

Socioeconomic Deprivation and Pertussis Incidence in Dublin and Midlands

C. Murray^{1,2}, S. Fennessy¹, D. McGlacken-Byrne^{1,2}, M. Ward¹, U. Fallon¹, R. Hurley O'Dwyer^{1,2}.

1. Department of Public Health, HSE Dublin and Midlands, Ireland.
2. Department of Public Health and Primary Care, School of Medicine, Trinity College Dublin, College Green, Dublin 2, Ireland.

Abstract

Aims

Pertussis incidence increased substantially in Ireland in 2024. This study examined the relationship between pertussis incidence and area-level socioeconomic deprivation in the HSE Dublin and Midlands region in 2024.

Methods

All 121 confirmed cases in the HSE Dublin and Midlands region in 2024 were collated, alongside demographic and clinical information. Each case was assigned the deprivation score of its residential Small Area using the Pobal HP Deprivation Index. Denominator population data from Health Atlas were used to calculate cumulative incidence and Poisson regression was used to assess the association with deprivation.

Results

Incidence rose from 1.2 cases per 100,000 in the most affluent areas to 15.4 cases per 100,000 in the most deprived. Every one-step increase in deprivation category was associated with a 16% increase in pertussis incidence (IRR 1.16, 95% CI 1.03–1.31, $p = 0.016$). Pairwise comparisons showed that deprived areas had a pertussis incidence up to 13 times higher than in the most affluent communities.

Discussion

Pertussis incidence increased progressively with area-level socioeconomic deprivation, with the highest incidence observed in the most disadvantaged communities. These results highlight major inequalities in pertussis burden and show the need for targeted vaccination campaigns in deprived areas.

Introduction

Pertussis is a highly infectious respiratory disease, affecting primarily infants and young children, that is largely prevented through routine childhood and maternal vaccination^{1,2}. In Ireland, there was a pronounced increase in pertussis notifications in 2024, with pertussis incidence almost 40-fold higher than the previous year. Even accounting for the cyclical pattern of pertussis infection², with periods of increased incidence generally occurring every three to five years, incidence in 2024 was approximately threefold higher than during the previous surge in 2017³. While the magnitude of this resurgence is unexplained, decreased circulation of *Bordetella pertussis* during the COVID-19 pandemic may have resulted in a decline in population immunity to this infection⁴.

In recent years, national uptake of routine childhood vaccines, including those that protect against pertussis, has remained consistently below the 95% level needed for herd immunity⁵. Similarly, uptake of the maternal pertussis vaccine during pregnancy, which helps protect newborns in their first weeks of life, is markedly low. While recent national data on maternal pertussis vaccine uptake in Ireland are limited, in 2018, a market research study by the HPSC showed that only 48.7% of women interviewed reported having received the vaccine during pregnancy⁶. Although pertussis vaccination is recommended and available free of charge to all pregnant women in Ireland, there is currently no dedicated national maternal pertussis vaccination programme comparable to the organised childhood and school immunisation programmes.

Previous Irish research has shown that children from socioeconomically disadvantaged families are both less likely to be fully vaccinated and that they carry a disproportionate burden of infectious disease⁷. The specific association between pertussis incidence and socioeconomic deprivation in Ireland, however, remains unclear.

This study explored the relationship between area-level socioeconomic deprivation and pertussis incidence across the HSE Dublin and Midlands region in 2024. It aimed to assess whether communities experiencing greater socioeconomic disadvantage were disproportionately affected by the disease.

Methods

This was a cross-sectional ecological study using data from the HSE Dublin and Midlands region of Ireland, which covers the counties of Kildare, Laois, Offaly, Westmeath, and Longford, together with parts of Dublin and Wicklow. All confirmed pertussis cases notified during 2024 in the region were included in the analysis. The study examined whether pertussis

incidence varied according to levels of area-based socioeconomic deprivation across the region.

A list of confirmed pertussis case notifications from 2024 was obtained from the Department of Public Health, HSE Dublin and Midlands surveillance database. For each case, demographic (age and sex) and clinical (hospitalisation status) information was recorded. Each case was geocoded to its residential Small Area (SA) and assigned the corresponding Pobal HP Deprivation Index score, which categorises areas from most affluent to most deprived based on census-derived socioeconomic indicators⁸.

Denominator population data for each Small Area were obtained from Health Atlas Ireland, using 2022 Census population figures⁹.

The primary exposure variable was area-level socioeconomic deprivation, expressed as a four-band categorical variable (extremely and very affluent; affluent and marginally above average; marginally below average and disadvantaged; very disadvantaged and extremely disadvantaged). The primary outcome utilised crude cumulative pertussis incidence per 100,000 population within each deprivation category.

Crude cumulative incidence rates were calculated using case counts and corresponding population denominators for each area-level deprivation category. Population denominators were derived from Small Area census populations and incidence was expressed per 100,000 population.

Associations between deprivation and pertussis incidence were analysed using Poisson regression. The natural logarithm of the Small Area population was included as an offset term to model incidence rates. Socioeconomic deprivation was examined both as an ordinal variable using the full eight-category Pobal HP Deprivation Index to assess linear trends and as a four-band categorical variable to facilitate interpretation and presentation of incidence gradients. Incidence Rate Ratios (IRRs) and 95% confidence intervals (CIs) were reported. Statistical significance was defined as $p < 0.05$.

All incidence modelling and regression analyses were conducted in R. Model fit was assessed by testing for overdispersion using the Pearson dispersion statistic. Where mild overdispersion was identified, sensitivity analyses were performed using both negative binomial regression and Poisson regression with robust standard errors to assess the stability of the findings. Model fit was also evaluated by comparing models that treated deprivation as a linear trend with models that included deprivation as a categorical variable, using likelihood ratio testing.

This study entailed secondary analysis of anonymised surveillance data collected as part of statutory infectious disease notification under the Infectious Diseases Regulations 1981 (as amended). No identifiable personal data were used. The project was conducted under the HSE

Department of Public Health's service evaluation remit and was therefore exempt from full research ethics committee review, in line with HSE and National Office for Research Ethics Committees guidance.

Results

Demographics and clinical characteristics

A total of 121 confirmed pertussis cases were reported in the HSE Dublin and Midlands region during 2024. Of the 121 confirmed cases, 68 (56%) were female and 53 (44%) male. The median age of cases was 2 years old (IQR: 0.5-11 years). Hospitalisation was strongly associated with age ($p < 0.0001$, Fisher's exact test). Infants aged <1 year had the highest hospitalisation rate (27/40 cases, 68%). No adults aged ≥ 18 years required hospitalisation. Overall, 40 of 121 cases (33%) were hospitalised.

Socioeconomic deprivation and disease incidence

Socioeconomic deprivation was analysed as both an ordinal exposure using the full eight-category Pobal HP Deprivation Index and as a four-band categorical variable to characterise incidence gradients.

Incidence patterns

Pertussis incidence increased steadily with increasing area-level socioeconomic deprivation. When deprivation was analysed using the full eight-category index, each one-category increase in deprivation status was associated with a 16% higher incidence rate (Incidence Rate Ratio [IRR] 1.16; 95% CI 1.03-1.31; $p=0.016$).

When grouped into four broader deprivation bands, crude cumulative incidence ranged from 1.2 per 100,000 population (95% CI 0.03-6.49) in the most affluent areas to 15.4 per 100,000 (95% CI 8.65-25.5) in the most deprived areas (Table 1; Figure 1). Compared with the most affluent group, incidence was between nine- and thirteen-fold higher in more deprived areas, although confidence intervals were wide due to very low case numbers in the most affluent category (Table 2; Figure 2). These findings demonstrate a clear socioeconomic gradient in pertussis incidence in the Dublin and Midlands region in 2024.

Table 1

Deprivation band	Incidence per 100,000 (95% CI)
Q1 (Extremely + Very affluent)	1.2 (0.03–6.49)
Q2 (Affluent + Marginally above average)	10.8 (8.02–14.2)
Q3 (Marginally below average + Disadvantaged)	12.8 (9.63–16.7)
Q4 (Very disadvantaged + Extremely disadvantaged)	15.4 (8.65–25.5)

Table 2

Comparison (vs Q1)	IRR (95% CI)
Q2 vs Q1	9.24 (2.0–164)
Q3 vs Q1	10.99 (2.4–194)
Q4 vs Q1	13.25 (2.7–240)

Figure 1

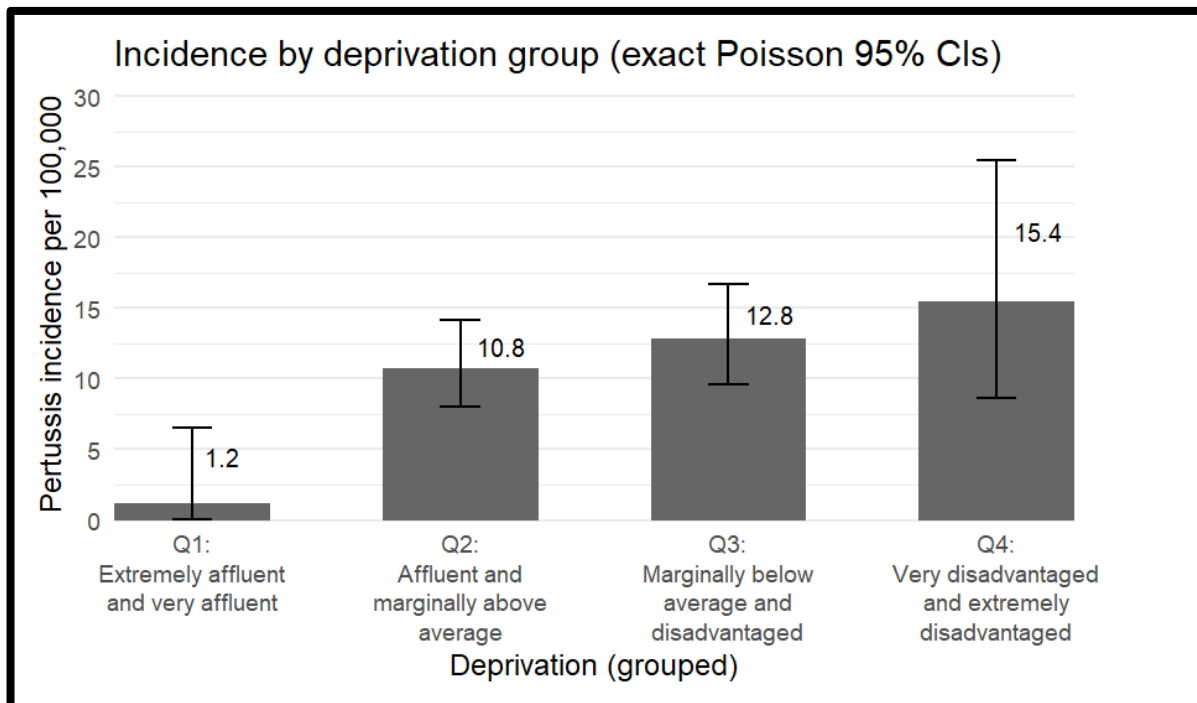
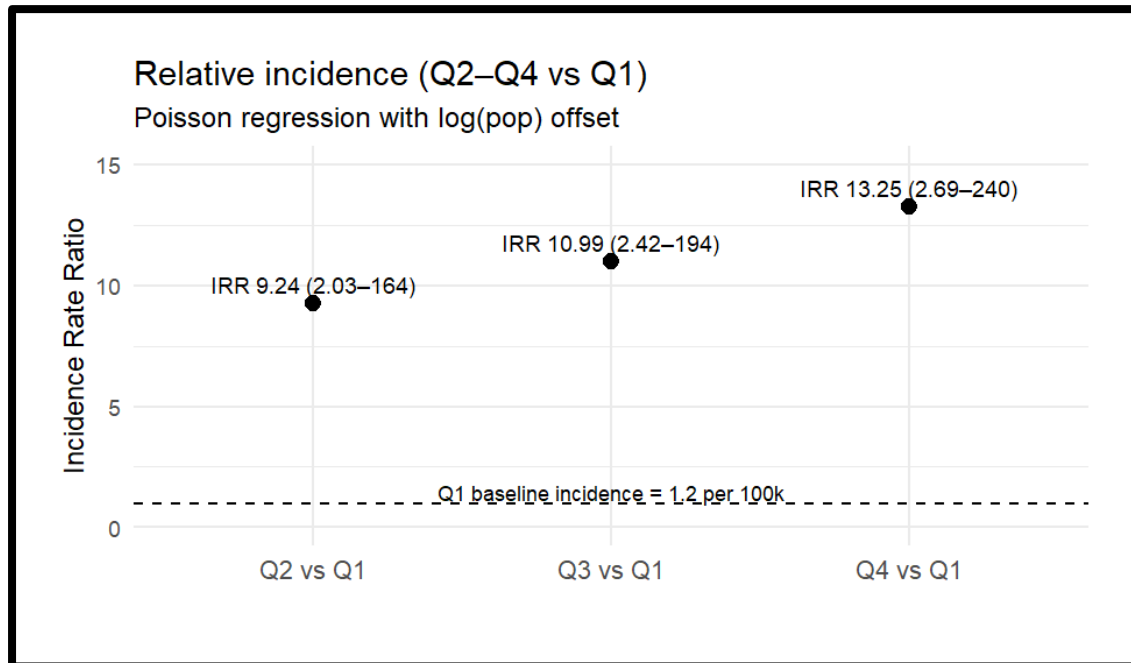


Figure 2



Sensitivity analyses and model diagnostics

Model fit testing showed only mild overdispersion (Pearson dispersion statistic = 1.43). Effect estimates were robust across sensitivity analyses, including negative binomial regression and Poisson regression with robust standard errors. All models produced a consistent IRR of approximately 1.16 per deprivation category.

A likelihood ratio test comparing a linear trend model with a fully categorical deprivation model showed no strong evidence of departure from linearity ($p \approx 0.06$).

Discussion

During the resurgence in pertussis cases noted in Ireland in 2024, individuals living in more deprived areas of the HSE Dublin and Midlands region experienced a significantly higher incidence of pertussis infection than those living in more affluent areas. This study illustrates a clear socioeconomic gradient across communities, with incidence increasing in parallel with worsening area-level deprivation status.

Numerous factors may contribute to the pattern observed. Previous studies have demonstrated that there is a marked socioeconomic gradient in childhood vaccination in

Ireland, with children from poorer households less likely to have received their full complement of routine childhood immunisations than their wealthier peers⁷. This inequality leaves deprived populations more susceptible to vaccine-preventable diseases such as pertussis. Furthermore, infants in deprived areas may be more likely to have underlying health conditions and poorer nutritional status than those in wealthier communities, again increasing vulnerability to infectious disease. Overcrowded housing may also facilitate the transmission of respiratory pathogens such as pertussis, particularly when infants or young children are not vaccinated¹⁰. Poor uptake of the pertussis vaccines in older generations may also be a contributing factor, particularly given that pertussis cases are often undiagnosed in adults¹¹.

The study also demonstrates the utility of the Pobal HP Deprivation Index in identifying populations at higher risk of disease. However, several limitations should be acknowledged. The Index is derived from 2022 Irish census data and thus may not fully reflect socioeconomic conditions in Ireland in 2024. And while “Small Areas”, comprising 50–120 households, offer greater granularity than larger electoral divisions, ecological fallacy remains a potential concern. In other words, associations observed at the area level do not reflect individual risk, given that individual socioeconomic circumstances do not always align with area-level measures. Furthermore, socioeconomic status is inferred from census-based indicators, including educational attainment and employment status, rather than direct measures of income or wealth. This may result in some misclassification of deprivation.

Several additional limitations relate to sample size, population structure and case ascertainment. The analysis was based on 121 confirmed cases from a single calendar year. This resulted in imprecise estimates in some deprivation strata, particularly the most affluent category. Furthermore, the incidence estimates were crude and did not account for potential differences in population age structure between deprivation categories. This is particularly relevant given the young age distribution of cases in this study, with a median age of two years and the recognised underdiagnosis of pertussis among adults. If population age structures differ systematically by deprivation level, some of the observed association could therefore reflect differences in age distribution. Future studies with larger case numbers and age-specific population denominators could examine age-standardised incidence and determine whether the observed gradient persists across different pertussis cycles.

Potential confounders must also be acknowledged. Most importantly, localised outbreak clusters are likely to have influenced observed incidence patterns. Spatial clustering may therefore have inflated the deprivation gradient observed. Differences in case ascertainment may also have affected the observed gradient. Pertussis testing can be undertaken in both general practice and hospital settings. However, socioeconomic differences in healthcare-seeking behaviour including access to primary care, clinician testing practices and thresholds

for investigation may influence the probability that pertussis infection is diagnosed and notified. Nevertheless, the consistency of the gradient across multiple analyses supports a meaningful relationship between deprivation and pertussis incidence.

From a public health perspective, the results of this study suggest that future pertussis control measures in Ireland should place particular emphasis on reducing barriers to vaccination and primary care in deprived communities. Targeted efforts to improve uptake of routine childhood and maternal pertussis vaccination, alongside promotion of existing school-based booster programmes, could help reduce inequalities in disease burden. Improving access to GP care is also important in facilitating timely vaccination, diagnosis and treatment. These healthcare measures should be complemented by attention to wider structural determinants, including housing.

In conclusion, area-level socioeconomic deprivation was associated with higher pertussis incidence in the HSE Dublin and Midlands region during the 2024 resurgence. Reducing inequalities in pertussis burden will require targeted efforts to improve vaccination uptake and access to primary care in deprived communities, while also addressing household overcrowding and other structural conditions that may facilitate transmission.

Declarations of Conflicts of Interest:

None declared.

Corresponding Author:

Ralph Hurley O'Dwyer,
Department of Public Health and Primary Care,
School of Medicine,
Trinity College Dublin,
College Green,
Dublin 2,
Ireland.

E-Mail: hurleyor@tcd.ie

References:

1. Pertussis vaccines: WHO position paper, August 2015—Recommendations. *Vaccine*. 2016;34:1423–5. doi:10.1016/j.vaccine.2015.10.136

2. Cherry JD. Epidemiological, clinical, and laboratory aspects of pertussis in adults. Clin Infect Dis Off Publ Infect Dis Soc Am. 1999;28 Suppl 2:S112-117. doi:10.1086/515058 PubMed PMID: 10447028.
3. HSE Health Protection Surveillance Centre. Infectious Disease Notifications in Ireland, 2020 - 2024. Dublin, Ireland; 2025.
4. Gorringer A, Cavell B, Beard F, Tsukada K, Otsuka N, Fu P, et al. Global Incidence of Pertussis After the COVID-19 Pandemic. JAMA Netw Open. 2025;8:e2545963. doi:10.1001/jamanetworkopen.2025.45963 PubMed PMID: 41324955.
5. HSE Health Protection Surveillance Centre. Vaccine uptake in junior infants and children aged 4-5 years in Ireland, 2022/2023. 2024.
6. The Medical Independent. Less than 50% uptake of pertussis vaccine among pregnant women [Internet]. 2018. Available from: <https://www.medicalindependent.ie/in-the-news/breaking-news/less-than-50-uptake-of-pertussis-vaccine-among-pregnant-women/>
7. Doherty E, Walsh B, O'Neill C. Decomposing socioeconomic inequality in child vaccination: Results from Ireland. Vaccine. 2014;32:3438-44. doi:10.1016/j.vaccine.2014.03.084
8. HP Pobal Deprivation Index [Internet]. 2022. Available from: data.pobal.ie
9. Health Atlas Ireland [Internet]. Available from: www.healthatlasireland.ie
10. Grant CC, Roberts M, Scragg R, Stewart J, Lennon D, Kivell D, et al. Delayed immunisation and risk of pertussis in infants: unmatched case-control study. BMJ. 2003;326:852-3. doi:10.1136/bmj.326.7394.852 PubMed PMID: 12702617; PubMed Central PMCID: PMC153471.
11. National Immunisation Advisory Committee (NIAC). Immunisation Guidelines for Ireland: Chapter 15 – Pertussis. 2016.