The Economic and Social Review, Vol. 56, No. 3 Autumn 2025, pp. 307-340

The Health Impacts of COVID-19 and Area-Level Deprivation in Ireland

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Abstract: This study examines COVID-19 infection rates and ICU admission rates in deprived areas in Ireland. Using area-level data from Electoral Division (ED) areas, the Pobal Haase-Pratschke Relative Deprivation Index (henceforth HP deprivation index) and Census data, the analysis finds that infection rates in the most deprived areas were about a third higher than those in affluent areas, even after controlling for age, minority communities, and communal establishments. Higher ICU admission rates are linked to minority communities, older populations, and poorer health. Non-deprived areas in border counties also exhibited notably high infection rates, highlighting the need for coordinated public health responses across jurisdictions. The findings highlight important policy implications for addressing inequalities in public health across Ireland and underscore the importance of addressing pre-existing health disparities and targeting pandemic planning efforts to mitigate the disproportionate impact on vulnerable populations.

Acknowledgements: The authors wish to thank all the individuals involved within Pobal who provided assistance during the early stages of this project. Thanks also to those who assisted in accessing the COVID-19 infection rate data. The authors are solely responsible for the content and the views expressed.

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I INTRODUCTION

The COVID-19 pandemic disproportionately impacted those in disadvantaged communities. A growing body of international research finds a substantial socio-spatial gradient in infections, hospital admissions and mortality, with deprived communities having experienced higher rates than more affluent areas. In particular, low-income areas and ethnic minority communities experienced the worst effects of the pandemic. As such, the pandemic exacerbated existing societal inequalities by inducing worse health outcomes among groups that were already disadvantaged prior to the onset of the virus. While empirical support for this finding exists for other countries, the evidence base for Ireland is notably limited, motivating our research. This paper examines the health impacts of the COVID-19 pandemic on disadvantaged communities in Ireland. Using Census data and the Pobal Haase-Pratschke (HP) Relative Deprivation Index, we analyse area-level COVID-19 infection rates and Intensive Care Unit (ICU) admission rates at the Electoral Division (ED) level.

Our research uncovers similar inequalities in infection rates in Ireland. Descriptively, we show that the average COVID-19 infection rate in the most deprived areas (5.6 per cent) was substantially higher than in more affluent areas (3.7 per cent). Through formal modelling, we find that the most deprived areas experienced higher infection rates than more affluent areas, controlling for other area-level demographics. Specifically, we found that the most deprived areas exhibited infection rates more than a third higher than those in affluent areas. Areas with higher shares of ethnic minorities and areas with communal establishments also had higher infection rates. Interestingly, non-deprived areas located in border counties exhibited notably high infection rates. Given the porous nature of the border between Ireland and Northern Ireland, this finding has significant policy implications for both jurisdictions on the island.

We did not find a direct association between area-level deprivation and ICU admissions due to COVID-19 infection. However, we provide tentative evidence of an indirect impact of deprivation via other area-level characteristics. The primary drivers of high ICU admission on area-level are the presence of communal establishments, and higher shares of the population that report having underlying health conditions. Ethnicity also appears to play a role. Areas with higher shares of ethnic minorities exhibited a greater likelihood of high ICU admissions. We show that these area-level drivers are highly correlated with deprivation, suggesting that deprivation may have played an indirect role in ICU admissions throughout the pandemic, having been mediated by other factors.

Our research gives policymakers cause to consider spatial and socio-economic factors when responding to future public health emergencies. We show that deprived communities experienced higher infection rates than less deprived areas. Policymakers should adopt a socio-spatially targeted approach when allocating resources toward mitigating infections and enhancing healthcare; deprived areas should be prioritised. Not only would this approach be more efficient in reducing overall infections, but it would also reduce the risk of further amplifying existing societal inequalities between communities.

II EXISTING LITERATURE

2.1 International Evidence

The empirical literature finds that living in deprived areas was positively associated with elevated 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). The magnitude of this relationship varies based on the context. KC *et al.* (2020) find that those living in the most deprived areas in Louisiana (US) had a 40 per cent higher risk of COVID-19 infection when compared to the most affluent areas. In Madrid, relative to the least deprived areas, those in the most deprived areas had a 17 per cent higher risk of infection (Gullón *et al*., 2021). Both studies take similar approaches using deprivation measures constructed with their respective Censuses. The Louisiana finding from KC *et al.* (2020) is one of the higher estimates, though is not the largest. Lewis *et al.* (2020) finds that for Utah (US) those in the most deprived areas were up to three times more likely to be infected with COVID-19 than their peers in less deprived areas. Gullón *et al.* (2021) is one of the lower estimates found. Nevertheless, most of the existing research base unveils elevated infection risk among deprived areas, relative to more affluent communities. One exception is Gaubert *et al*. (2023), who find that COVID-19 infection rates were not correlated with area-level deprivation in France, although they did find that hospitalisation rates were more prevalent in deprived areas.

The temporal aspect of the pandemic has also been found to be important. By their nature, viral pandemics manifest in periods of outbreaks with varying levels of prevalence, severity, and community transmission. It is therefore unsurprising that socio-economic impacts from the pandemic varied across time. Meurisse *et al*. (2022) find that more deprived areas in Belgium were at greater risk of infection in the later stages of the pandemic (i.e. when the virus spread more widely). Gullón *et al*. (2022) also showed that the infection gap between deprived and affluent communities was widest in the later months of the pandemic. Further evidence of this temporal effect has been confirmed for Italy (Mateo-Urdiales *et al.,* 2021) and Germany (Manz *et al.,* 2022). These studies suggest that the intensity of infection waves may have a role to play in the relationship between deprivation and infection rates. Unfortunately, the recency of the COVID-19 pandemic limits many existing studies to examine the earlier phases, curbing the prospect of teasing out these effects (Adjei-Fremah *et al.*, 2023; Moissl *et al.*, 2022; Ingraham *et al*., 2021), with few extending beyond the first four months of 2021 (Rohleder *et al.*, 2022; Manz *et al*., 2022; Gullón *et al*., 2022). This is largely due to the (lack of) data available to researchers covering later stages of the pandemic.

Further research suggests that the more severe health impacts of COVID-19 – hospital admissions, ICU admissions, and mortality – were also more prevalent in deprived areas than in more affluent communities. For example, Patel *et al*. (2020) show that hospitalisation rates were substantially higher among deprived communities in the UK, while Lewis *et al.* (2020) demonstrate a similar pattern in Utah. Furthermore, mortality rates exhibited a socio-economic gradient, with deprived areas being the most affected (Lone *et al*., 2021; Kim and Bostwick, 2020; Chen and Krieger, 2020; Brandily *et al*., 2021). In a scoping review of the literature, McGowan and Bambra (2022) show that of the 95 papers examined in their study, 86 papers found mortality rates to be higher in more deprived areas. However, the majority of the studies were limited to examining the early stages of the pandemic (i.e. the first nine months of 2020), further highlighting the scarcity of literature examining the later stages.

A number of studies highlight the significant role of socio-economic factors in shaping health outcomes during the pandemic. Bennett *et al*. (2025) examined the association between area deprivation and COVID-19 mortality in England, finding that deprived areas experienced higher mortality rates, despite the national vaccination programme's efforts to reduce disparities. Similarly, Aalto *et al*. (2025) developed a networked SIRS model with Kalman filter state estimation to improve epidemic forecasting across Europe, demonstrating that interconnectedness and mobility play a crucial role in enhancing prediction accuracy. Together, these studies emphasise the need for targeted public health interventions and more sophisticated models for epidemic monitoring. Lunn *et al.* (2025) examine how different social groups responded to the COVID-19 restrictions in Ireland. Contrary to assumptions, individuals in higher social grades were quicker to return to normal activities as restrictions eased. In contrast, those in lower social grades, often from more deprived areas, were slower to resume typical social activities. This finding suggests that socio-economic status played a critical role in both the health impact of the pandemic and the pace of recovery.

Clearly, deprived communities were hit hardest by the pandemic. However, understanding the specific mechanisms through which inequalities in health outcomes were propagated is important for policy to respond effectively. While few studies examine such mechanisms, those that do provide important insights. One such study comes from Albani *et al.* (2022), who find that inequalities in mortality in England could be partially explained by overcrowding, high housing occupancy and the prevalence of pre-existing health conditions among deprived communities. An additional example comes from McLaughlin *et al*. (2020), who identify US counties with overcrowding, poorer air quality, lower proportions of the population with adequate health insurance, and higher incidence of travel to non-residential locations[1] as having a greater risk of population infection and mortality.

2.2 Ethnic Minorities

As well as deprived communities, a growing strand of the COVID-19 literature examines the differential health outcomes for ethnic minority groups. Pan *et al*. (2020) conduct a systematic review of this literature early in the pandemic. The authors found that the experiences and outcomes of ethnic minorities were not widely included in the published medical literature at the time of writing, but were present in the emerging literature, grey literature and preprint material. Within this body of work, the authors identified that Black, Asian and other ethnic minority groups were found to have an increased risk of being infected with COVID-19, as well as more severe health outcomes. Mackey *et al*. (2020) uncover a similar finding for Black and Hispanic communities in the US in their review of the early pandemic literature. The authors attributed these differences between groups to unequal healthcare access, as well as differential exposure to the virus.

Some more recent literature affirms that inequalities between ethnic groups in infection and severe health outcomes persisted throughout the pandemic. Reitsma *et al.* (2021) confirm this for Latino communities in California, with similar patterns emerging for Black and South Asian communities in the UK (Prats-Uribe *et al*., 2020; Wilkinson *et al.,* 2022). As discussed above, understanding the pathways through which these outcomes emerge matters. Once again, the evidence base for such pathways is limited, though some evidence from the UK provides insight.[2] Nafilyan *et al.* (2021) attribute higher mortality rates among some ethnic minority groups to the composition of households; some minority groups were more likely to live in multi-generational households. Given that multi-generational households are both more crowded and that residents are older, the risk of both infection and severe health outcomes is greater. In addition, members of ethnic minority groups were found to be less likely to work in occupations that facilitated working from home (Atchinson *et al*., 2021), meaning that their exposure to COVID-19 was elevated. The authors acknowledge that while the Irish and US responses differed considerably during the pandemic, most existing research examining ethnic/racial/social differences is based on data from the US. This highlights the need for localised studies.

There is also significant literature on the uptake of preventative heath behaviours during pandemics which also considers ethnicity and race. Non-White ethnicities and ethnic minority groups are more likely to utilise health-protecting

[1] While the data do not explicitly capture the reasons for non-residential travel, the authors speculate that the majority of this mobility could be attributed to work that could not be performed from home (i.e. 'frontline' work).

[2] Focusing on studies from the UK is appropriate, given that it is the closest geographical country to Ireland, with a similar demographic and economic profile.

behaviours than people who are White (Smith *et al.,* 2022; Bish and Michie, 2010; Rubin *et al*., 2009).[3] In a study of UK students, Barrett and Cheung (2021) found that non-White students were more likely to undertake hygiene behaviours which reduce the transmission of COVID-19.

2.3 COVID-19 in Ireland

Local literature examining the effects of COVID-19 on disadvantaged communities is limited but growing. 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 socio-economically deprived areas in Ireland and elevated COVID-19 infection rates between March 2020 and February 2021. The authors recommend that socio-economically 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 plays a determining role in COVID-19 outcomes in Ireland.

Perhaps the study most similar to our work comes from McKeown *et al*. (2023). The authors used individual-level data to examine the health outcomes (hospital admissions, ICU admissions and mortality) of Irish citizens from March 2020 to May 2021. Using area-level deprivation as a predictor, the authors found that individuals living in deprived areas were more likely to be admitted to hospital due to COVID-19 than their peers from more affluent areas. However, no statistically significant associative relationship between deprivation and ICU admission or mortality was found. The primary difference between this paper and our work lies in the unit of analysis; we examine area-level factors, while McKeown *et al*. (2023) focus on individual-level determinants.

In addition, the border between Ireland and Northern Ireland was an important factor throughout the pandemic for two reasons. First, public policy approaches to limiting the spread of COVID-19 differed between the jurisdictions. In addition, the border remained open throughout the pandemic. This meant that those travelling between jurisdictions were subject to different sets of public health restrictions and advice, which may have limited the efficacy of public messaging and restrictions. Kennelly *et al*. (2020) argued that the border required a coordinated public health response across jurisdictions due to cross-border mobility and differential policy responses (i.e. testing strategies and physical distancing restrictions). Two pieces of qualitative evidence provide valuable insight into this policy-behaviour dynamic. The policy side of the coin was analysed by Nolan *et al*. (2021), who compared

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

public health strategies on both sides of the border throughout the first wave of the virus. Using the Oxford COVID-19 Government Response Tracker, the authors find that public health responses were broadly aligned across jurisdictions in the early stages of the pandemic. O'Connor *et al*. (2021) provided insight into perspectives from border residents on the public health responses north and south. Drawing on focus groups, news articles and Twitter posts, the authors conclude that residents of border counties viewed policy responses as uncoordinated and politicised, and broadly favoured an all-island approach. These considerations motivate our specific focus on area-level health outcomes in border counties in Ireland.

III DATA AND METHODS

3.1 Data

3.1.1 COVID-19 Data

The COVID-19 infection rate data used in this research were accessed via the Central Statistics Office (CSO) COVID-19 Data Hub following approval being granted by the ESRI Research Ethics Committee, the Health Research Consent Declaration Committee, the CSO and the Research Data Governance Board. Most COVID-19 cases in theory should be recorded on the Computerised Infectious Diseases Reporting (CIDR) system. Confirmed cases notified on this CIDR system must meet the Health Protection Surveillance Centre's definition of a case which requires the detection of SARS-CoV-2 nucleic acid or antigen in a clinical specimen. Therefore, positive tests as a result of a self-administered rapid antigen test were not considered to be confirmed cases.

The data used cover the period March 2020 (the beginning of the pandemic) through April 2021 (when the COVID-19 data were initially applied for). There are 238,907 observations in the infection rate data, with each observation representing a distinct recorded infection. The dataset also contains the individual's information such as age, gender, ethnicity, occupation, country of birth, healthcare worker status, and possible source of transmission. Unfortunately, these variables were not well populated in the dataset despite their obvious utility. Age and gender were the only variables consistently recorded. Health information such as BMI, smoker status, and the presence of certain underlying conditions – chronic respiratory disease, diabetes, and any other underlying chronic condition – is also recorded for a minority of individuals. Again, these were not well populated either. Some variables were recorded for only about 10 per cent of the sample.

The area of residence at the Electoral Division (ED) is also recorded in the dataset and this is what allows us to conduct an area-level analysis. Using the ED identifier, we generate an area-level infection rate for each ED in Ireland by dividing the number of infections by the population (based on Census data). This infection rate is then used for the purposes of our analysis.

The COVID-19 dataset also has the date admitted to ICU for those who spent time in intensive care. We calculate the number of infected people in an ED who were treated in ICU and divide this by the number of people who had COVID-19. This is our area-level ICU admission rate.

The data predate the roll-out of widespread vaccination against the infection, thus we are not concerned with the potential bias introduced by vaccination coverage which may be higher in more affluent areas. Additionally, it may be that testing was slow to roll out at the beginning of the pandemic. As testing was introduced, those with the means to access testing (e.g. those with private cars to travel to test sites) may have been more likely to test when symptoms presented. Therefore, any relationship between deprivation and COVID-19 infection in the data may be somewhat attenuated.

3.1.2 HP Deprivation Index

We aim to quantify the relationship between area-level deprivation and area-level COVID-19 infection rates. To capture deprivation, the Pobal HP Deprivation Index is the main explanatory variable used in the analysis. The index is constructed using data from the Irish Census (2022) at the ED level on a range of indicators for demographic profile, social class, and labour market measures. Figure 1 shows the variables from the Census used to generate the index.[4] In total, there are ten measures from the Census used from these three categories, which are operationalised to form the index.

The index is in the form of a continuous variable which ranges from –40 (most deprived) to +20 (least deprived). Table 1 shows common categories used by the creators of the index as well as how EDs are distributed across these categories. In the final column, we display the classification we use going forward in our analysis.

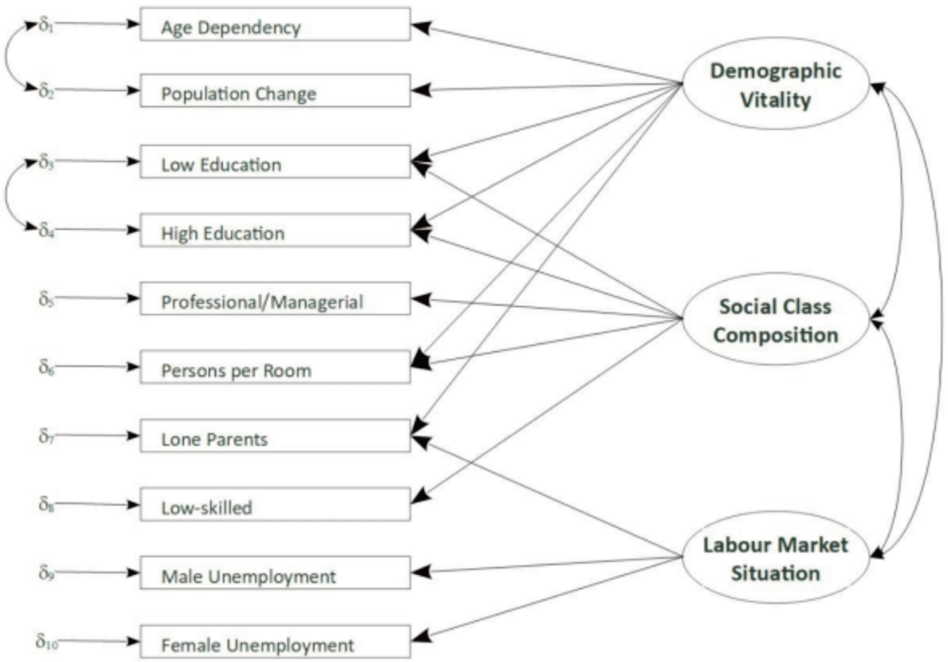
Table 1: Classification of HP Relative Deprivation Index Scores at ED Level in Ireland, 2022

Relative Index Score	*Label*	*Number of EDs in 2022*	*Percentage of EDs in 2022*	*Our Classification (1-4)*
10 to 20	Affluent	129	3.81%	*4*
0 to 10	Marginally Above Average	1,538	45.41%	*3*
0 to – 10	Marginally Below Average	1,481	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		3,387	100%	

Source: Pobal (2022).
Notes: This is restricted to the EDs used for the analysis going forward.

[4] For more info on the methods used to create the index see: https://www.pobal.ie/app/uploads/2023/11/Pobal-HP-Deprivation-Index-Briefing.pdf.

Figure 1: Basic Model of HP Deprivation Index Components



Source: Pobal (2022).

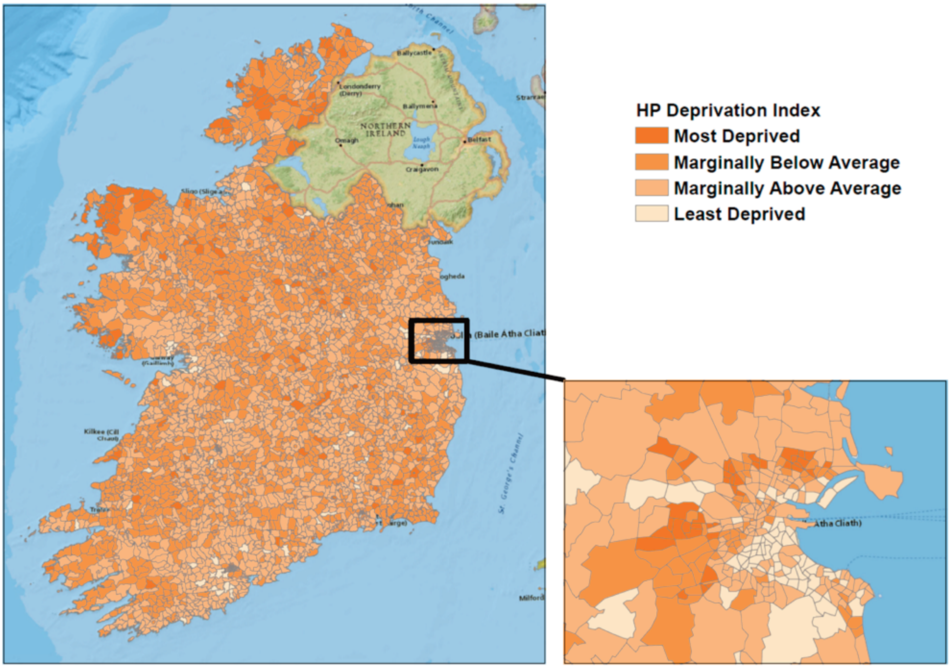
The cut-off for the four categories we use in the analysis may be considered arbitrary. However, we utilised various methods of splitting the HP deprivation index into categories and find the results to be consistent regardless of what method is used.

Area-level deprivation in Ireland varies spatially across the country. Figure 2 maps deprivation using the HP deprivation index at the ED level. More deprived areas are shown in darker orange and are evident across the country but with a particular concentration in the West of Ireland as well as a spine up the middle of the country. There are also pockets of deprivation in and around the main cities of Dublin, Cork, Limerick and Galway.

Additional data used in our econometric analysis come from the 2022 Census. Area-level data are extracted from the Census based on what we learned from the literature. The share of Irish Travellers, the share of Black people, the share of Asian people, the share of older people, and the presence of communal establishments are all included.

The COVID-19 infection rate data are attached to 2016 ED boundaries, while the Census and the HP deprivation index use updated 2022 boundaries. Of the initial 3,409 EDs using the 2016 boundaries, a certain number cannot be matched to the 2022 boundaries. The final number of EDs used for the analysis in this paper is

Figure 2: Spatial Distribution of the HP Relative Deprivation Index, 2022



Source: Authors' own using Pobal HP Deprivation Index.

3,338. For the ICU admission models, the number of observations is somewhat lower due to the omission of EDs with fewer than five people admitted to the ICU due to statistical disclosure controls.[5] Table 2 displays descriptive information of the area-level controls used in the Census data analysis.

3.2 Methods

3.2.1 Infection Rates

Our empirical strategy is designed to quantify the extent to which the COVID-19 infection rate varies in more deprived areas while controlling for other relevant area-level factors. The dependent variable, the area-level COVID-19 infection rate, is presented as a decimal and therefore ranges from zero to one (and can include values at both zero and one). On this basis we utilise a fractional logit model as is standard practice in the economic literature with such dependent variables. This approach was developed by Papke and Woolridge (1996).

[5] The analysis presented in this paper uses the 2022 Census. The analysis was also conducted with the 2016 Census data and the results are robust regardless of which are used. The results can be requested from the authors.

Table 2: Descriptive Statistics of Area-Level Census Controls

	Proportion	*Minimum*	*Maximum*
Irish Travellers	0.42	0	28.3
Black People	0.64	0	25.4
Asian People	1.4	0	25.6
People in bad/very bad health	1.73	0	8.2
People over 80	4	0	16.4
Communal Establishments	0.5	0	1
Residents over 65 and Resident in Communal Establishments	0.76	0	57.5
Population Density	765.1	1.3	26,184.7
Occupational Make-up			
Managers	7.1	2.7	21.4
Professional Occupations	18.4	0.9	45.8
Associate Professional	10.2	0	23
Administrative	9.12	0	20.5
Skilled Trades	18.8	1.7	45.6
Caring, Leisure and Other Service	7.8	0	19.5
Sales and Customer Service	5.3	0	16.1
Process Plant and Machinery	7.8	0	25.9
Elementary	7.6	0	27.8
Not Stated	7.9	0	63.4

Source: Authors' own using 2022 Census.

Papke and Woolridge (1996) utilised a non-linear function for estimating expected values of dependent variable y_i, conditional on a vector of covariates, x_i, as shown in Equation 1:

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

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:

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

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

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

Deprivation is included as a set of binary variables for each of four categories as outlined in Table 1, and is the main explanatory variable. The 2022 Census variables are also included as controls. The area-level information extracted from the Census includes the proportion of residents over the age of 80 and the ethnic/racial composition of areas (more specifically, the proportion of Irish Travellers, Black people, and Asian people). Given the prevalence of outbreaks in nursing homes and similar residential institutions, the presence of a communal establishment within an area is also controlled for, as is the share of the ED's population who are over 65 and resident in a communal establishment, to isolate the impact of nursing homes from other communal residential facilities. Population density is also controlled for to account for heterogeneity between EDs and, perhaps more importantly, to reflect the importance of proximity to others in transmitting the virus. It is also worth noting that persons per room is included as a component of the HP deprivation index. A further specification also controls for border areas given the high infection rates seen when we map infection rates across the country; higher rates of infection were found in early studies during the pandemic. Specifically we include an interaction variable between the border area and deprivation levels. Results from these specifications are displayed as marginal effects in Table 5. Standard errors are clustered at the ED level to account for within-area correlation (Abadie *et al*., 2017).

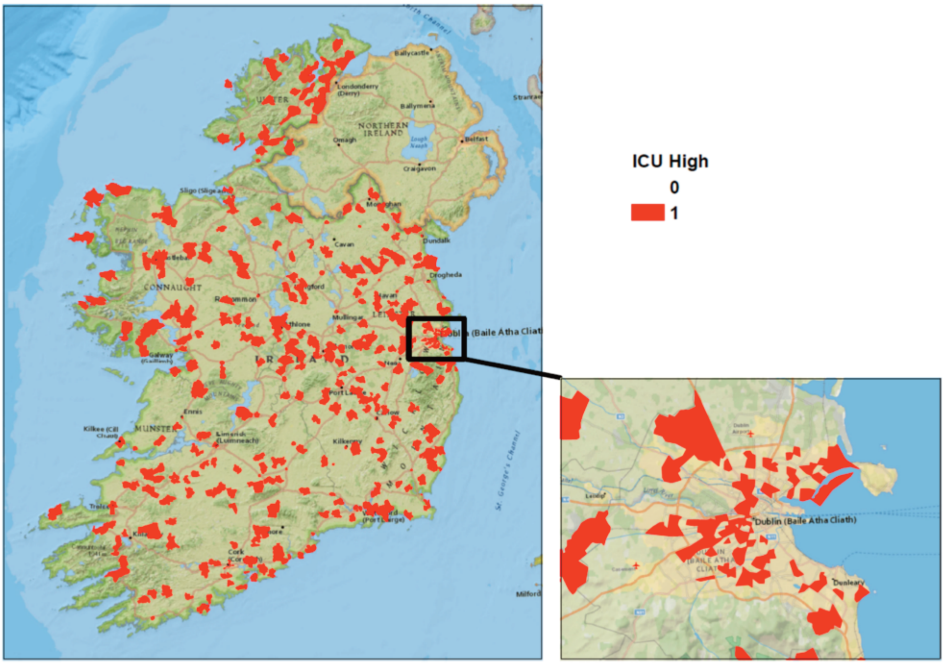
3.2.2 ICU Admission Rates

Given the different structure of the ICU admission rate variable, we take another methodological approach. The ICU admission rate data are heavily skewed to the right (Figure 6) with most values falling between 0 and 1 per cent (84 per cent of EDs). Considering this pronounced right skew, we use a probit model with a constructed binary dependent variable. This variable is equal to 1 if the ICU admission rate is more than 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 as shown in Equation 4:

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

Where $ICU > 1\%_j^*$ equals 1 when the ED ICU admission rate is more than 1 per cent, X_j represents a vector of area-specific characteristics, DEP_j is the main variable of interest measuring the deprivation category of each ED, and ε_j is an i.i.d. error term. Table 5 shows the marginal effects as a result of 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 used the same variables employed in the infection rate models (above), which offer an examination of the relationship between area-level deprivation and the likelihood of an area having an ICU admission rate of greater than 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 likelihood of being admitted to ICU with COVID-19. The binary outcome variable is mapped in Figure 3.

Figure 3: Areas with High ICU Admission Rates, Electoral Division Level



Source: Authors' own using COVID-19 data.

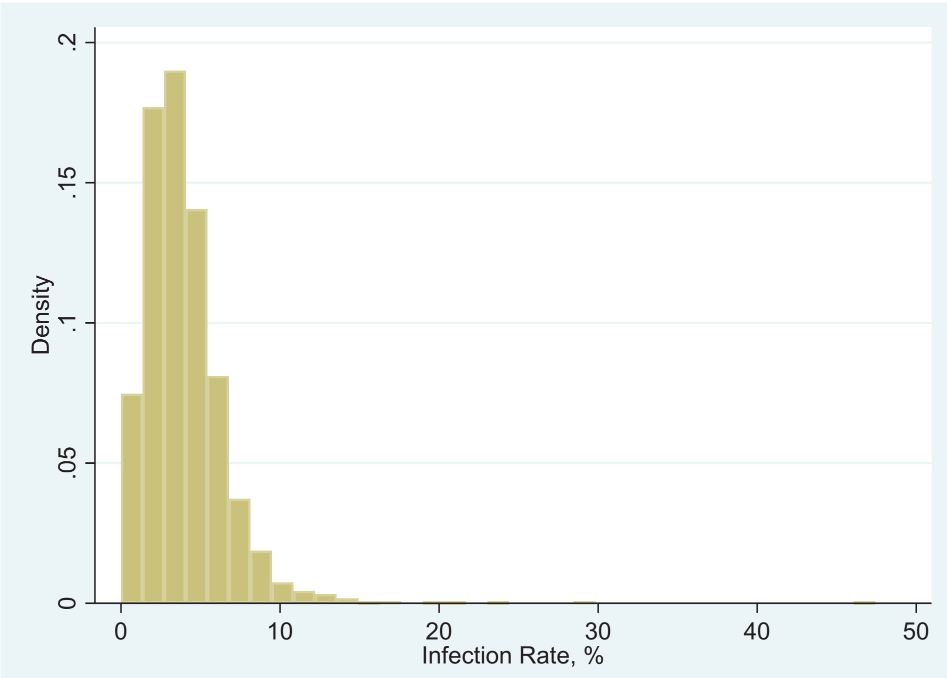
IV FINDINGS

4.1 Descriptive Analysis

The COVID-19 infection rate data used in the analysis are outlined below. The average ED infection rate is 3.9 per cent with a range of between 0 per cent and 47.4 per cent. However the data are highly positively skewed; 98 per cent of EDs have an infection rate below 10 per cent. Figure 4 illustrates the distribution of the area-level COVID-19 infection rates.

The infection rate varies substantially across EDs and, in line with our research aims, we conducted a descriptive analysis to examine how infection rates differ across deprivation groups. Amongst the most deprived EDs, the average infection rate is 5.6 per cent. It is lowest amongst the Marginally Above Average deprivation

Figure 4: Histogram of Infection Rate, Electoral Division Level



Source: Authors' own using COVID-19 data.

group ($\overline{x}$ = 3.7 per cent), as displayed in Table 3. The descriptive analysis suggests that there is a relationship between deprivation and infection rates, with COVID-19 infection rates in the most deprived areas being more than a third higher than the most affluent areas.

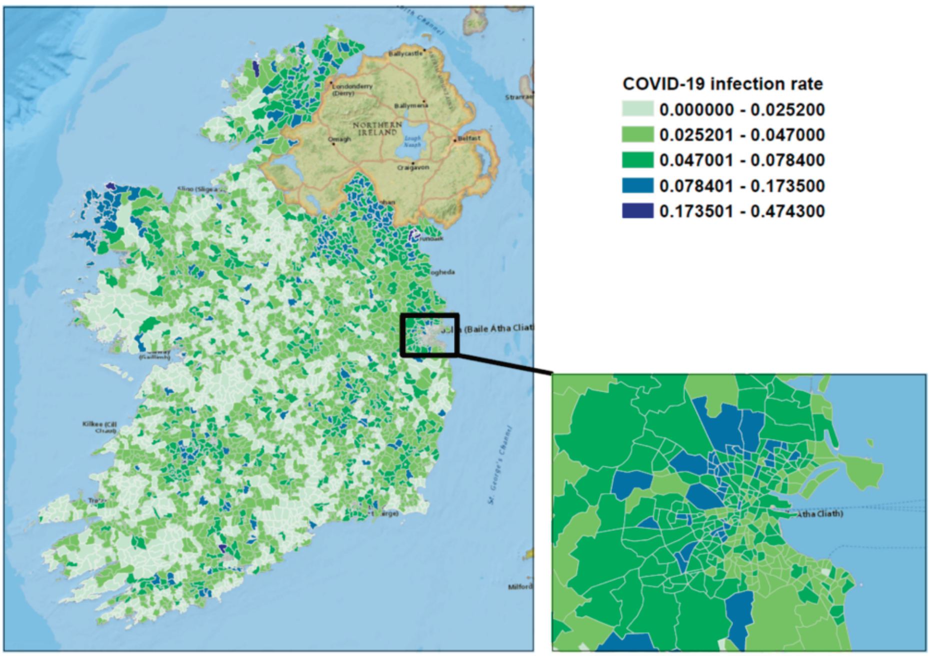
Table 3: COVID-19 Infection Rate by Electoral Division, 2022

	Mean
All	3.92%
Deprivation	
1 (Most Deprived)	5.56%
2	3.91%
3	3.66%
4 (Least Deprived)	4.05%

Source: Authors' own using COVID-19 data.

Figure 5 maps the infection rate at the ED level across Ireland, revealing substantial spatial variation across the country. Notably, higher COVID-19 infection rates are observed in Donegal and the border counties, as well as in Dublin and some other cities and large towns. When Figure 2 and Figure 5 are considered alongside one another similarities emerge, suggesting potential correlation between deprivation and infection rates at the area-level. This indicates that socio-economic factors may be linked to the spatial variation in COVID-19 infection rates.

Figure 5: Spatial Distribution of COVID-19 Infection Rates, Electoral Division Level

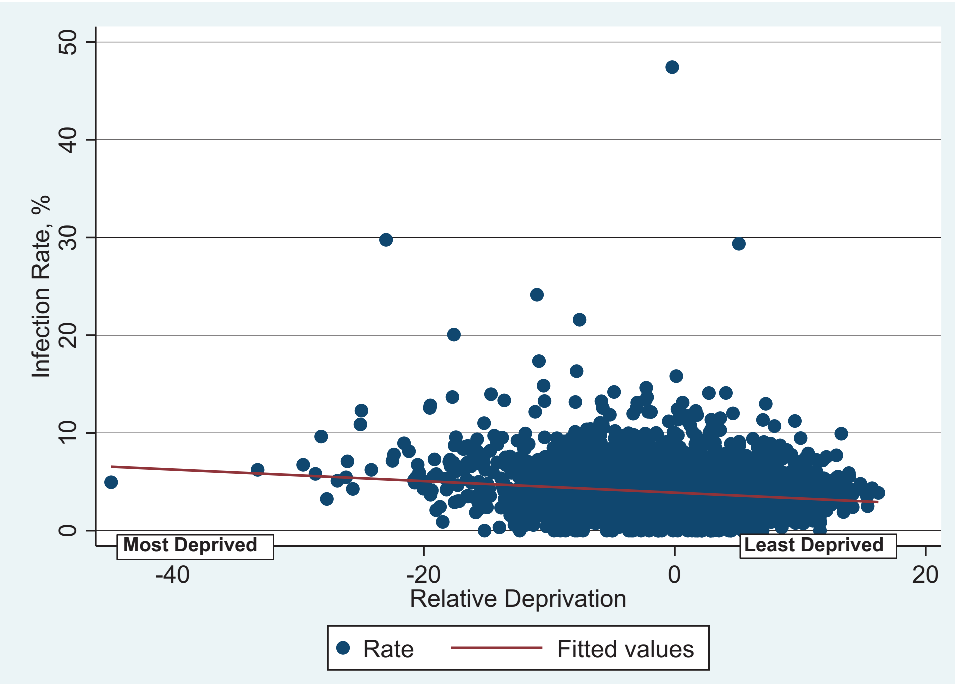


Source: Authors' own using COVID-19 data.

Plotting COVID-19 infection rates against area-level deprivation also shows a descriptive relationship, as can be seen in Figure 6. There is a clear pattern of higher COVID-19 infection rates in more deprived areas and lower rates in more affluent areas (correlation coefficient = –0.15).

We also examine ICU admission rates at the ED level, calculated as a proportion of the infected population that were admitted to the ICU. Examining ICU data and the relationship between data and deprivation allows us to better understand the interaction between severity of the infection and deprivation. While ICU admission can be somewhat objective as it is a clinical decision, it is more reflective of severity than infection. Therefore, understanding it is also useful for health and policy planners. Figure 7 displays the distribution of the ICU data at the

Figure 6: Scatterplot of Infection Rate vs Relative Deprivation, Electoral Division Level



Source: Authors' own using COVID-19 data and Pobal HP Deprivation Index.

area level. Although the variable ranges between 0 and 20 per cent, the majority of EDs (84 per cent) have a rate of less than 1 per cent.

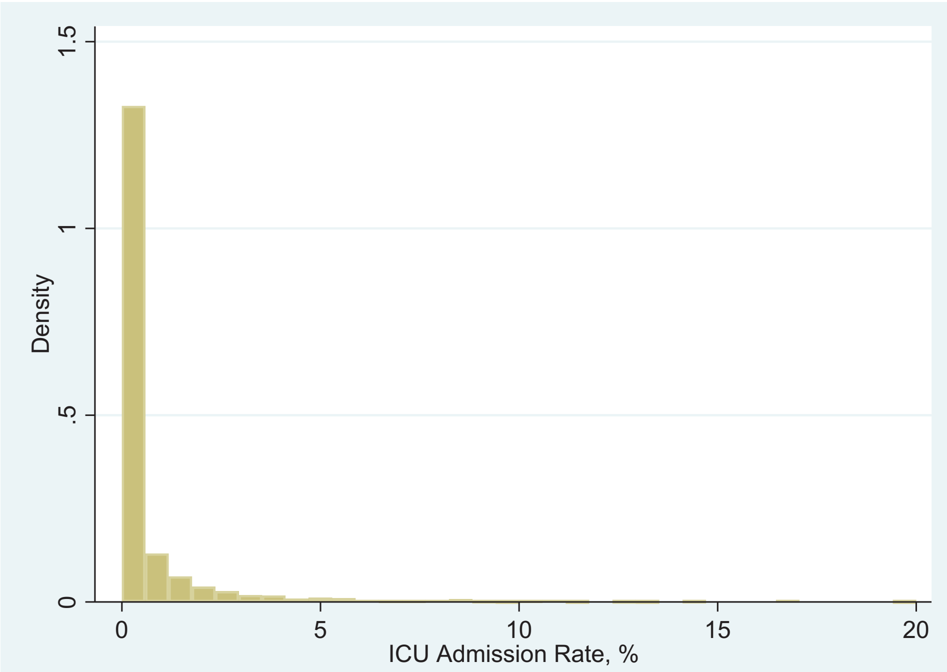
The mean ICU admission rate across EDs is 0.7 per cent amongst the most deprived EDs compared to 0.5 per cent amongst the most affluent. Table 4 displays the mean ICU admission rate across EDs for each deprivation category. Unlike COVID-19 infection rates there is a more linear relationship between deprivation

Table 4: ICU Admission Rate by Electoral Division, 2022

	Mean	*N*
All	0.62%	2,964
Deprivation		
1 (Most Deprived)	0.70%	215
2	0.66%	1,285
3	0.59%	1,344
4 (Least Deprived).	0.45%	120

Source: Authors' own using COVID-19 data.

Figure 7: Histogram of ICU Admission Rate, Electoral Division Level



Source: Authors' own using COVID-19 data.

and ICU admission rates, at least when examining unadjusted descriptive information.

Figure 8 spatially maps the ICU admission rate at the ED level across Ireland. Higher rates of ICU admission are distributed across the country with no apparent spatial pattern, albeit with the exception of a few areas with high rates clustered around the border in Donegal and in Dublin City.

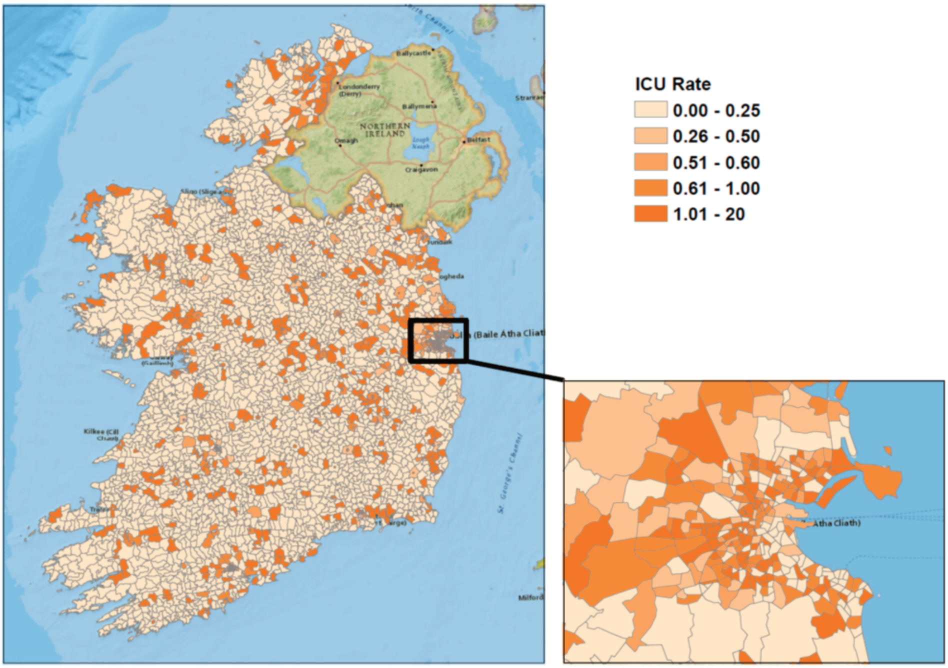
Figure 9 plots ICU admission rates (as a proportion of the infected) against deprivation. A relationship is evident again. Descriptively we see higher rates of ICU admission amongst the COVID-19 infected population in more deprived areas. It is worth noting, however, that the relationship is not as pronounced as was seen in the case of infection rates in Figure 6.

While many ICU admission rates are below 1 per cent, some outliers occur, as can be seen in Figure 10. While deprived areas have the highest ICU admission rates on average, they also have a lower spread. The Marginally Above Average deprivation category (3) has a low average but a large range of values.

4.2 Infection Rate Results

The results of fractional logit models, with COVID-19 infection rates as the dependent variable, are displayed as marginal effects in Table 5. A stepwise

Figure 8: Spatial Distribution of ICU Admission Rates, Electoral Division Level



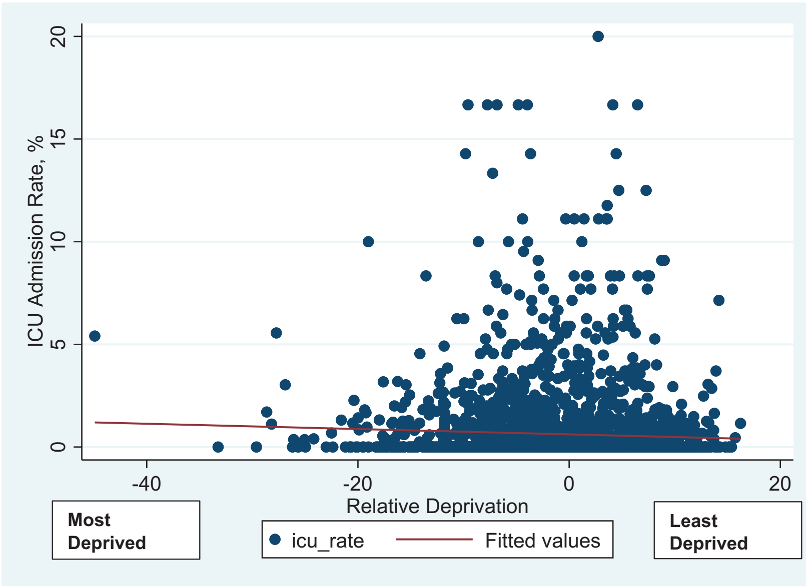
Source: Authors' own using COVID-19 data.
Notes: ICU Admission rates at the ED level are calculated as a proportion of the infected for comparability.

approach is applied to ensure robust models are utilised and to examine how relationships change with the introduction of additional controls. Standard errors are clustered at the area level. We begin by estimating a model which includes only area-level deprivation as a set of independent variables.[6] In this initial specification, we find that infection rates are highest in the most deprived areas. More precisely, the most deprived areas have infection rates 1 percentage point higher than the most affluent areas. This is a considerable magnitude given the mean infection rate is 3.92 per cent. Interestingly, marginally affluent areas have lower infection rates than the most affluent group. The relationship between the four categories of deprivation and infection rates is therefore not linear. For this reason we use deprivation categories rather than a continuous variable i.e. most deprived, below average, above average and least deprived/most affluent.

In the subsequent specifications (Columns 2-5) we add area-level Census controls which are likely to be relevant for COVID-19 infection rates, based on the

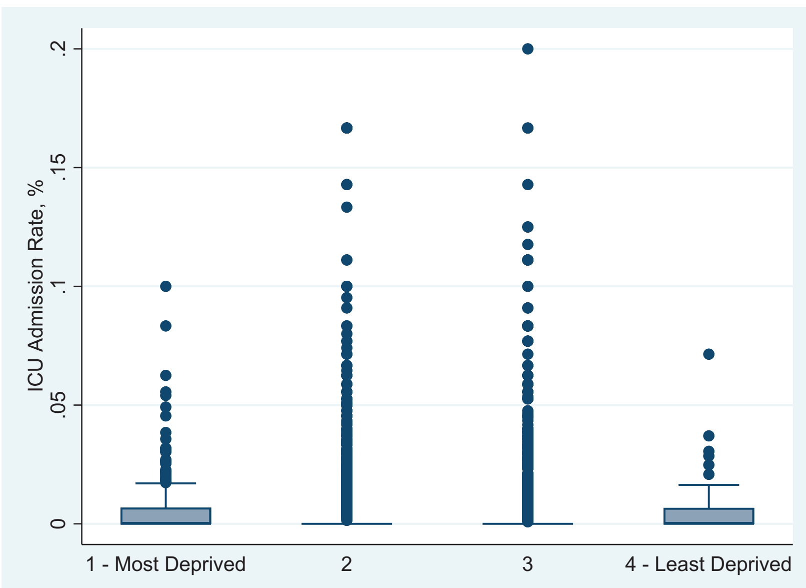
[6] The results are robust to other deprivation categories/cut-offs being used.

Figure 9: Scatterplot of ICU Admission Rate vs Relative Deprivation, Electoral Division Level



Source: Authors' own using COVID-19 data and Pobal HP Deprivation Index.

Figure 10: Boxplot of Area-Level ICU Admission Rate by Deprivation Category



Source: Authors' own using COVID-19 data and Pobal HP Deprivation Index.

existing literature.[7] Areas with higher proportions of Irish Travellers, Black ethnic groups and Asian ethnic groups also have higher COVID-19 infection rates even with deprivation being controlled for. Areas with poorer health also have higher infection rates, albeit at relatively small magnitudes. When these area-level factors are included in the specification, the only statistically significant estimate for the deprivation categories is for the most deprived group which decreased slightly from the first specification, from 0.012 to 0.009 (both significant at the 1 per cent level). The marginally deprived and marginally affluent areas have no statistically significant difference in infection rates relative to the most affluent areas in this specification. In the third specification, the presence of communal establishments in the ED is controlled for, as well as the share of people above 65 years of age in such establishments, and population density. Areas with communal establishments have higher infection rates all else being equal. Areas with higher proportions of people over 65 residing in communal establishments also have higher infection rates. When these variables are added to the model, the relationship between the most deprived small areas and the infection rate increases. It may be that communal establishments are more likely to be located in more affluent areas, therefore its inclusion in our models increases the magnitude of the deprived category.

In the fourth specification, occupational composition of the area is also included. Jobs which are not suitable for working from home or which increase exposure risk may be a potential source of transmission (Albani *et al*., 2022). Including occupational make-up increases the marginal effect of the most deprived group, and the marginally deprived group become statistically significant. In this specification the marginally deprived group have infection rates 0.01 percentage points higher than the most affluent areas. This increase between Models 3 and 4 may be due those in deprived areas disproportionately undertaking occupations more likely to have been shut down with government restrictions. Devlin *et al.* (2025) found that those in deprived areas were more likely to receive Pandemic Unemployment Payment (PUP), reinforcing this potential explanation. The marginal effects for the area-level controls are consistent regardless of whether occupational make-up of the area is controlled for or not. In particular, the relationship between the share of Irish Travellers in an area and the infection rate is consistent in all specifications. Certain occupations have a statistically significant relationship with infection rates, but the results are of small magnitudes. It is, however, worth noting that these occupation categories are broad and can encompass a range of heterogeneous roles, e.g. caring, leisure, and other service occupations. Some of these workers will be deemed essential workers (e.g. carers), while others (e.g. non-essential retail) would have been more susceptible to social

[7] The controls include the share of Irish Travellers, the share of Black people, the share of Asian people, the share of people in bad or very bad health, the share of people over 80 years of age, a binary indicator for the presence of communal establishments, the share of the population that are both over 65 years of age and reside in a communal establishment, population density, and the occupational composition of the area.

Table 5: Area-Level Infection Rates, Fractional Logit Model

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
Deprivation					
1 (Most Deprived)	0.012 ***	0.009 ***	0.013 ***	0.018 ***	0.018 ***
2	–0.001	0.000	0.003	0.007 ***	0.005 **
3	–0.004 ***	–0.002	0.000	0.003	0.003
4 (Least Deprived/ Most Affluent)	Ref	Ref	Ref	Ref	Ref
Additional Area-Level Controls					
Share of Irish Travellers		0.001 **	0.002 ***	0.002 ***	0.002 ***
Share of Black people		0.001 ***	0.000	0.000	0.000 *
Share of Asian people		0.001 ***	0.000 *	0.000	0.000 *
Share of People with Bad or Very Bad Health		0.001 **	0.000	0.001	0.001
Share of People over 80		0.000	–0.000	–0.000 *	–0.000
Communal Establishments Indicator			0.005 ***	0.003 ***	0.003 **
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 ***
Occupation Type (Ref: Managers)					
Professional Occupations				0.000	0
Associate Professional				–0.001 *	–0.000
Administrative				0.001 ***	0.001 ***
Skilled Trades				–0.000 *	–0.000
Caring, Leisure and Other Service				–0.000	–0.000
Sales and Customer Service				0.000	0.000
Process Plant and Machinery				0.000	0.000
Elementary				0.001	0.000
Not Stated				–0.000	–0.000

Table 5: Area-Level Infection Rates, Fractional Logit Model (Contd.)

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
Border					
Non-Border					
Border # Not deprived					0.016 ***
Border # Deprived					0.005
N	3,338	3,338	3,338	3,338	3,338
Pseudo R^2	0.00	0.00	0.01	0.01	0.01

Source: Authors' own using COVID-19 data, Pobal HP Deprivation Index and 2022 Census.
Notes: *** p<0.01, ** p<0.5, * p<0.1. Standard errors are clustered at the area level. Standard errors and confidence intervals are available from the authors on request.

distancing and lockdown measures. This may explain why there are no notable relationships with area-level infection rates. Areas with higher proportions of residents employed in administrative roles relative to the proportion of managers had higher infection rates. This is statistically significant at the 1 per cent level. Associate professional occupations, on the other hand, have a negative relationship with infection rate, although this is only statistically significant at the 10 per cent level.

In a final specification (Column 5), proximity to the border is controlled for by including a border dummy for all counties adjacent to the Northern Ireland (NI) border, interacting with deprivation (most deprived category). We find that non-deprived EDs in border counties had higher COVID-19 infection rates than non-border areas. Taking the results as a whole, the highest rates of infection are found across the country in the most deprived areas and also in non-deprived areas on the border. These findings on border influence have significant policy implications, given pandemic responses in Ireland and Northern Ireland were not well coordinated at the time and restrictions and responses differed considerably at times.

4.3 ICU Admission Rate Results

In this section, we examine the relationship between deprivation and relatively high ICU admission rates. The estimated marginal effects associated with the model outlined in Equation 4 are displayed in Table 6. Again, a stepwise approach is taken. In our initial specification – where the set of deprivation categories are the only independent variables – the only statistically significant result is for the most deprived areas, at approximately 8 percentage points more likely to have high ICU rates than the most affluent areas. However, when we include area-level controls for other socio-demographic factors, the effect dissipates (Column 2).

Areas with higher proportions of Irish Travellers and Black people are associated with higher rates of ICU admission. We find no substantial evidence of any such relationship for areas with larger Asian populations or higher proportions of older people. Potential explanations for the latter group are that we also control for the share of people in poor health and that these two groups are correlated, or that it is health rather than age in and of itself which is the driver. Areas with higher proportions of people who reported being in poor health were more likely to have higher ICU rates. An increase of 10 percentage points in the proportion of people who report being in poor health sees an increase of 0.3 percentage points in the ICU admission rate. While this is a small magnitude, it is relatively large when we consider the average ICU admission rate for EDs across Ireland is 0.62 per cent.

In our third specification, we again add the indicator for presence of a communal establishment in an ED, as well as the proportion of residents over 65 years of age in communal establishments, and population density. This attenuates the deprivation variables further. In this specification, the proportion of Black ethnic minorities variable is no longer statistically significant. This could be due to a relationship between the share of Black people in an area and the presence of communal establishments. More specifically, it may be due to Black people being more likely to be employed in communal establishments. The share of Asian people which was statistically insignificant in the second specification becomes significant (at the 10 per cent level) and negative (-0.006) in this third specification.

Areas with communal establishments have ICU admission rates 0.7 percentage points higher than areas without. Somewhat counterintuitively, areas with higher shares of people who are over 65 and resident in communal establishments have lower ICU admission rates. This may be reflective of the subjectivity associated with being admitted to ICU especially during COVID-19 when there were significant concerns around resource constraints. On a brighter note, it may also be possible that those with COVID-19 in communal establishments such as nursing homes perhaps received better care or were aware of the virus earlier, which may have improved outcomes.

In our final specification, we use the additional health data provided in the COVID-19 dataset, which relate to whether those infected with COVID-19 had underlying clinical conditions (Column 4). It could be the case that high ICU admission rates were driven by higher proportions of people with underlying conditions being adversely impacted to a greater extent (Albani *et al*., 2022). While the estimates suggest that this could be a contributing factor, the magnitude of the coefficient is small (0.005, significant at the 1 per cent level). That said, its inclusion results in a slightly diminished coefficient for the proportion of those in bad/very bad health. This suggests that there are health issues pertinent to COVID-19 severity which may not be captured by the clinical conditions variable. Coefficient estimates for the proportion of the population that are Irish Travellers remain broadly the same under this specification, albeit with diminished statistical significance. These results are robust compared to other cut-offs being used.[8]

4.4 Deprivation and Other Area-Level Characteristics

In our previous specifications, we do not find evidence of a clear relationship between deprivation and high ICU admission rates. However, we identify that other area-level characteristics – the share of Irish Travellers, Black people, and those in bad/very bad health – may explain higher ICU admission rates at the area level. These variables tend to be correlated with area-level deprivation. The scatterplots displayed in Figures 11 to 16 show the relationship between area-level deprivation and the controls included in the models in Table 6.

Area-level deprivation is positively correlated with the share of Irish Travellers (Figure 11), those in bad health (Figure 14), and those aged 80 or over (Figure 15).[9]

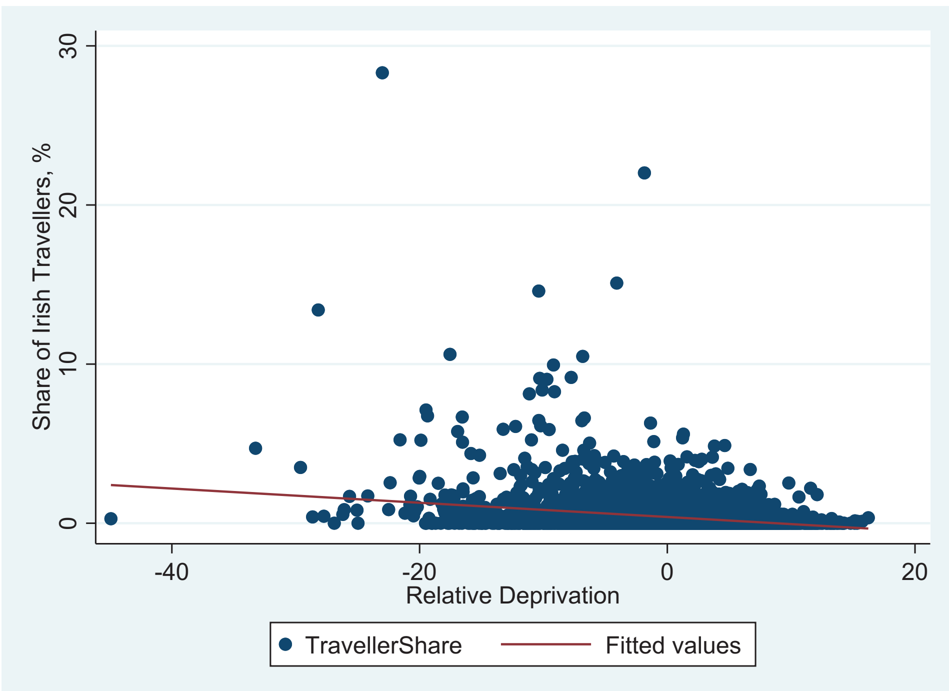
[8] See authors for results using a cut-off of ICU admission rate of more than 2 per cent.

[9] The relative deprivation measure runs from – 44.92 (most deprived) to 16.23 (least deprived/most affluent). Therefore, a variable being positively correlated with deprivation is characterised by a downward-sloping line.

There is also a slightly positive correlative pattern between the share of Black people and area-level deprivation (Figure 12), although the slope of the fitted line is less pronounced. On the other hand, the data exhibit a negative correlative relationship between the proportion of Asian people and relative deprivation (Figure 13). Finally, information on underlying clinical conditions amongst those infected with COVID-19 is plotted against relative deprivation (Figure 16). There is considerable variation in this variable across EDs, although a positive relationship between clinical conditions and area-level deprivation is apparent in the trendline, with more deprived areas having higher proportions of infected people reporting underlying clinical conditions.

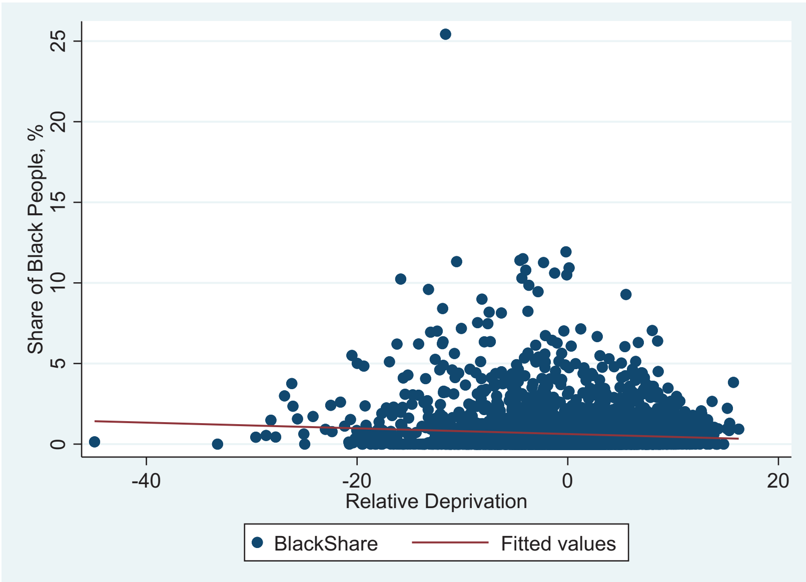
While area-level deprivation itself is not related to ICU admission rates when controlling for these area-level characteristics, deprivation appears to exhibit a relationship with those variables that are related to ICU admission rates. This gives us tentative grounds to believe that these characteristics play a mediating role in determining high ICU admission rates at the area level.

Figure 11: Scatterplot of Relative Deprivation vs Proportion of Irish Travellers



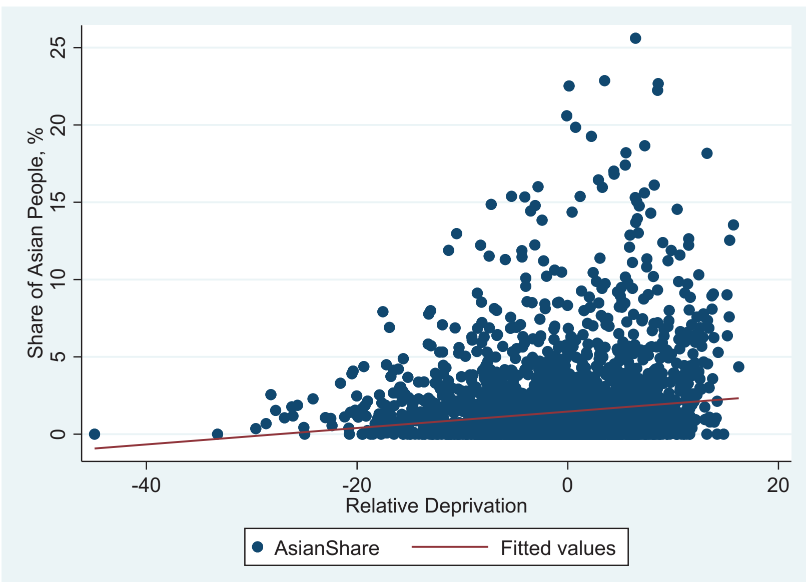
Source: Authors' own using Pobal HP Deprivation Index and 2022 Census.

Figure 12: Scatterplot of Relative Deprivation vs Proportion of Black People



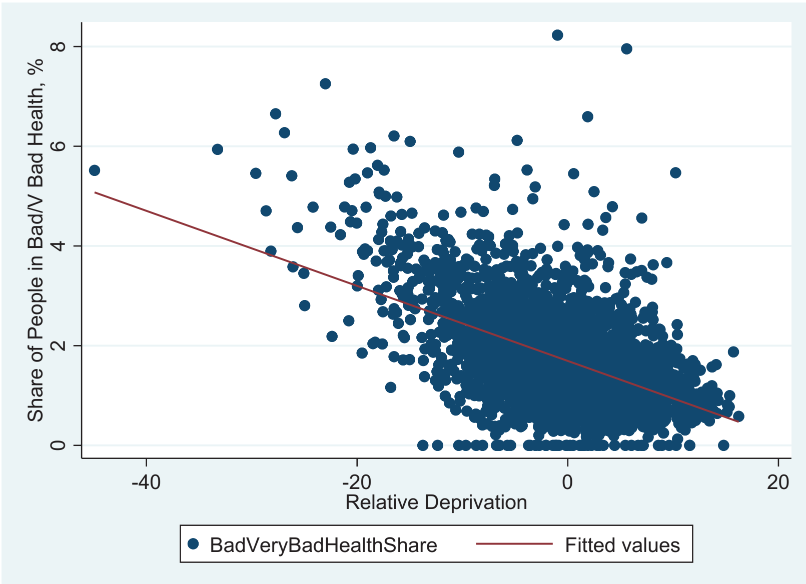
Source: Authors' own using Pobal HP Deprivation Index and 2022 Census.

Figure 13: Scatterplot of Relative Deprivation vs Proportion of Asian People



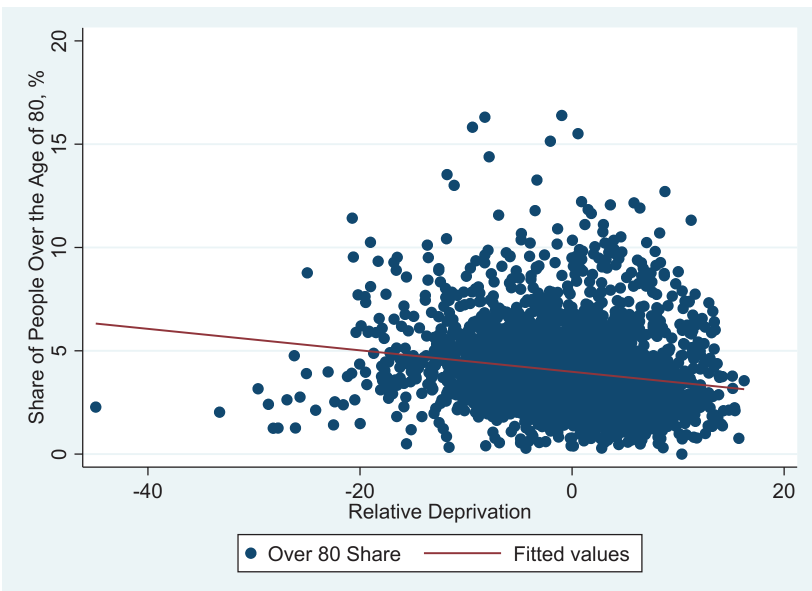
Source: Authors' own using Pobal HP Deprivation Index and 2022 Census.

Figure 14: Scatterplot of Relative Deprivation vs People in Bad/Very Bad Health



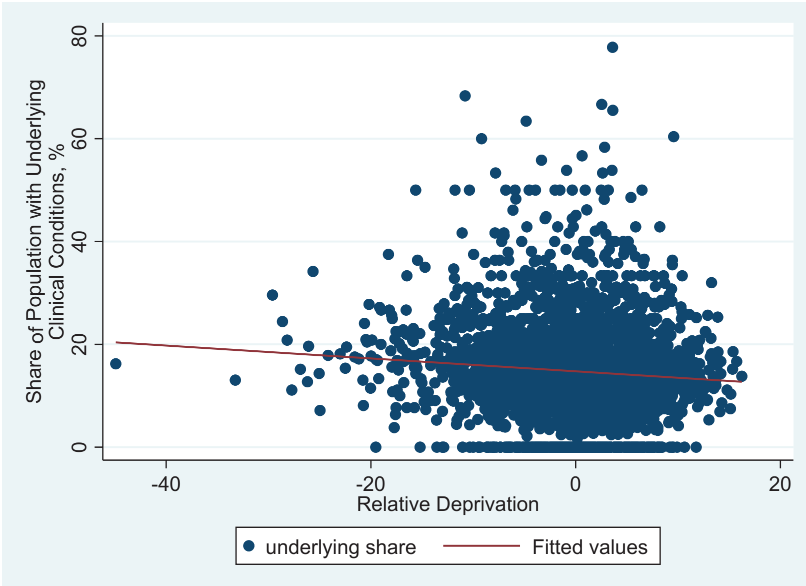
Source: Authors' own using Pobal HP Deprivation Index and 2022 Census.

Figure 15: Scatterplot of Relative Deprivation vs Proportion of People Aged 80+



Source: Authors' own using Pobal HP Deprivation Index and 2022 Census.

Figure 16: Scatterplot of Relative Deprivation vs Share With Underlying Clinical Conditions



Source: Authors' own using Pobal HP Deprivation Index and COVID-19 data.

V CONCLUSIONS

COVID-19 has been well documented globally to have excessively impacted the already disadvantaged in our societies. This disparate impact has been seen across both economic and health outcomes. As such we set out herein to examine if this holds in the Irish context, and to what extent. The average COVID-19 infection rate across EDs in Ireland varied considerably from 5.6 per cent in the most deprived EDs to 3.7 per cent in the most affluent EDs. Thus, descriptively we can already see that more deprived areas in Ireland experienced higher rates of infection. This is confirmed by our formal modelling. More specifically, when we control for other area-level characteristics such as age structure, presence of minority communities and health of the area, we still find infection rates to be higher in the most deprived areas in Ireland. In fact, after controlling for these other factors, the most deprived EDs had infection rates about a third higher than the most affluent areas. In terms of these other area-level factors, infection rates were also higher in areas with higher proportions of Irish Travellers, in areas with communal establishments (e.g. nursing homes, prisons, direct provision centres), and in areas with higher proportions of residents over 65 and living in communal establishments.

Additionally, we find that infection rates were also higher in non-deprived areas close to the border with Northern Ireland. This finding is robust to several definitions of border areas (all counties that touch the border, areas 20 miles from the border, and all areas within ten miles of the border). Whether or not there should have been increased all-island cooperation during the pandemic was a contentious subject at the time and, like many things in Northern Ireland, it became polarised. Our findings however suggest that border areas could have benefited from a targeted policy response, with due regard given to the porous nature of the land border and the interconnectedness across the jurisdictions for those who live close to the border.

In terms of the ICU admission, we found no direct evidence of a relationship between area-level deprivation and ICU admission rates. However, we believe that deprivation may have an indirect impact as we consistently see higher ICU admission rates in areas with higher shares of ethnic minority groups, in areas with communal establishments, and in areas with higher proportions of individuals with underlying health conditions. These likely reflect pre-existing health inequalities experienced by more deprived communities.

Area-level examination of ICU admission rates is important as ICU admission during a pandemic requires a significant use of limited resources at a time when they are under particular pressure. Moreover, those who ended up in ICU with a COVID-19 infection may be more likely to have longer-term implications, of which some would have implications for healthcare provision and planning now and into the future, given the increasing literature and awareness of long COVID.

Unfortunately, it is expected that pandemics will become more frequent in the future (Marani *et al*., 2021); thus learning what we can from COVID-19 is particularly important. The findings in this report point to a need for future pandemic planning to account for spatial inequalities. And more specifically, there would be benefit from accounting for pre-existing health inequalities in Ireland amongst minority communities, especially Irish Travellers.

We also found in taking a stepwise approach to our model specifications that there were higher infection rates in areas with higher shares of Black people or higher shares of Asian people, before communal establishments were controlled for. Upon adding controls for communal establishments, these ethnic minority variables became statistically insignificant which may point to specific implications. It may be that these minority groups are disproportionately likely to work within communal establishments, e.g. in healthcare or other caring roles, and thus had increased exposure to the virus; or that ethnic minorities are more likely to reside in certain communal establishments and therefore social distancing and isolating in response to the pandemic is more challenging (Irish Refugee Council, 2020). This has also been found to be the case in other international contexts.

Overall, this work has significant policy implications for Ireland as COVID-19 (while no longer considered a pandemic) persists in circulation amongst the population. The international literature suggests that the relationship between deprivation and COVID-19 health outcomes increased as the pandemic progressed, with deprived areas and those living in poverty being disproportionately impacted

(Meurisse *et al.,* 2022; Gullón *et al*., 2022). Thus, the findings here may be a lower bound. The findings also have significant implications for pandemic and healthcare planning as we move forward.

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