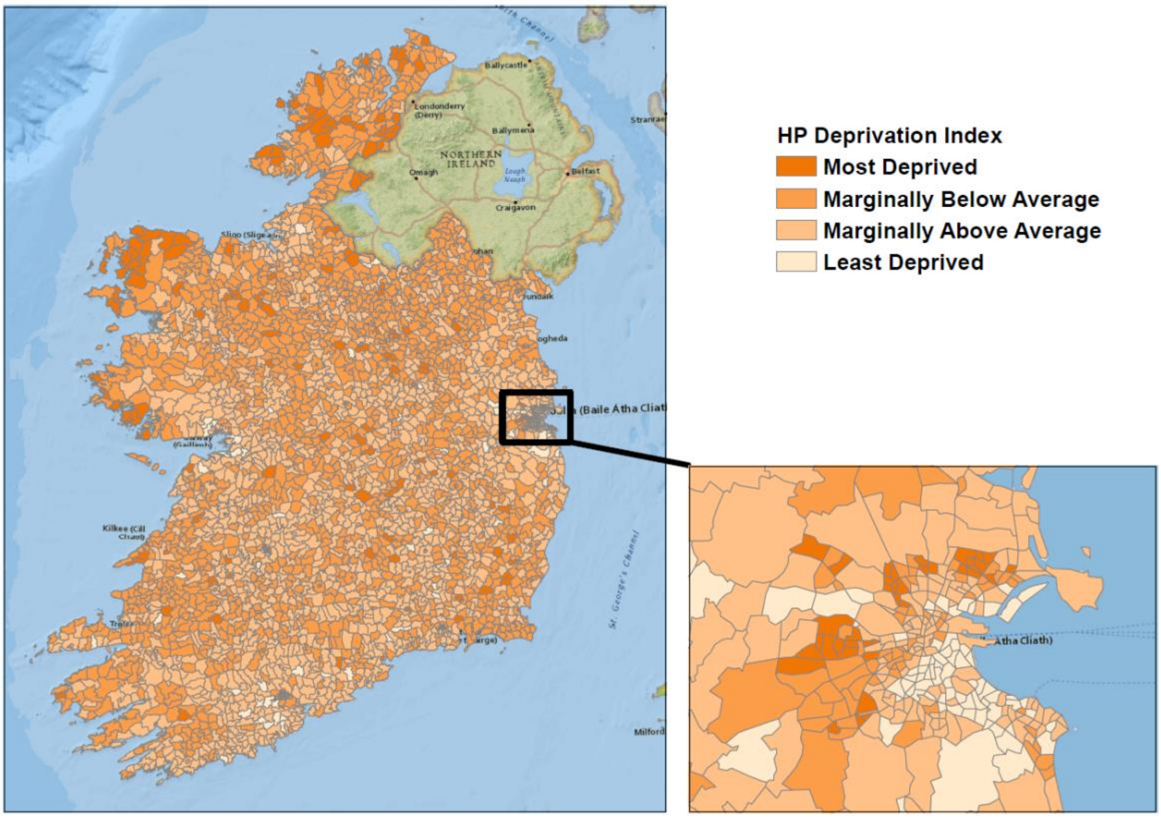
We use deprivation categories which build on those used by the producers of the index to reflect different degrees of area-level deprivation; however, the cut-offs may be considered somewhat arbitrary. In an appendix, we display the average infection rate at ED level across deprivation categories using alternative cut-off points. While the three-category split is the basis for the analysis herein, Table A.2 displays mean infection rates using a four-category split derived from the official deprivation categories[9] as well as a five-category split, which we generate by splitting the continuous relative deprivation index into quintiles[10]. Infection rates are highest in the most deprived EDs regardless of which measure is used.

There is considerable spatial variation in deprivation across Ireland. Figure 3.1 displays the spatial distribution of deprivation on a map of Ireland. More deprived areas are shown in darker orange and are evident across the country but are particularly concentrated in the West of Ireland, as well as in a spine up the middle of the country. There are also pockets of deprivation alongside areas of affluence in and around the main cities of Dublin, Cork, Limerick and Galway.

[9] The producers of the Pobal HP Deprivation Index split it into eight categories which we group together given the size of some categories into four categories: extremely disadvantaged, very disadvantaged and disadvantaged; marginally below average; marginally above average; and affluent, very affluent and extremely affluent. This approach is used in Whelan et al. (2023).

[10] National Cancer Registry Ireland also takes this approach, see: 'New report by the National Cancer Registry assesses the effect of deprivation on cancer', National Cancer Registry Ireland (ncri.ie).

FIGURE 3.1 SPATIAL DISTRIBUTION OF THE HP RELATIVE DEPRIVATION INDEX, 2022



Additional data at the ED area level is also extracted from the 2022 Census. This supplementary data is used to extract variables that are potentially related to the incidence of COVID-19 infections based on the literature to date. Ethnic make-up of an area is controlled for: the share of Irish Travellers; the share of Black people; the share of Asian people; and the share of people over 80. While occupational make-up is available in the Census data, this is not included due to its collinearity with the HP Relative Deprivation Index.

The COVID-19 infection rate data is attached to 2016 ED boundaries; this is important to note as a small number of EDs changed between 2016 and 2022, when the most recent census was captured and the subsequent development of the 2022 HP Deprivation Index. Out of the initially identified 3,409 EDs using the 2016 boundaries, two EDs were excluded from the analysis due to recorded infection rates exceeding 100 per cent, which were considered erroneous. Additionally, a further 20 EDs were excluded during the process of aligning infection rates with the 2022 Census and 2022 HP Deprivation Index data. That is due to the changes in area boundaries between 2016 and 2022; less than 1 per cent of EDs are not included in the analysis. We were unable to match the presence of communal establishments and population density to a further 49 EDs and consequently, the final number of EDs forming the basis of our analysis is 3,338.

For the ICU admission models, the number of observations is somewhat lower again. This is attributed to the omission of Eds, with fewer than five people admitted to the ICU, driven by concerns regarding data disclosure and CSO reporting requirements. Therefore, the number of EDs in the ICU admission analysis is reduced to 2,926.

Our results are consistent when the 2016 HP Deprivation Index and 2016 Census variables were used rather than the 2022 versions.

3.3 METHODOLOGY

3.3.1 Infection rates

The empirical strategy used is designed to measure the extent to which health outcomes, specifically infection rate and ICU admission rate, vary in more deprived areas while controlling for other relevant factors at the ED level. In the first instance, we examine infection rates. Since the dependent variable, the area-level COVID-19 infection rate, is a continuous variable ranging from zero to one (when presented as a decimal) and can include values at both ends, we utilise a fractional logit model. This modelling approach was developed by Papke and Wooldridge (1996) and is standard practice in the econometric literature for such variables.

Papke and Wooldridge (1996) utilise a non-linear function for estimating the expected values of dependent variables, y_i, condition on a vector of covariates, x_i, as shown in Equation 1:

$$E(y_i|x_i) = G(x_i\beta) \tag{1}$$

Where G is a cumulative distribution function, and the betas (β), are the true population parameters. A logistic distribution is employed as shown in Equation 2 and suggests the use of the Bernoulli log-likelihood function in Equation 3:

$$E(y_i|x_i) = \frac{exp(x_i\beta)}{1+exp(x_{i\beta})} \tag{2}$$

$$l_i(\beta) = y_i \log[G\,(x_i\beta)] + (1-y_i) \log[1 - G(\,x_i\beta)] \tag{3}$$

Equation 3 then calculates the quasi-maximum likelihood estimator, $\hat{\beta}$.

Deprivation is the main explanatory variable and is included as three categories as outlined in Table 3.1. The 2022 Census was used in the models presented herein. The COVID-19 data is from 2020 and 2021 and is connected to the pre-existing 2016 ED boundaries.

The area-level information extracted from the Census includes the proportion of residents aged over 80 and the ethnic/racial composition of areas (proportion of Irish Travellers, Black, and Asian populations). Given the prevalence of outbreaks in nursing homes and similar residential institutions, the presence of communal establishments within an ED is controlled for as is the share of the ED's population who is over 65 and resident in a communal establishment. Population density is also controlled for to account for heterogeneity between EDs. Recognising the pronounced high infection rates along the border, as illustrated in Figure 4.1, a final specification includes an interaction variable between the border area and deprivation levels. Results from these specifications are displayed as marginal effects in Table 4.3.

In an appendix, Table A.3, the same specifications are modelled whereby the main variable of interest is area-level deprivation from the HP Deprivation Index split into four categories rather than three. More specifically, the marginally above average group and the affluent group are separated compared to the models specified in Table 4.3. We opt for the more amalgamated (three-category) approach as our main analysis, as this allows us to implement effective propensity score matching techniques as a robustness check. These propensity score matching models allow us to clearly demonstrate that our estimates are robust to sample selection bias and collinearity. A more disaggregated approach (four categories) does not support such robustness tests, as there is insufficient data to allow for effective balancing. There is a trade-off, in our modelling choices, between having the data as refined as possible and demonstrating robustness, and we believe that it is important to demonstrate the reliability of our estimates. Nevertheless, as can be seen by comparing our core estimates with the results in Table A.3, our results are consistent irrespective of the cut-off points used.

3.3.2 ICU admission rates

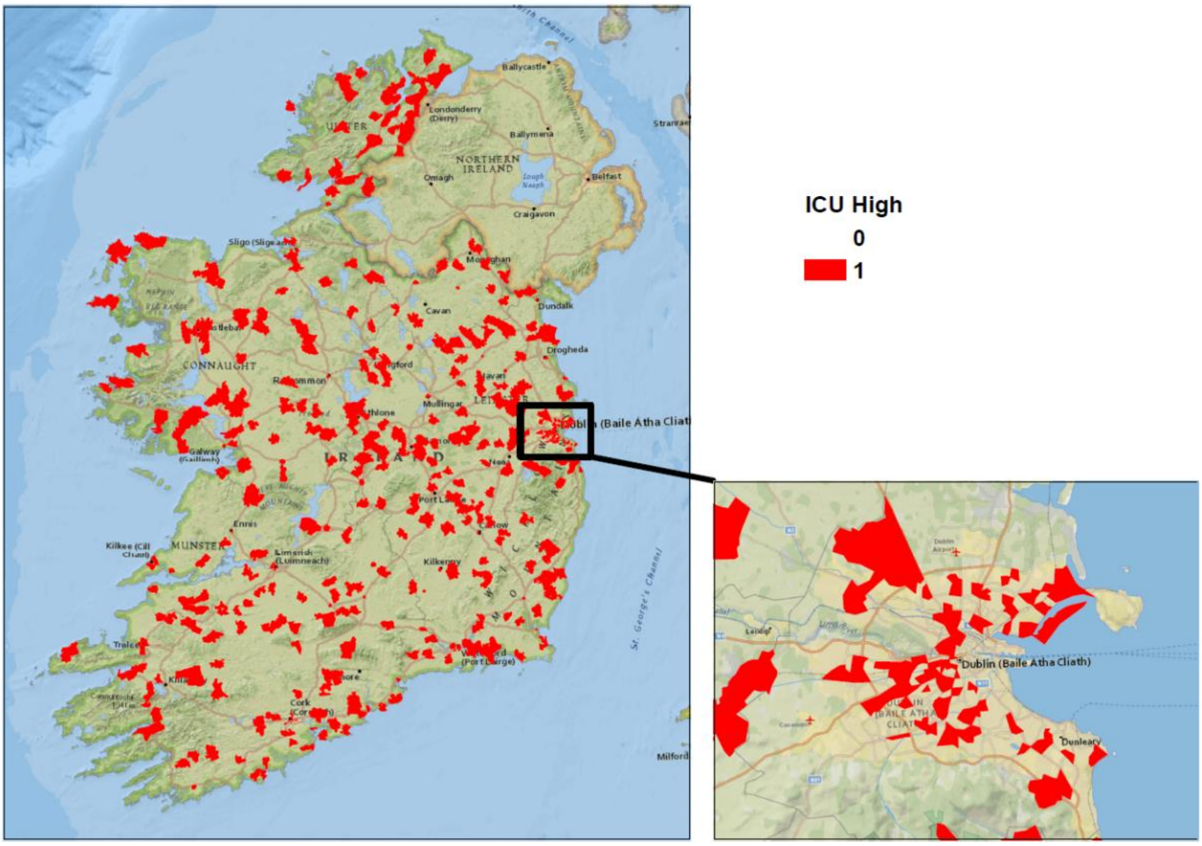
A different methodological approach is taken for the ICU admission models. The ICU admission data is heavily skewed to the right (as shown in Figure 4.3) with the vast majority of values falling between 0 and 1 per cent (84% of EDs). In light of this pronounced right skew, we use a probit model with a binary dependent variable. This variable is equal to 1 if the ICU admission rate of an ED is above 1 per cent, specifically examining the relationship between area-level deprivation and an area having a higher ICU admission rate compared to most other areas.

The probit model takes the standard form to examine the effect of deprivation on ICU admission rates at an ED level as shown in Equation 4:

$$\boldsymbol{ICU > 1\%^*_j = \beta_1 X_j + \beta_2 DEP_j + \varepsilon_j} \tag{4}$$

where $ICU > 1\%^*_j$ equals 1 when the ED ICU admission rate is greater than 1%, $\boldsymbol{X_j}$ represents a vector of area-specific characteristics, $\boldsymbol{DEP_j}$ is the main variable of interest measuring the deprivation category of each ED, and $\boldsymbol{\varepsilon_j}$ is an i.i.d. error term. Table 4.4 shows the marginal effects derived from the probit models, each with different specifications. We undertake this stepwise forward model approach, whereby more variables are added to the specification sequentially, as a check against potential collinearity. For the first two models, we utilise the same variables employed in the infection rate models, offering a comprehensive examination of the relationship between area-level deprivation and the likelihood of an area having an ICU admission rate exceeding 1 per cent. In a final model, we also control for the presence of underlying conditions amongst the infected population at the area level given the relationship between previous health conditions and the likelihood of being admitted to ICU with COVID-19. The binary outcome variable is mapped in Figure 3.2.

FIGURE 3.2 AREAS WITH HIGH ICU ADMISSION RATES, ELECTORAL DIVISION



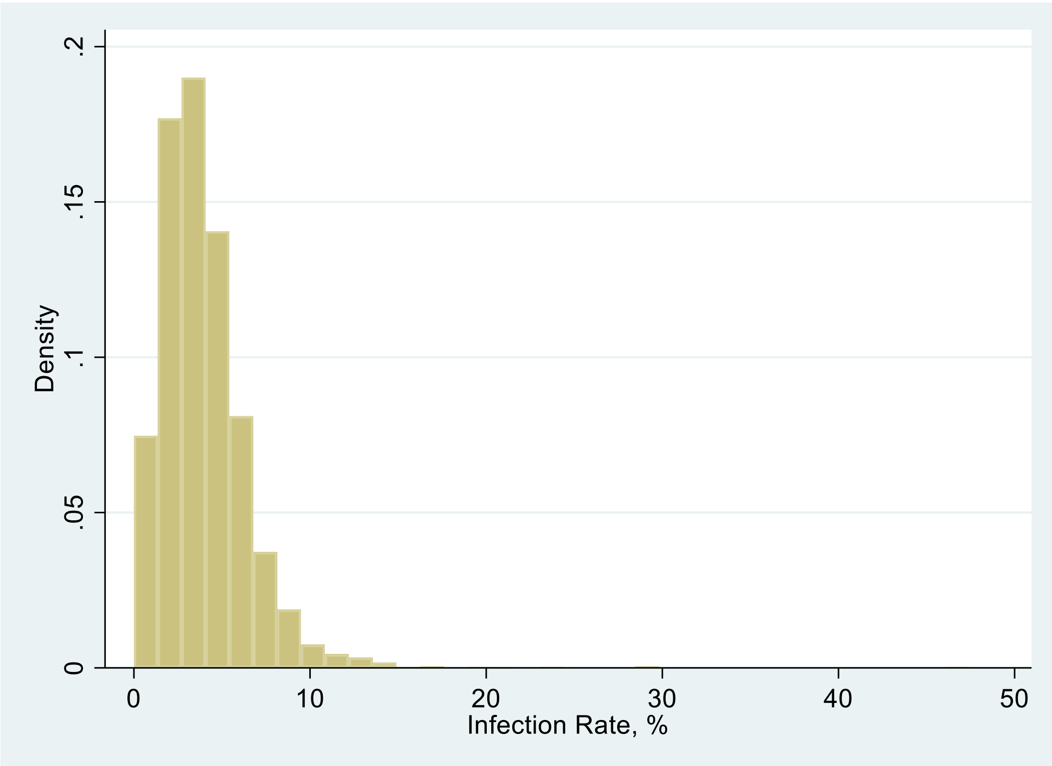
CHAPTER 4

Results

4.1 DESCRIPTIVE ANALYSIS

The COVID-19 data employed in this analysis is outlined below. The average ED infection rate is 3.9% of the population with a range from 0% to 47.4%. It is noteworthy that the distribution is positively skewed, with a large majority of EDs exhibiting infection rates below 10% (98% of EDs). Figure 4.1 illustrates the distribution of the area-level COVID-19 infection rates.

FIGURE 4.1 HISTOGRAM OF INFECTION RATE, ELECTORAL DIVISION



The infection rate varies substantially across EDs, and in line with our research objectives, we conduct a descriptive analysis to analyse how the infection rates differ across the deprivation groups utilised in our econometric analysis. The average infection rate is 5.6% amongst the most deprived EDs and 4.0% amongst the most affluent groups, as displayed in Table 4.1. The average infection rate however is lowest amongst the marginally affluent/most affluent group at 3.7%. The descriptive analysis suggests that the average COVID-19 infection rate in the most deprived areas was more than a half higher than the average in the most affluent areas.

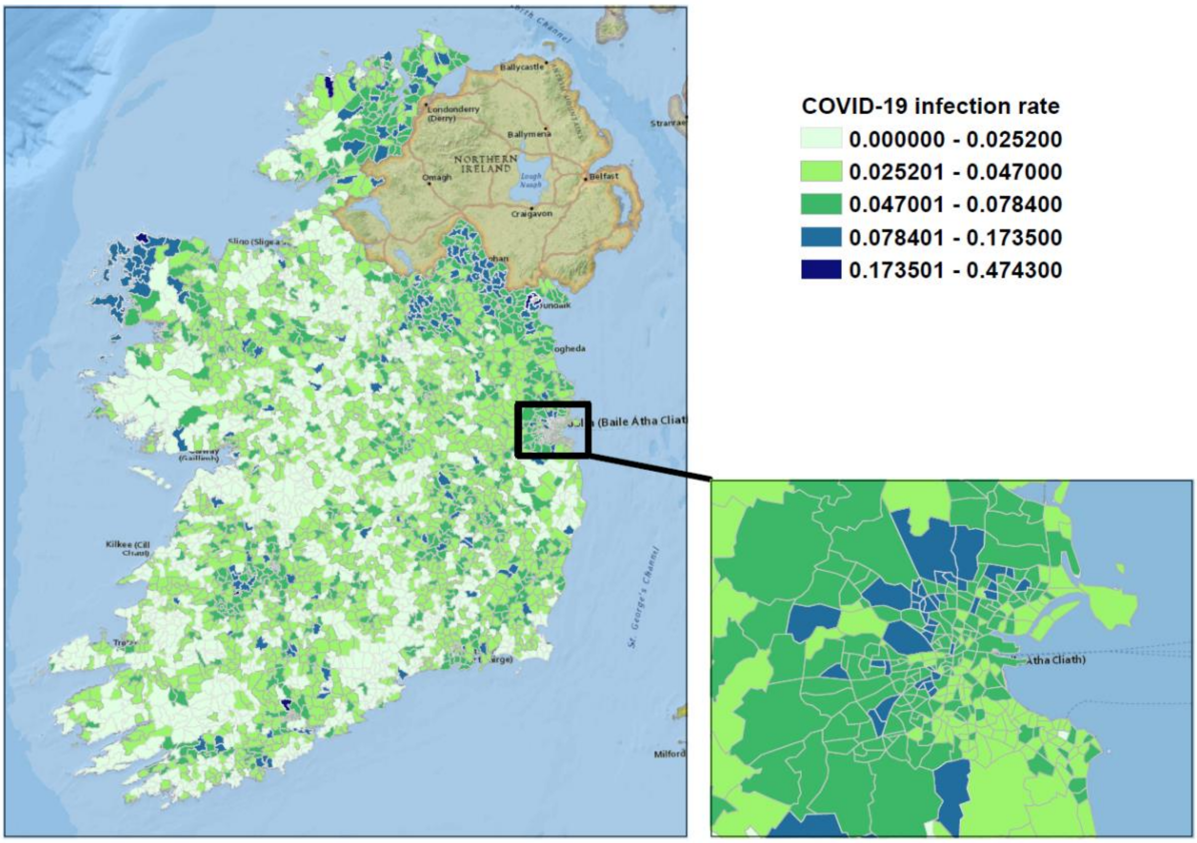
Table 4.1 also displays the number of observations examined.

TABLE 4.1 COVID-19 INFECTION RATE BY ED, 2022

	Mean	Number of EDs
All	3.9%	3,387
Deprivation		
1 (Most deprived)	5.6%	239
2 (Marginally below average)	3.9%	1,481
3 (Marginally above average/Least deprived)	3.7%	1,667

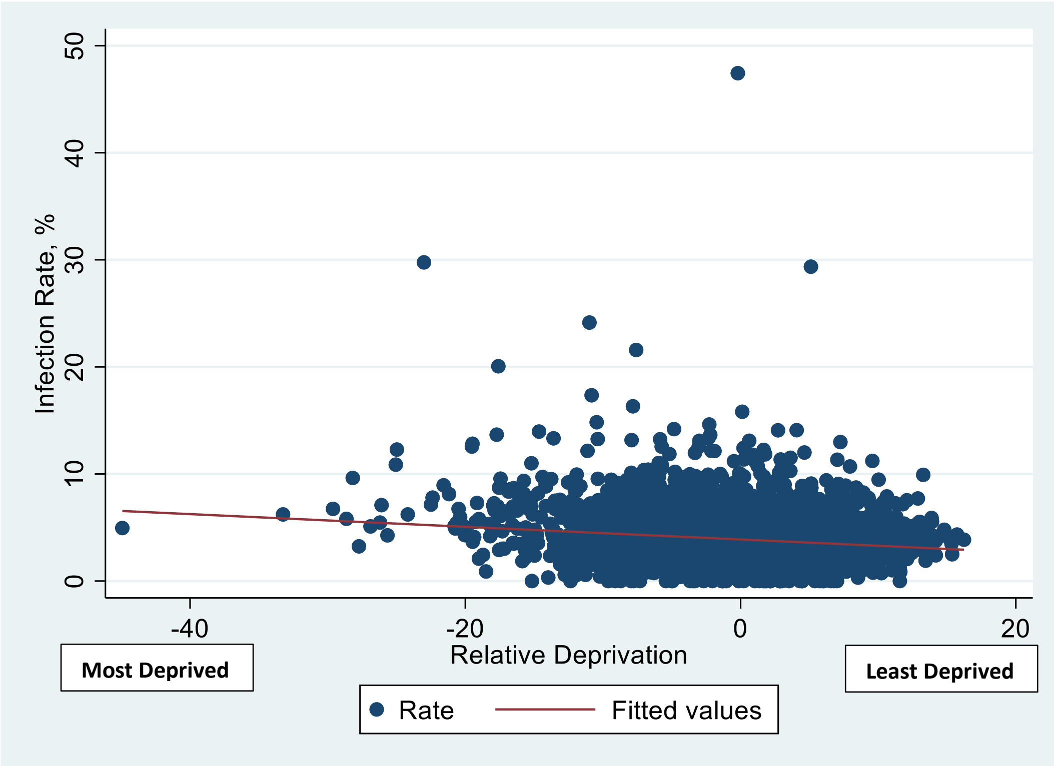
Figure 4.2 maps the COVID-19 infection rate at ED level across Ireland, revealing significant spatial variation across the country. Notably, higher infection rates are observed in Donegal and the border area, as well as in Dublin and some other cities and large towns. When Figure 3.1 and Figure 4.2 are considered together, similarities between the two emerge, suggesting a potential correlation between area-level deprivation and area-level COVID-19 infection rates. This suggests that socio-economic factors may be linked to the varying rates of COVID-19 infections in different areas.

FIGURE 4.2 SPATIAL DISTRIBUTION OF COVID-19 INFECTION RATES, ELECTORAL DIVISION



Further descriptive evidence on the relationship between deprivation and infection rate at the ED level highlights a correlation between the two variables. Figure 4.3 plots area-level deprivation at the ED level from the HP Deprivation Index against the area-level COVID-19 infection rate. There is a clear pattern showing higher infection rates in more deprived areas and lower rates in the most affluent areas[11] (a correlation coefficient of -0.15).

FIGURE 4.3 SCATTERPLOT OF INFECTION RATE VS RELATIVE DEPRIVATION, ED LEVEL



We also examine ICU (Intensive Care Unit) admission rates at the ED level, calculated as a proportion of the infected population within a specific ED. This enables a more focused examination of the health impacts associated with the infection and its relationship with deprivation. Figure 4.4 shows the distribution of the ICU rate at the ED level. Though the ICU rate ranges from 0 to 20 per cent, the majority of EDs record a rate of less than 1 per cent. Approximately 84 per cent of EDs have an ICU rate below 1 per cent.

[11] A large negative number represents the most deprived areas with the most positive numbers representing the most affluent areas.

FIGURE 4.4 HISTOGRAM OF ICU ADMISSION RATE, ELECTORAL DIVISION

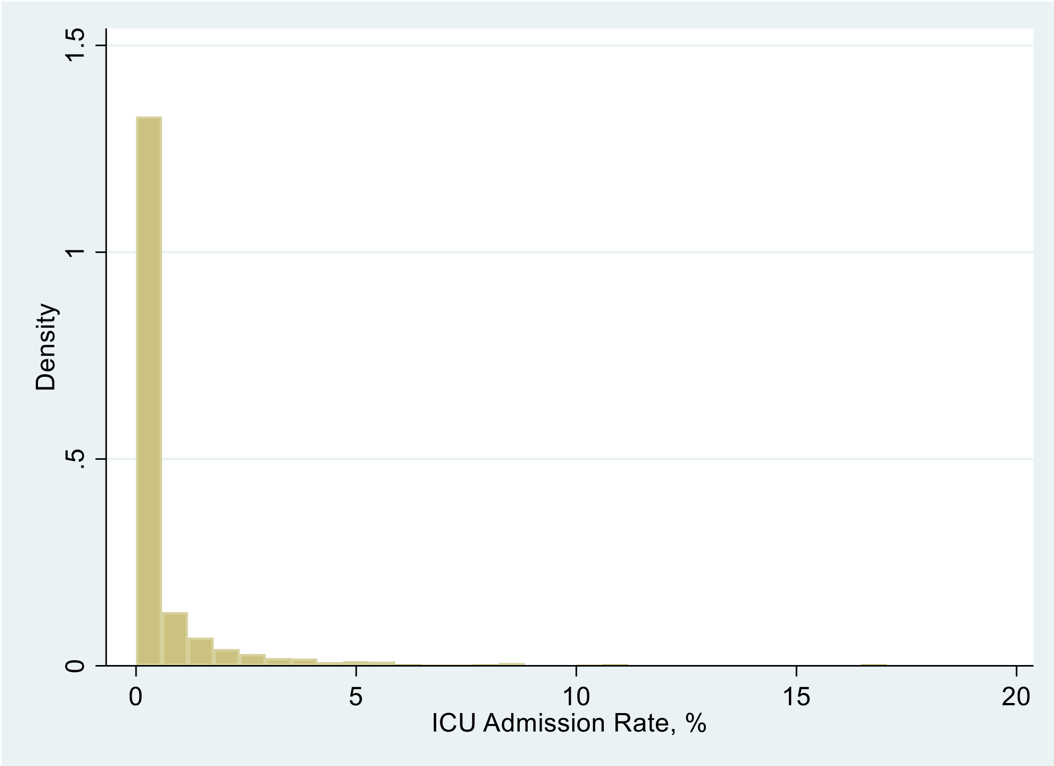


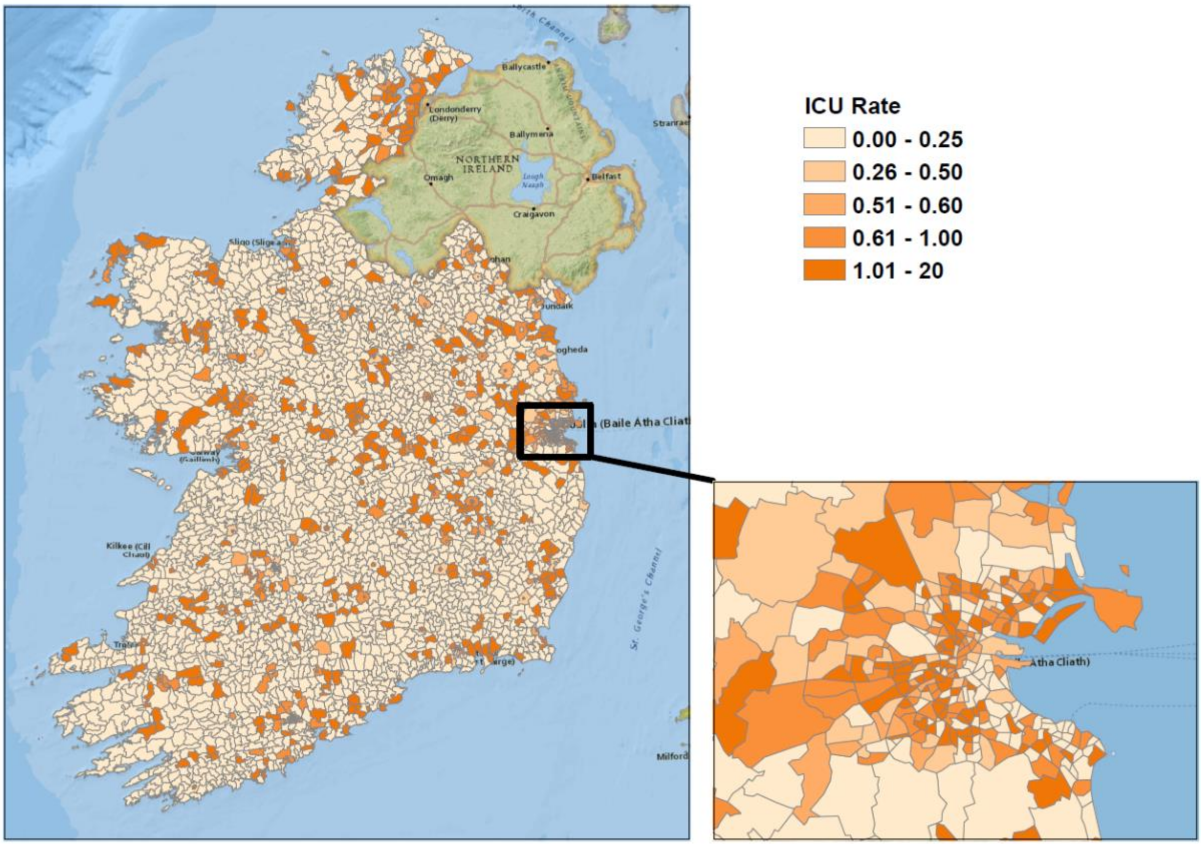
Table 4.2 displays the mean ICU admission rate across the EDs as well as the mean ICU admission rate for each deprivation category. The relevant number of observations is also included. The ICU admission rate is 0.7 per cent amongst the most deprived EDs compared to 0.5 per cent amongst the most affluent EDs. Unlike infection rates, there is a more linear relationship between area-level deprivation and ICU admission rates at least when examining the descriptive information presented in Table 4.2.

TABLE 4.2 ICU ADMISSION RATE BY ED, 2022

	Mean	N
All	0.62%	2,964
Deprivation		
1 (Most deprived)	0.70%	215
2 (Marginally below average)	0.66%	1,285
3 (Marginally above average/Least deprived)	0.58%	1,464

Figure 4.5 maps the ICU admission rate across Ireland and in this instance, there is less of an obvious spatial pattern. Higher rates of ICU admission are spread across the country, although there are a few areas clustered around the border with Northern Ireland in Donegal and in Dublin City.

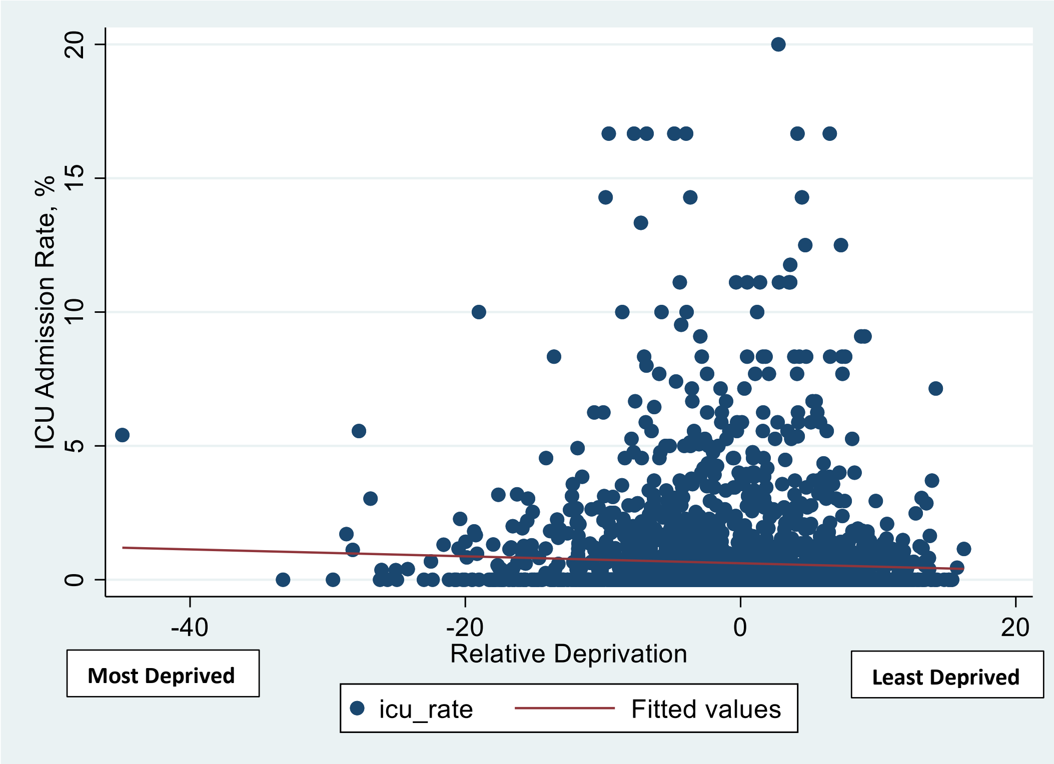
FIGURE 4.5 SPATIAL DISTRIBUTION OF ICU ADMISSION RATES, ELECTORAL DIVISION



Notes: ICU admission rates at the ED level are calculated as a proportion of the infected for comparability.

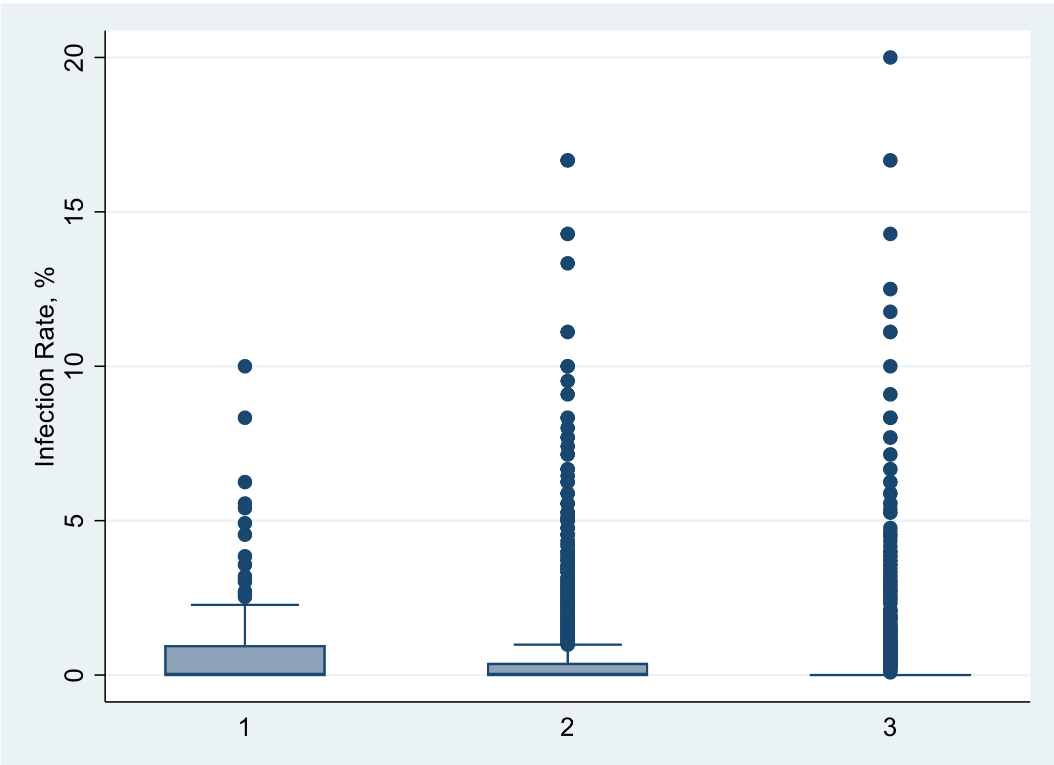
Figure 4.6 plots ICU admission rates (as a proportion of those infected with COVID-19) against deprivation. Again, a relationship between the two is evident whereby higher rates of ICU admission amongst the COVID-19 infected are more prevalent in more deprived areas. However, it is worth noting that the relationship doesn't appear as pronounced as seen in Figure 4.3, which illustrates infection rates.

FIGURE 4.6 SCATTERPLOT OF ICU ADMISSION RATE VS RELATIVE DEPRIVATION, ED LEVEL



There is substantial variation in the ICU admission rate. This is shown in Figure 4.7, a boxplot of ICU admission rates by deprivation category.

FIGURE 4.7 BOXPLOT OF AREA-LEVEL ICU ADMISSION RATE BY DEPRIVATION CATEGORY



4.2 INFECTION RATE

The results of the fractional logit models with COVID-19 infection rates as the dependent variable (Table 4.3, Column 1) reveal that, in the absence of other controls, the highest infection rates occur in the most deprived areas. Specifically, infection rates in these areas are 1.6 percentage points higher than in the most affluent areas, a significant magnitude given the mean infection rate of 3.92 per cent. This result is consistent with the descriptive statistics reported earlier.

In the second specification (Column 2), we introduce area-level controls from the Census which are likely to be relevant for COVID-19 infection rates according to the existing literature. Areas with higher proportions of racial/ethnic minorities exhibit elevated COVID-19 infection rates. For example, a 10 percentage point increase in the population share of Irish Travellers will lead to a 0.2 percentage point increase in the area-level infection rate. When these controls are included, the marginal effect of the most deprived category falls from 0.016 to 0.013. That is to say, the most deprived areas have infection rates 1 percentage point higher than the marginally above average and most affluent areas after controlling for other area-level characteristics. Marginally deprived areas also have slightly higher infection rates than the marginally affluent and most affluent areas. In a third specification (Column 3), we control for additional area-level variables; the presence of a communal establishment(s) within the ED, the share of the population in each ED who are over 65 and resident in a communal establishment (to proxy more specifically for nursing homes), and population density. Infection rates are higher in EDs with communal establishments, and which have higher shares of people over the age of 65 who live in communal establishments. When these controls are added, the marginal effect of some racial minorities dissipates (share of Black people and share of Asian people). This may be reflective of minority groups potentially being overrepresented as residing in communal establishments or being in employment within communal establishments and thus having a higher risk of transmission.

In the fourth specification, we incorporate a variable to control for the impact of border counties (Column 4). As there is a high level of collinearity between area-level deprivation and a border location, as displayed in our earlier maps, an interaction term between border location and deprivation is included with the reference category being a non-border ED. In this model, the results are what might be expected with our prior expectations and knowledge. Higher infection rates are found in the most deprived areas as was the case in specifications 1 and 2 as well as in EDs which aren’t deprived but are located in border counties. These findings are consistent when a more precise border indicator is used. In the appendices, results are shown for two additional specifications which consider the border area to be those EDs within 16km or 32kms of the border (Table A.2).

These outcomes bear significant policy implications, particularly in light of the disparate responses to the pandemic across jurisdictions, with notable differences in restrictions and coordination. This finding suggests that the well-documented failure to align public health responses on an all-island basis played some role in stimulating infection rates, presumably by greater south to north movements of persons from more prosperous areas in the Republic of Ireland during periods when restrictions were lesser in Northern Ireland. This would suggest that, on average, persons from areas with the greater economic means were most likely to exploit variations in restriction levels, leading to high infection rates in those border areas. Further research is required to establish if these patterns were repeated on the Northern Ireland side of the border. After controlling for these border and other area-level effects, we see in our final specification that infection rates in the most deprived areas were 1.3 percentage points higher than those in the above average or most affluent EDs, which is a large effect given that the national average infection rate was 3.92 per cent.

TABLE 4.3 AREA-LEVEL INFECTION RATES, FRACTIONAL LOGIT MODEL

	(1)		(2)		(3)		(4)	
Area-Level Deprivation								
1 (Most deprived)	0.016	***	0.013	***	0.014	***	0.013	***
2 (Marginally below average)	0.002	***	0.002	**	0.003	***	0.000	
Ref: 3 (Marginally above average/Least deprived)								
Area-Level Controls								
Share of Irish Travellers			0.002	**	0.002	***	0.002	***
Share of Black people			0.001	***	0.000		0.000	*
Share of Asian people			0.001	***	0.000	*	0.000	**
Share of people over 80			0.000	*	-0.000		0.000	
Communal Establishments Indicator					0.005	***	0.004	***
Share of population who are over 65 resident in communal establishments					0.001	***	0.001	***
Population Density					-0.000	***	-0.000	***
Border#Dep								
Non-border							Ref	
Border#notdeprived							0.02	***
Border#deprived							0.01	
N	3387		3387		3338		3338	
Pseudo R2	0.00		0.00		0.00		0.01	

4.3 ICU ADMISSION

In this section, we examine the relationship between area-level deprivation and ICU admission rates at the ED level.[12] ICU admissions at area level are both important for pandemic planning and also for targeting supports for potential long-term health impacts. As discussed in Section 3.3.2, we take a different methodological approach when ICU admission rates are the variable of interest. The marginal effects derived from a series of probit regression models are displayed in Table 4.4. The dependent variable here is binary in nature and indicates if the ED is among the 16 per cent of areas with the highest ICU admission rates. Specifications were also modelled whereby the dependent variable was a binary if the ICU rate was more than 2 per cent; findings were consistent regardless of which measure was used[13].

In our initial model, in which deprivation is the only independent variable, the only statistically significant result is for the most deprived category (Table 4.4, Column 1). Specifically, the most deprived areas are 10 percentage points more likely to have high ICU rates (that is rates of more than 1%) compared to the marginally above average or most affluent areas. EDs which are classified as marginally below average show no significant difference in the likelihood of high ICU admission rates among their infected populations when compared to marginally above average or the most affluent areas. When controls for ethnic/racial make-up of the area and age structure are included, the deprivation effect falls somewhat from a marginal effect of 10 percentage points to 6 percentage points. Areas with higher proportions of Irish Travellers and Black people have higher rates of ICU admission, which is in line with the existing literature. The results for the share of Asian people and the share of people over 80 in an area are not statistically significant.

In the next model (Column 3), when we include area-level controls for ethnicity/race, share of people over 80, as well as the presence of communal establishments and population density, the previously observed deprivation effect is no longer significant. Areas with higher proportions of Irish Travellers and Black people have higher rates of ICU admission. The coefficients indicate that a 10 percentage point increase in the share of Travellers or Black people in an ED increases the probability that an area will have high ICU admission rates (that is a rate of more than 1%) by 1 percentage point, although for the share of Black people this is only significant at the 10 per cent level. Despite the literature suggesting ethnic/racial minorities are more susceptible to COVID-19, we find that there is no statistically significant relationship between the share of Asian people in an area

[12] Data are recorded on CIDR and reported for cases where the primary reason for admission to ICU was COVID-19, as assessed by the Intensive Care Medical Team. Incidental findings of COVID-19 in people admitted to ICU for other reasons including trauma are not recorded on CIDR and are not reported (HPSC, 2022).

[13] For the results of these models, contact the authors.

and the ICU admission rate. There is also no relationship with the share of the ED population that is over 80 years of age and ICU admission rates, which is more than likely due to any age correlation being driven by poor health, which is already accounted for in our controls. Areas with communal establishments are more likely to have higher rates of ICU admission; while, on the other hand, areas with higher shares of over 65s resident in communal establishments had lower ICU admission rates. This seems counterintuitive but may reflect the ongoing care they were in receipt of which meant they did not need ICU care or that as admission to ICU is a subjective decision made by healthcare professionals, may reflect decisions being made due to resource constraints during the pandemic. Population density, while statistically significant, has no measurable impact on ICU admission rates.

In this analysis of high ICU admission rates, we also utilise the additional health data provided in the COVID-19 dataset, specifically information on underlying clinical conditions among those infected (Column 4). Those with underlying clinical conditions may be more severely impacted by the virus than those without underlying conditions, as has been shown in the literature (Treskova-Schwarzbach, M. et al., 2021; Bucholc et al., 2022). In this final specification, we find that areas with large shares of COVID-19-infected people with underlying clinical conditions have higher rates of ICU admission, albeit with a modest effect size; while the marginal effects for the ethnic composition variables remain consistent with the previous specification.

TABLE 4.4 AREA-LEVEL ICU ADMISSION RATES OF MORE THAN 1%, PROBIT REGRESSION RESULTS

	(1)		(2)		(3)		(4)	
Area-Level Deprivation								
1 (Most deprived)	0.10	***	0.062	**	0.040		0.030	
2 (Marginally below average)	0.02		0.017		0.020		0.020	
Ref: 3 (Marginally above average/Least deprived)								
Area-Level Controls								
Share of Irish Travellers			0.013	***	0.014	***	0.013	**
Share of Black people			0.013	**	0.010	*	0.010	*
Share of Asian people			0.005		-0.006	*	-0.006	
Share of people over 80			0.006		0.005		0.003	
Communal Establishments Indicator					0.074	***	0.067	***
Share of population who are over 65 resident in communal establishments					-0.008	**	-0.011	***
Population Density					0.000	***	0.000	***
Health of the Infected Population								
Underlying Clinical Conditions							0.005	***
N	2926		2926		2926		2926	
Pseudo R2	0.00		0.02		0.03		0.05	

4.4 ROBUSTNESS CHECK

Sample selection bias, whereby the right hand side variables are non-randomly correlated with the outcome measure (or each other) can potentially distort estimates. To account for this, we re-estimate the relationship between area-level deprivation and both infection rates and ICU admission rates using a non-parametric framework. Propensity Score Marching allows us to compare the infection rates between deprived and non-deprived areas with similar area-level observable demographic characteristics and in doing so, eradicate any biases associated with sample selection or collinearity. The propensity score is defined as the conditional probability of receiving a treatment given certain determining characteristics,

$$p(X) = Pr\{D = 1/X\} = E\{D/X\} \quad (5)$$

where D is a binary term indicating exposure to the treatment, in this case being defined a deprived area, and X is a vector of determining demographic characteristics (share of individuals from ethnic minorities, share of older people, etc). In the second stage, ED areas in the treatment group are 'matched' with counterparts in the control group (affluent areas) that have similar propensity scores and their actual outcomes (infection rates) are compared. Rosenbaum and Rubin (1983) show that matching individuals or areas on the basis of propensity scores is equivalent to matching on actual characteristics. Essentially, the only observable distinguishing factor separating the control and treatment groups will be the level of area deprivation. Therefore, to the extent that area-level infection rates are being influenced by, for instance, demographic composition, this will be eradicated under this approach, which will ensure that areas in the control and treatment groups are matched across all area characteristics of relevance to the treatment variable.

The results from our propensity score matching (PSM) analysis for infection rate and ICU admission rate are presented in Table 4.5 and are wholly consistent with those generated by our fractional logit and probit models respectively, demonstrating that our initial estimates are robust to the influences of selection bias and collinearity.

TABLE 4.5 PROPENSITY SCORE MATCHING (PSM) MODELS, INFECTION RATES AND ICU ADMISSION RATES

	Fraclogit Marginal Effect	PSM (ATT)	Pseudo R2 (Pre)	Pseudo R2 (Post)	B	R	Rbounds
Infection Rates							
Area-Level Deprivation							
1 (Most deprived)	0.013 ***	0.016 ***	0.239 ***	0.017	30.4	0.9	2
2 (Marginally below average)	0.000	0.004 ***	0.060 ***	0.002	9.6	0.88	1.5
Ref: 3 (Most affluent/ Marginally above average)							
ICU Admission Rates	**Probit Marginal Effect**	**PSM (ATT)**	**Pseudo R2 (Pre)**	**Pseudo R2 (Post)**	**B**	**R**	
Area-Level Deprivation							
1 (Most deprived)	0.04	0.045	0.254 ***	0.009	22.9	0.67	
2 (Marginally below average)	0.02	0.020	0.066 ***	0.002	9.2	0.9	
Ref: 3 (Most affluent/ Marginally above average)							

4.5 NATURE OF RELATIONSHIPS WITH ETHNIC/RACIAL COMPOSITION AND HEALTH OF AREAS

Despite there not being a clear relationship between area-level deprivation and area-level ICU admission rates in the multivariate analysis, it is noteworthy that variables correlated with ICU admission rates, i.e. share of Irish Travellers and proportion of residents who are Black, are likely to be highly correlated with area-level deprivation. Therefore, while area-level deprivation does not have a direct impact on ICU admission rates, it appears to be having an indirect impact through these other area-level characteristics.

Figure 4.8 displays the correlation between relative deprivation and the share of Irish Travellers at the ED level, revealing a distinct relationship. Areas with high levels of deprivation[14] also have larger shares of Irish Travellers resident. There is a similar relationship between area-level deprivation and the share of Black people at the ED level as shown in Figure 4.9.

Figure 4.10 highlights a strong positive correlation with the share of people over the age of 80, indicating higher proportions in more deprived areas.

Finally, information on underlying clinical conditions amongst those infected with COVID-19 is plotted against relative deprivation in Figure 4.11. There is considerable variation in this variable across EDs yet a relationship between underlying clinical conditions and area-level deprivation is apparent in the trendline. More deprived areas tend to have higher shares of infected individuals reporting underlying clinical conditions. Blundell et al. (2020) argues that health vulnerability to the virus for those in deprived areas is driven by the well-documented socio-economic gradient in health.

Therefore, while area-level deprivation *per se* is not related to ICU admission rates after including area-level controls in our regression models, as shown in Table 4.4, deprivation has a relationship with those variables associated with ICU admission rates. Specifically, there is a relationship between ICU admittance and the share of Irish Travellers, the share of Black people, and the share of infected individuals with underlying clinical conditions. Therefore, we can infer that area-level ethnic/racial composition and health indicators at the area-level serve as mediators in the relationship between area-level deprivation and ICU admission rates.

[14] The relative deprivation measure runs from -44.92 (most deprived) to 16.23 (least deprived/most affluent).

FIGURE 4.8 SCATTERPLOT OF RELATIVE DEPRIVATION VS SHARE OF TRAVELLERS

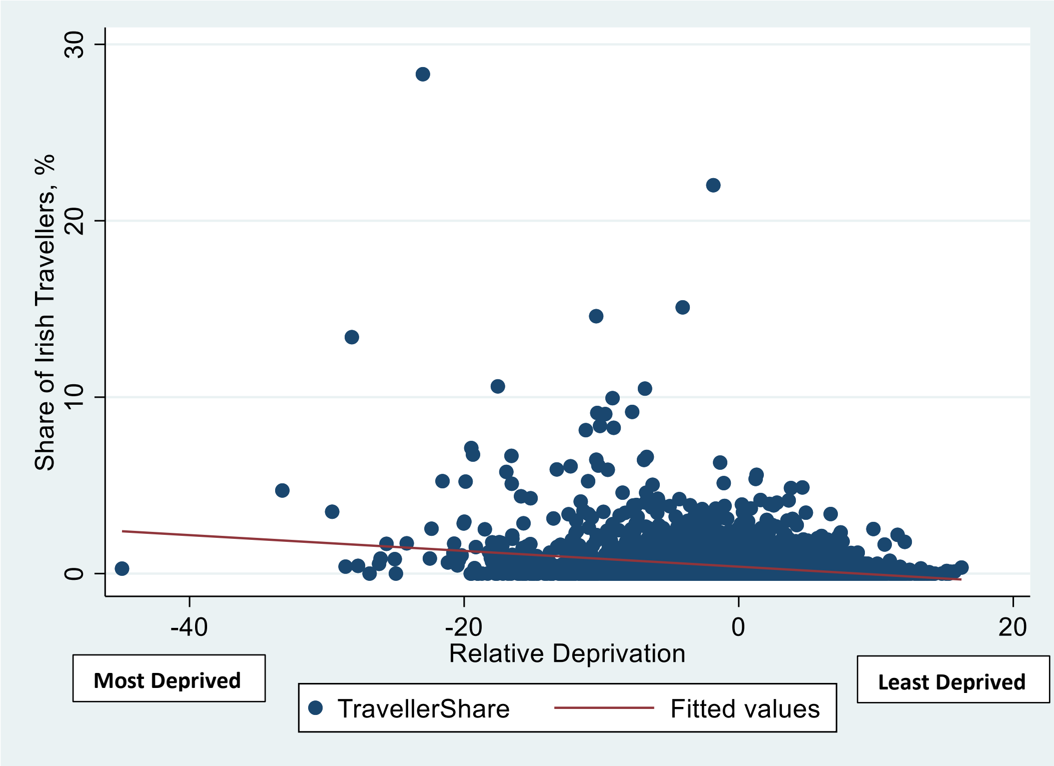


FIGURE 4.9 SCATTERPLOT OF RELATIVE DEPRIVATION VS SHARE OF BLACK RESIDENTS

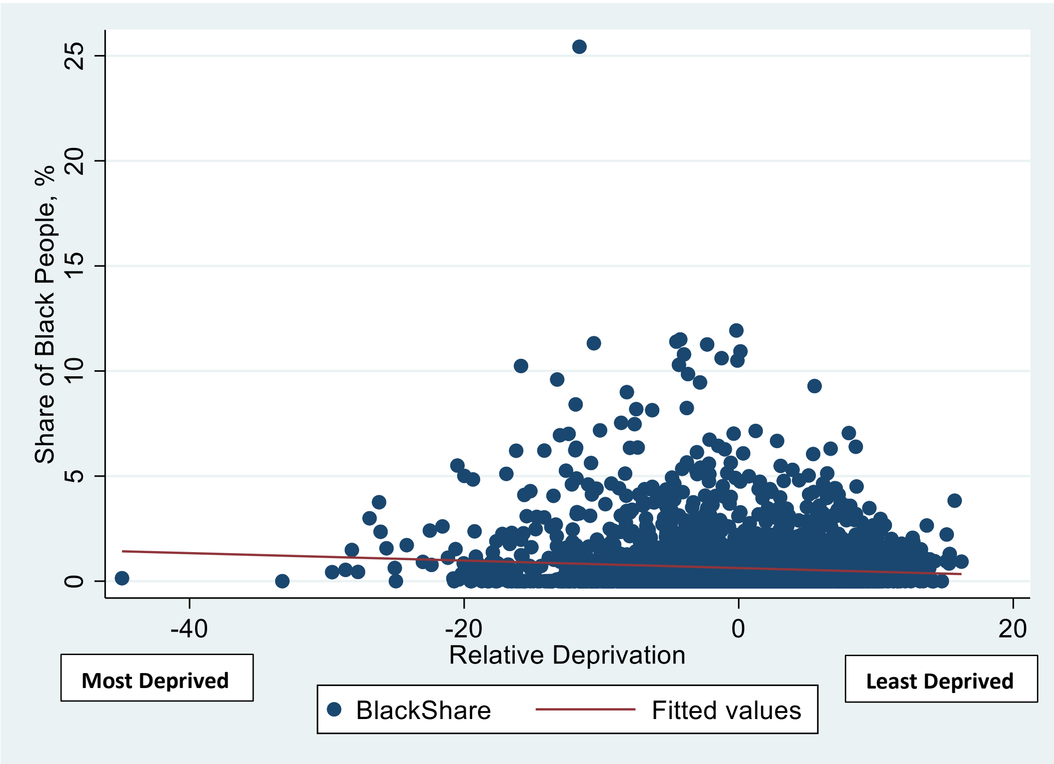


FIGURE 4.10 SCATTERPLOT OF RELATIVE DEPRIVATION VS SHARE AGED 80+

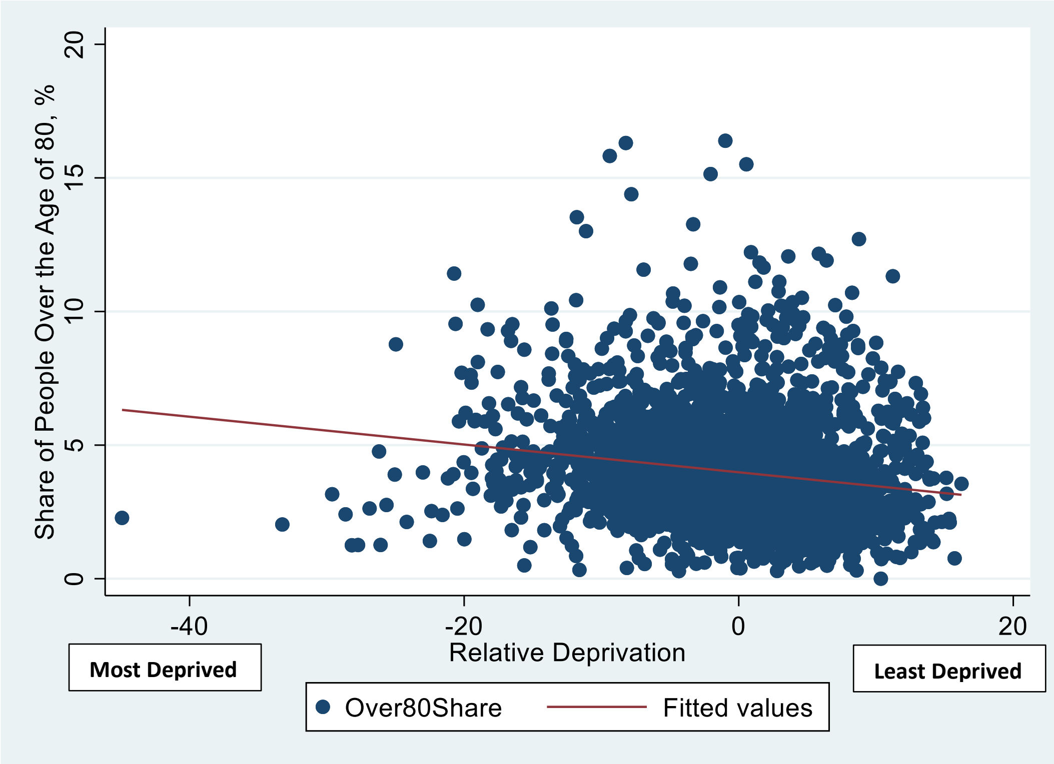
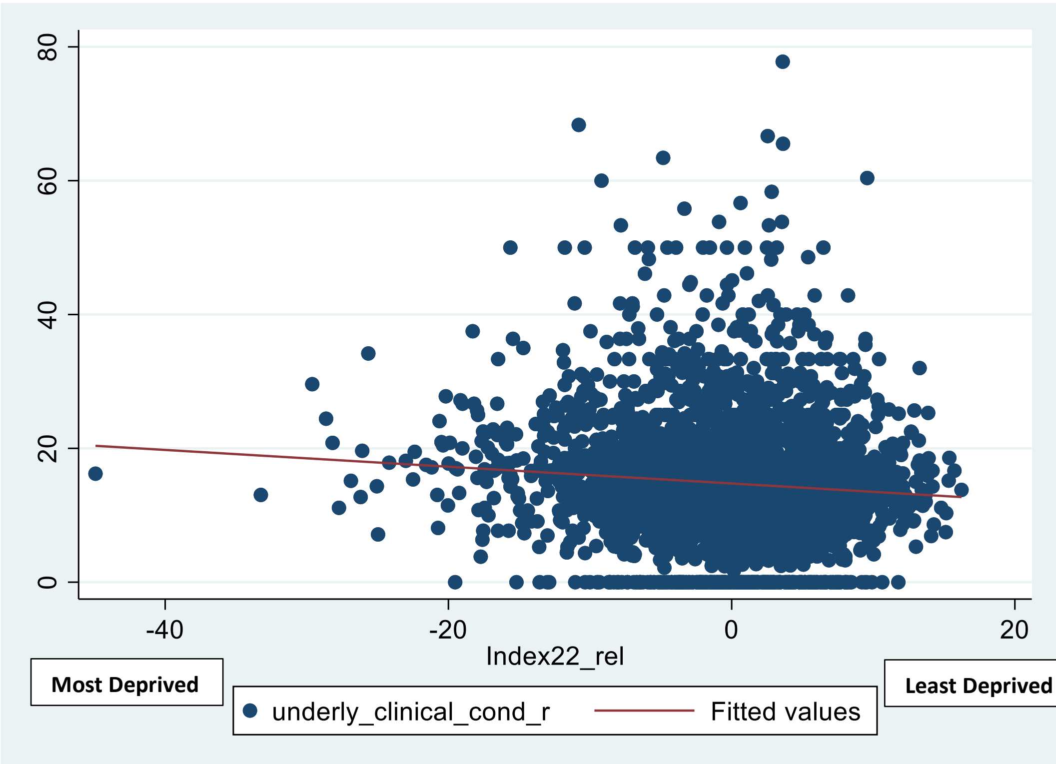


FIGURE 4.11 SCATTERPLOT OF RELATIVE DEPRIVATION VS SHARE WITH UNDERLYING CLINICAL CONDITIONS



CHAPTER 5

Conclusions

COVID-19 is well known to have disproportionately impacted the most disadvantaged in our society, affecting both economic and health outcomes. This research aims to examine the extent to which COVID-19 infection rates and ICU admission rates are associated with area-level deprivation in Ireland. This study builds upon previous research that examined the economic impact of COVID-19 on disadvantaged areas in Ireland in terms of job losses (Whelan et al., 2023b).

The average infection rate is 5.6% amongst the most deprived EDs and 3.7% amongst the marginally affluent and affluent. Thus, the descriptive analysis suggests that the average COVID-19 infection rate in the most deprived areas was more than a half higher than the average in more affluent areas.

Our econometric analysis confirms that infection rates were highest in the most deprived areas in Ireland. Specifically, after controlling for other area-level factors, infection rates in the most deprived areas were 1.3 percentage points higher than those in the most affluent areas. That is the most deprived areas had infection rates more than a third higher than the most affluent areas when controlling for other area-level factors. Over and above deprivation, infection rates were higher in areas with higher shares of Irish Travellers, in areas with communal establishments and with higher shares of over 65s living in communal establishments, aligning with established findings in the literature. It is worth noting here that communal establishments include, but are not limited to, nursing homes, direct provision centres, prisons, and university accommodation. These results are robust when accounting for potential collinearity.

Additionally, infection rates were also higher in non-deprived EDs which were close to the border, specifically those located in one of the border counties (Cavan, Donegal, Leitrim, Louth, or Monaghan). This finding is robust to other definitions of border areas. This finding holds particular policy significance, considering Ireland's porous land border with Northern Ireland, where the COVID-19 policy response often diverged significantly.

Based on the literature, our results may be a lower bound in terms of the relationship between deprivation and infection rates. The period of study here is early in the pandemic and previous studies found that inequalities were more pronounced in later waves of the pandemic.

ICU admission rates are also examined at the area level. ICU admittance during a pandemic requires a significant use of resources at a time of considerable constraint of those resources and has implications for healthcare planning. Furthermore, there are also likely to be more long-term health impacts for those severely impacted by the pathogen (i.e. those who had to receive care in ICU) so they are an important part of understanding the COVID-19 health outcomes in Ireland and the future issues which may arise in terms of population health as well as healthcare needs.

Our econometric analysis found no direct evidence that the most deprived areas were more likely to have the highest incidence of ICU admittance. However, our models show consistently that areas with higher shares of Irish Travellers and Black people were more likely to have high ICU admission rates amongst the infected. In the case of these ethnic/racial minorities, it is probable that this reflects pre-existing health inequalities for these groups. Areas with communal establishments were also significantly more likely to have higher ICU rates. Furthermore, areas with larger shares of the infected with underlying clinical conditions also had higher ICU admission rates, although the magnitude of this effect was modest. While there was no directly observable, statistically significant relationship between area-level deprivation and ICU admission rates, there is significant correlation between area-level deprivation, the ethnic/racial composition and health of areas at an ED level. Therefore, it is likely to be the case that the impact of deprivation on area-level ICU admission rates is mediated through these area-level characteristics.

CHAPTER 6

Policy implications

In terms of policy implications, the findings in this report suggest that future pandemic planning should consider existing spatial inequalities that specifically account for higher infection rates in the most deprived areas. Moreover, existing health inequalities amongst minority groups, particularly Irish Travellers, should be considered in pandemic planning.

We also find that areas with higher shares of Black people or higher shares of Asian people had higher infection rates before communal establishments were controlled for. When these variables were added, the relationship with race became statistically insignificant. This may be reflective of two things: 1) that these minority groups are disproportionately likely to work within these settings, e.g. in healthcare or other caring roles within communal establishments, and thus have increased exposure to the virus; or 2) ethnic minorities are more likely to reside in certain communal establishments and therefore social distancing and isolating in response to the pandemic is more difficult (Irish Refugee Council, 2020). This is in line with existing findings in the international literature.

Another key policy implication arising from these findings relates to the border with Northern Ireland (NI). The results show that the well-documented failure to align public health measures on an all-island basis played some role in stimulating infection rates in border areas. Further research is required to establish if these patterns were repeated on the NI side of the border. There is also a need to understand why this was the case and what the mechanisms were for these higher infection rates. Nolan et al. (2021) begins this discussion and found that at least early in the pandemic, for people who lived in proximity to the border, while restrictions were similar, there was diverging public health messaging on either side of the border, which meant that they lacked credibility.

This work has significant policy implications for Ireland, as even though COVID-19 has subsided and is no longer classified as a pandemic, it persists in circulation. Furthermore, the findings have important implications for future pandemic planning, which is imperative, as it is believed that future pandemics are more likely (Marani et al., 2021).

REFERENCES

Albani, V. et al. (2022). 'Explaining the deprivation gap in COVID-19 mortality rates: A decomposition analysis of geographical inequalities in England', *Social Science & Medicine*, Vol. 311, 115319, https://doi.org/10.1016/j.socscimed.2022.115319.

Atchison, C. et al. (2021). 'Early perceptions and behavioural responses during the COVID-19 pandemic: A cross-sectional survey of UK adults', *BMJ Open*, 11, https://bmjopen.bmj.com/content/bmjopen/11/1/e043577.full.pdf.

Ayers, C.K. et al. (2021). 'Disparities in H1N1 vaccination rates: A systematic review and evidence synthesis to inform COVID-19 vaccination efforts', *Journal of General Internal Medicine,* Vol. 36, pp.1734–1745, https://doi.org/10.1007/s11606-021-06715-7.

Barrett, C., and Cheung, K.L. (2021). 'Knowledge, socio-cognitive perceptions and the practice of hand hygiene and social distancing during the COVID-19 pandemic: A cross-sectional study of UK university students', *BMC Public Health,* Vol. 21, 426, https://doi.org/10.1186/s12889-021-10461-0.

Bish, A., and Michie, S. (2010). 'Demographic and attitudinal determinants of protective behaviours during a pandemic: A review', *British Journal of Health Psychology,* Vol. 15, No. 4, pp.797–824, https://doi.org/10.1348/135910710X485826.

Blundell, R. et al. (2020). 'COVID-19 and inequalities', *Fiscal Studies,* Vol. 41, No. 2, pp.291–319, https://doi.org/10.1111/1475-5890.12232.

Brandily, P., Brébion, C., Briole, S., and Khoury, L. (2021). 'A poorly understood disease? The impact of COVID-19 on the income gradient in mortality over the course of the pandemic', *European Economic Review*, Vol. 140, 103923, https://doi.org/10.1016/j.euroecorev.2021.103923.

Bucholc, M. et al. (2022). 'Identifying pre-existing conditions and multimorbidity patterns associated with in-hospital mortality in patient with COVID-19', *Nature,* Vol. 12, 17313, https://doi.org/10.1038/s41598-022-20176-w.

Chen, J.T., and Krieger, N. (2021). 'Revealing the unequal burden of COVID-19 by income, race/ethnicity, and household crowding: US county versus zip code analyses', *Journal of Public Health Management and Practice*, Vol. 27, No. 1, S43–S56, https://doi.org/10.1097/PHH.0000000000001263.

Clouston, S.A., Natale, G., and Link, B.G. (2021). 'Socioeconomic inequalities in the spread of coronavirus-19 in the United States: A examination of the emergence of social inequalities', *Social Science & Medicine*, Vol. 268, 113554, https://doi.org/10.1016/j.socscimed.2020.113554.

CSO (2024). *Survey on Income and Living Conditions (SILC): Enforced Deprivation 2023*, www.cso.ie/en/releasesandpublications/ep/p-silced/surveyonincomeandlivingconditionssilcenforceddeprivation2023/keyfindings.

Department of Finance (2023). *Economic Insights – Summer*, https://assets.gov.ie/263496/766cc6cd-9aae-4cfd-b6ca-a750bbf1d77a.pdf.

Department of the Taoiseach (2020). *Report on Social Implications of COVID-19 in Ireland: Preliminary Assessment*, https://assets.gov.ie/75567/644ff379-a523-40ef-a9af-20935da0d91c.pdf.

Doran, A., Colvin, C., and McLoughlin, E. (2024). 'What can we learn from historical pandemics? A systematic review of the literature', *Social Science & Medicine*, Vol. 342, https://doi.org/10.1016/j.socscimed.2023.116534.

European Union Agency for Fundamental Rights (2019). *Travellers in Ireland: Key Results from the Roma and Travellers Survey 2019*, https://fra.europa.eu/sites/default/files/fra_uploads/fra-2020-roma-and-travellers-survey-country-sheet-ireland_en.pdf.

European Union Agency for Fundamental Rights (2020). *Implications of COVID-19 pandemic on Roma and Travellers communities*, https://fra.europa.eu/sites/default/files/fra_uploads/ie_report_-_covid-19_impact_on_roma_en.pdf.

Eurostat (2024). 'Living conditions in Europe – poverty and social exclusion', https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Living_conditions_in_Europe_-_poverty_and_social_exclusion&oldid=584082#:~:text=and%20social%20exclusion-,Key%20findings,of%20poverty%20or%20social%20exclusion.

Fortunato, F. et al. (2023). 'Association of socio-economic deprivation with COVID-19 incidence and fatality during the first wave of the pandemic in Italy: Lessons learned from a local register-based study', *International Journal of Health Geography*, Vol. 22, No. 1, https://doi.org/10.1186/s12942-023-00332-9.

Gaubert, G., Nauleau, S., Franke, F., Rebaudet, S., Mosnier, E., and Landier, J. (2023). 'Deprivation effect on COVID-19 cases incidence and severity: A geo-epidemiological study in PACA region, France', *medRxiv*, preprint, https://doi.org/10.1101/2023.04.18.23288723.

Green, M.A., García-Fiñana, M., Barr, B., Burnside, G., Cheyne, C.P., Hughes, D., Ashton, M., Sheard, S., and Buchan, I.E. (2021). 'Evaluating social and spatial inequalities of large scale rapid lateral flow SARS-CoV-2 antigen testing in COVID-19 management: An observational study of Liverpool, UK (November 2020 to January 2021)', *The Lancet Regional Health – Europe*, Vol. 6, https://doi.org/10.1016/j.lanepe.2021.100107.

Gullón, P., Cuesta-Lozano, D., Cuevas-Castillo, C., Fontán-Vela, M., and Franco, M. (2022). 'Temporal trends in within-city inequities in COVID-19 incidence rate by area-level deprivation in Madrid, Spain', *Health & Place*, Vol. 76, 102830, https://doi.org/10.1016/j.healthplace.2022.102830.

Haase, T., Pratschke, J., and Gleeson, J. (2014). *The 2011 All-Island HP Deprivation Index*, Dublin, Ireland: Pobal.

HPSC (2022). *Objectives of COVID-19 and influenza ICU enhanced surveillance*, https://www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/surveillance/covid-19intensivecareadmissions/Objectives%20of%20COVID-19%20ICU%20Surveillance%20v0.2.pdf.

Ingraham, N.E., Purcell, L.N., Karam, B.S., Dudley, R.A., Usher, M.G., Warlick, C.A., Allen, M.L., Melton, G.B., Charles, A., and Tignanelli, C.J. (2021). 'Racial and ethnic disparities in hospital admissions from COVID-19: Determining the impact of neighborhood deprivation and primary language', *Journal of General Internal Medicine*, Vol. 36, pp.3462–3470, https://doi.org/10.1007/s11606-021-06790-w.

Irish Refugee Council (2020). *"Powerless" Experiences of Direct Provision During the COVID-19 Pandemic*, available from: Download.ashx (rit.org.uk).

KC, M., Oral, E., Straif-Bourgeois, S., Rung, A.L., and Peters, E.S. (2020). 'The effect of area deprivation on COVID-19 risk in Louisiana', *Plos One*, Vol. 15, No. 12, e0243028, https://doi.org/10.1371/journal.pone.0243028.

Kennelly, B. et al. (2020). 'The COVID-19 pandemic in Ireland: An overview of the health service and economic policy response', *Health Policy and Technology*, Vol. 9, No. 4, p.419–419, https://doi.org/10.1016/j.hlpt.2020.08.021.

Kim, S.J., and Bostwick, W. (2020). 'Social vulnerability and racial inequality in COVID-19 deaths in Chicago', *Health Education & Behavior*, Vol. 47, No. 4, pp.509–513, https://doi.org/10.1177/1090198120929677.

Lewis, N.M., Friedrichs, M., Wagstaff, S., Sage, K., LaCross, N., Bui, D., ... and Dunn, A. (2020). 'Disparities in COVID-19 incidence, hospitalizations, and testing, by area-level deprivation—Utah, March 3–July 9, 2020', *Morbidity and Mortality Weekly Report*, Vol. 69, No. 38, 1369.

Lone, N.I., McPeake, J., Stewart, N.I., Blayney, M.C., Seem, R.C., Donaldson, L., ... and Puxty, K. (2021). 'Influence of socioeconomic deprivation on interventions and outcomes for patients admitted with COVID-19 to critical care units in Scotland: A national cohort study,' *The Lancet Regional Health–Europe*, Vol. 1, https://doi.org/10.1016/j.lanepe.2020.100005.

Mackey, K. et al. (2020). 'Racial and ethnic disparities in COVID-19-related infections, hospitalizations, and deaths: A systematic review', *Annals of Internal Medicine,* Vol. 174, No. 3, pp.362–373, https://doi.org/10.7326/M20-6306.

Madden, J.M., More, S., Teljeur, C., Gleeson, J., Walsh, C., and McGrath, G. (2021). 'Population mobility trends, deprivation index and the spatio-temporal spread of coronavirus disease 2019 in Ireland', *International Journal of Environmental Research and Public Health*, Vol. 18, No. 12, 6285, https://doi.org/10.3390/ijerph18126285.

Mamelund, S.E., (2018). '1918 pandemic morbidity: the first wave hits the poor, the second wave hits the rich', *Influenza and Other Respiratory Viruses*, Vol. 12, No. 3, pp.307–313, https://doi.org/10.1111/irv.12541.

Manz, K.M., Schwettmann, L., Mansmann, U., and Maier, W. (2022). 'Area deprivation and COVID-19 incidence and mortality in Bavaria, Germany: A Bayesian geographical analysis', *Frontiers in Public Health*, Vol. 10, 927658, https://doi.org/10.3389/fpubh.2022.927658.

Marani, M., Katul, G.G., Pan, W.K., and Parolari, A.J. (2021). 'Intensity and frequency of extreme novel epidemics', *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 118, No. 35, e2105482118, https://doi.org/10.1073/pnas.2105482118.

Mateo-Urdiales, A., Fabiani, M., Rosano, A., Vescio, M.F., Del Manso, M., Bella, A., ... and Andrianou, X. (2021). 'Socioeconomic patterns and COVID-19 outcomes before, during and after the lockdown in Italy (2020)', *Health & Place*, Vol. 71, 102642, https://doi.org/10.1016/j.healthplace.2021.102642.

Mathur, R. et al. (2021). 'Ethnic differences in SARS-CoV-2 infection and COVID-19-related hospitalisation, intensive care unit admission, and death in 17 million adults in England: An observational cohort study using the OpenSAFELY platform', *The Lancet,* Vol. 397, No. 10286, pp.1711–1724, https://doi.org/10.1016/S0140-6736(21)00634-6.

McGowan, V.J., and Bambra, C. (2022). 'COVID-19 mortality and deprivation: Pandemic, syndemic, and endemic health inequalities', *The Lancet Public Health*, Vol. 7, No. 11, pp.966–975, https://doi.org/10.1016/S2468-2667(22)00223-7.

McGuinness, S., et al. (2018). *Profiling barriers to social inclusion in Ireland: The relative roles of individual characteristics and location*, ESRI Research Series No. 71, Dublin: The Economic and Social Research Institute, https://doi.org/10.26504/rs71.

McKeown, D., McCourt, A., Hendrick, L., O'Farrell, A., Donohue, F., Grabowsky, L., ... and Johnson, H. (2023). 'COVID-19 incidence and outcome by affluence/deprivation across three pandemic waves in Ireland: A retrospective cohort study using routinely collected data', *Plos One*, Vol. 18, No. 7, e0287636, https://doi.org/10.1371/journal.pone.0287636.

McLaughlin, J.M. et al. (2020). 'County-level predictors of coronavirus disease 2019 (COVID-19) cases and deaths in the United States: What happened, and where do we go from here?', *Clinical Infectious Disease,* Vol. 73, No. 7, pp.e1814–e1821, https://doi.org/10.1093/cid/ciaa1729.

Meurisse, M., Lajot, A., Devleesschauwer, B., Van Cauteren, D., Van Oyen, H., Van den Borre, L., and Brondeel, R. (2022). 'The association between area deprivation and COVID-19 incidence: A municipality-level spatio-temporal study in Belgium, 2020–2021', *Archives of Public Health*, Vol. 80, No. 1, 1–10, https://doi.org/10.1186/s13690-022-00856-9.

Moissl, A.P., Lorkowski, S., and März, W. (2022). 'Socio-economic deprivation and COVID-19 in Germany', *Scandinavian Journal of Public Health*, Vol. 50, No. 6, pp.668–670, https://doi.org/10.1177/14034948221080397.

Morrissey, K., Spooner, F., Salter, J., and Shaddick, G. (2021). 'Area level deprivation and monthly COVID-19 cases: The impact of government policy in England', Social Science & Medicine, Vol. 289, 114413, https://doi.org/10.1016/j.socscimed.2021.114413.

Nafilyan, V. et al. (2021). 'Ethnicity, household composition and COVID-19 mortality: A national linked data study', *Journal of the Royal Society of Medicine,* Vol. 114, No. 4, pp.182–211, https://doi.org/10.1177/0141076821999973.

Nolan, A., Burke, S., Burke, E., Darker, C., Barry, J., O'Connell, N., Zgaga, L., Mather, L., Nicholson, G., Dempster, M., Graham, C.D., Crowley, P., O'Connor, C., Tobin, K., Scally, G. (2021). 'Obstacles to public health that even pandemics cannot overcome: The politics of COVID-19 on the island of Ireland', *Irish Studies in International Affairs*, Vol. 32, No. 2, pp.225–246, https://doi.org/10.3318/isia.2021.32b.22.

O'Connor, C. et al. (2021). 'Bordering on crisis: A qualitative analysis of focus group, social media, and news media perspectives on the Republic of Ireland-Northern Ireland border during the "first wave" of the COVID-19 pandemic', *Social Science & Medicine*, Vol. 282, 114111, https://doi.org/10.1016/j.socscimed.2021.114111.

Pan, D. et al. (2020). 'The impact of ethnicity on clinical outcomes in COVID-19: A systematic review', *eClinical Medicine*, Vol. 23, https://doi.org/10.1016/j.eclinm.2020.100404.

Patel, A.P., Paranjpe, M.D., Kathiresan, N.P., Rivas, M.A., and Khera, A.V. (2020). 'Race, socioeconomic deprivation, and hospitalization for COVID-19 in English participants of a national biobank', *International Journal for Equity in Health*, Vol. 19, 1–4, https://doi.org/10.1186/s12939-020-01227-y.

Pobal (2023). *Pobal HP Deprivation Index Launched*, www.pobal.ie/pobal-hp-deprivation-index.

Prats-Uribe, A., Pareded, R., and Prieto-Alhambra, D. (2020). 'Ethnicity, comorbidity, socioeconomic status, and their associations with COVID-19 infection in England: A cohort analysis of UK Biobank data', *medRxiv,* https://doi.org/10.1101/2020.05.06.20092676.

Reitsma, M.B. et al. (2021). 'Racial/ethnic disparities in COVID-19 exposure risk, testing, and cases at the subcounty level in California', *Health Affairs*, Vol. 40, No. 6, pp.870–878, https://doi.org/10.1377/hlthaff.2021.00098.

Rohleder, S., Costa, D., and Bozorgmehr, K. (2022). 'Area-level socioeconomic deprivation, non-national residency, and Covid-19 incidence: A longitudinal spatiotemporal analysis in Germany', *eClinicalMedicine*, Vol. 49, https://doi.org/10.1016/j.eclinm.2022.101485.

Rose, T.C., Mason, K., Pennington, A., McHale, P., Buchan, I., Taylor-Robinson, D.C., and Barr, B. (2020). 'Inequalities in COVID19 mortality related to ethnicity and socioeconomic deprivation', *MedRxiv*, 2020–04, https://doi.org/10.1101/2020.04.25.20079491.

Rubin, G.J. et al. (2009). 'Public perceptions, anxiety, and behaviour change in relation to the swine flu outbreak: Cross sectional telephone survey', *BMJ*, Vol. 339, https://doi.org/10.1136/bmj.b2651.

Singh, G.K. (2003). 'Area deprivation and widening inequalities in US mortality, 1969–1998', *American Journal of Public Health*, Vol. 93, No. 7, pp.1137–1143, https://doi.org/10.2105/ajph.93.7.1137.

Smith, L.E., et al. (2022). 'Worry and behaviour at the start of the COVID-19 outbreak: Results from three UK surveys (the COVID-19 rapid survey of adherence to interventions and responses [CORSAIR] study)', *Preventative Medicine Reports,* Vol. 25, 101686, https://doi.org/10.1016/j.pmedr.2021.101686.

Steelfisher, G.K. et al. (2015). 'Adoption of preventive behaviors in response to the 2009 H1N1 influenza pandemic: A multiethnic perspective', *Influenza and Other Respiratory Viruses*, Vol. 9, No. 3, pp.131–142, https://doi.org/10.1111/irv.12306.

Sze, S. et al. (2020). 'Ethnicity and clinical outcomes in COVID-19: A systematic review and meta-analysis', *EClinicalMedicine*, Vol. 29, https://doi.org/10.1016/j.eclinm.2020.100630.

Teljeur, C., Darker, C., Barry, J., and O'Dowd, T. (2019). *The Trinity National Deprivation Index for Health and Health Services Research 2016*, Department of Public Health & Primary Care, Trinity College Dublin.

Treskova-Schwarzbach, M. et al. (2021). 'Pre-existing health conditions and severe COVID-19 outcomes: An umbrella review approach and meta-analysis of global evidence', *BMC Medicine*, Vol. 19, 212, https://doi.org/10.1186/s12916-021-02058-6.

Whelan, A., Devlin, A., and McGuinness, S. (2023a). 'Barriers to social inclusion and levels of urbanisation: Does it matter where you live?', *Cambridge Journal of Regions, Economy and Society*, Vol. 17, No. 1, pp.59–74, https://doi.org/10.1093/cjres/rsad036.

Whelan, A., Devlin, A., and McGuinness, S. (2023b). *Pandemic unemployment and social disadvantage in Ireland*, ESRI Research Series Number 163, Dublin: ESRI, https://www.esri.ie/system/files/publications/RS163_0.pdf.

Wilkinson, T.J., et al. (2022). 'Association of ethnicity and socioeconomic status with COVID-19 hospitalization and mortality in those with and without chronic kidney disease', *Kidney International Reports*, Vol. 7, No. 2, pp.334–338, https://doi.org/10.1016/j.ekir.2021.11.040.

APPENDIX

TABLE A.1 COVERAGE OF HEALTH INFORMATION IN COVID-19 DATASET

	Number	Proportion
BMI > 40	1408	0.6%
Chronic Respiratory Conditions	24684	10.3%
Diabetes	22697	9.5%
Underlying Chronic Conditions	217059	90.9%
All	**238907**	**100%**

TABLE A.2 MEAN INFECTION RATES BY DEPRIVATION CATEGORY, USING VARIOUS DEPRIVATION CATEGORY CUT-OFFS

Mean Infection Rate across EDs					
Researchers 3 category split		Pobal HP 4 category split		Deprivation Quintiles	
1	5.60%	1	5.60%	1	4.70%
2	3.90%	2	3.90%	2	3.80%
3	3.70%	3	3.70%	3	3.70%
		4	4.10%	4	3.60%
				5	3.80%

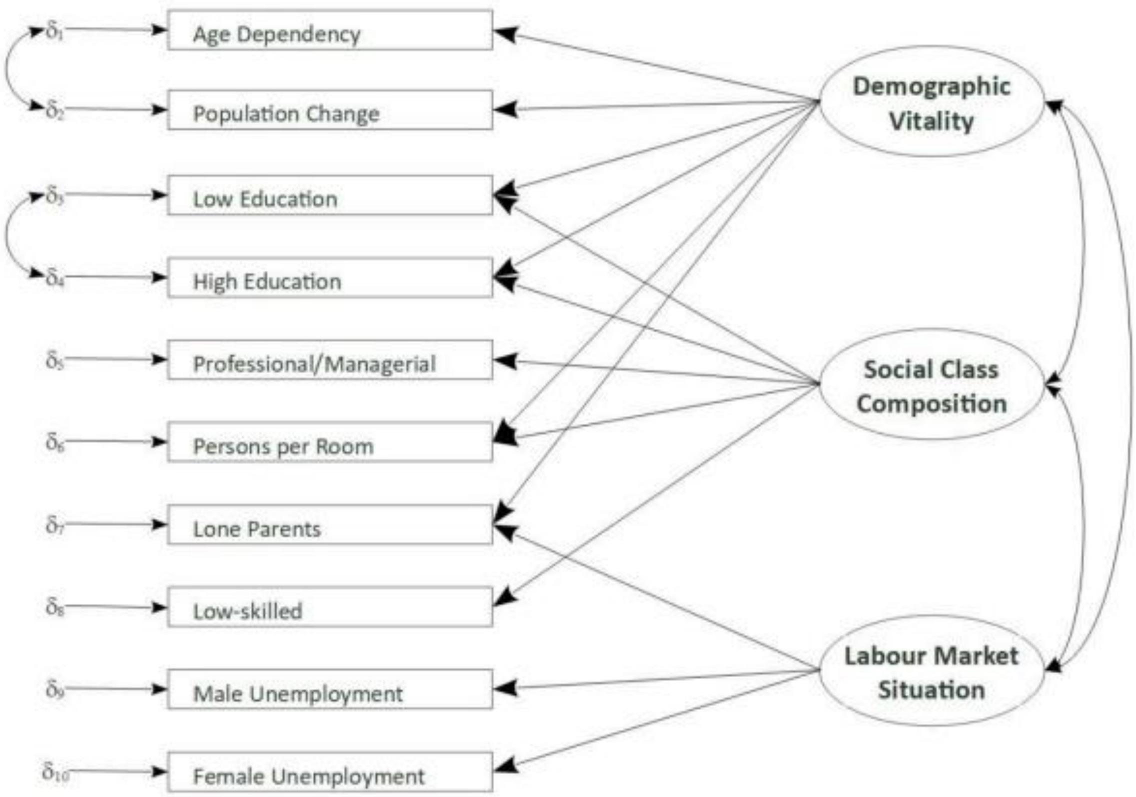
TABLE A.3 AREA-LEVEL INFECTION RATES, FRACTIONAL LOGIT MODEL, DIFFERENT MEASURES OF BORDER AREA

	Border Counties		16km from border		32km from border	
Area-Level Deprivation						
1 (Most deprived)	0.013	***	0.013	***	0.013	***
2 (Marginally below average)	0.000		0.002	*	0.001	
Ref: 3 (Marginally above average/Least deprived)						
Area-Level Controls						
Share of Irish travellers	0.002	***	0.002	***	0.002	***
Share of Black people	0.000	*	0.000	*	0.000	
Share of Asian people	0.000	**	0.000	**	0.000	**
Share of people over 80	0.000		0.000		0.000	
Communal Establishments Indicator	0.004	***	0.004	***	0.004	***
Share of population who are over 65 resident in communal establishments	0.001	***	0.001	***	0.001	***
Population Density	-0.000	***	-0.000	***	-0.000	***
Border#Dep						
Non-border	Ref		Ref			
Border#notdeprived	0.020	***	0.019	***	0.17	***
Border#deprived	0.010		0.009	**	0.008	*
N	3338		3338		3338	
Pseudo R2	0.01		0.01		0.01	

TABLE A.4 AREA-LEVEL INFECTION RATES, FRACTIONAL LOGIT MODEL, FOUR CATEGORIES OF DEPRIVATION

	(1)		(2)		(3)		(4)	
Area-Level Deprivation								
1 (Most deprived)	0.012	***	0.012	***	0.014	***	0.013	***
2	-0.001		0.001		0.003	**	0.000	
3	-0.004	***	-0.001		0.000		-0.000	
Ref: Least deprived/Most affluent	*Ref*		*Ref*		Ref		*Ref*	
Area-Level Controls								
Share of Irish Travellers			0.002	**	0.002	***	0.002	***
Share of Black people			0.001	***	0.000		0.000	*
Share of Asian people			0.001	***	0.000	*	0.000	**
Share of people over 80			0.000	*	-0.000		0.000	
Communal Establishments Indicator					0.005	***	0.004	***
Share of population who are over 65 and resident in communal establishments					0.001	***	0.001	***
Population Density					-0.000	***	-0.000	***
Border#Dep								
Non-border							*Ref*	
Border#notdeprived							0.018	***
Border#deprived							0.005	
N	3387		3387		3338		3338	
Pseudo R2	0.00		0.00		0.00		0.01	

FIGURE A.1 COMPONENTS OF THE POBAL HP DEPRIVATION INDEX



Source: www.pobal.ie/app/uploads/2023/11/Pobal-HP-Deprivation-Index-Briefing.pdf.

Whitaker Square,
Sir John Rogerson's Quay,
Dublin 2
Telephone **+353 1 863 2000**
Email **admin@esri.ie**
Web **www.esri.ie**
Twitter **@ESRIDublin**

AN INSTITIÚID UM THAIGHDE EACNAMAÍOCHTA AGUS SÓISIALTA
ESRI ECONOMIC & SOCIAL RESEARCH INSTITUTE