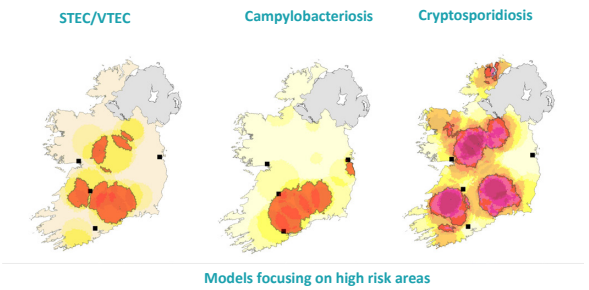

Models focusing on high risk areas

epa Research

Report No. 474

STEP_WISE: Spatiotemporal Epidemiology of Primary Waterborne Infections – *Cryptosporidium* and VTEC

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Identifying pressures

Ireland regularly reports the highest annual crude incidence of verotoxin-producing Escherichia coli (VTEC) enteritis and cryptosporidiosis in Europe, with notified crude incidence rates typically 5–10 times the European average. Short-term hydrometeorological conditions, elevated levels of pastoral agriculture and high reliance on septic tanks and private domestic groundwater sources have long been acknowledged as drivers of the transmission of infectious waterborne diseases. In addition, extreme weather events, including flooding, have been identified as the source of numerous outbreaks. Recent forecasts indicate that Ireland is particularly likely to experience significant hydrometeorological pattern changes due to global warming, with a 2–3°C increase in average temperature expected by 2100, in concurrence with higher winter rainfall, significantly drier summers and an increased frequency of extreme weather events. These changes are likely to increase the incidence of environmentally acquired, and particularly waterborne, infections across the country. However, to date, no study has sought to investigate the concurrent influence of shifting socioeconomic, environmental, meteorological and infrastructural profiles on these infections in Ireland. The STEP_WISE project seeks to address this knowledge gap by increasing current scientific understanding of the spatiotemporal mechanisms associated with waterborne VTEC enteritis and cryptosporidiosis in Ireland, and translate findings into enhanced environmental, infrastructural and healthcare policies.

Informing policy

Recent estimates suggest the annual cost of gastroenteric infection in Ireland surpasses €150 million, with VTEC infection and cryptosporidiosis the most frequently reported bacterial and protozoan infections, respectively. Transmission sources, pathways and source–pathway interactions associated with both infections in Ireland are multifaceted, resulting in a complex exposure profile. Sporadic cases of infection are inherently difficult to attribute to specific risk factors for reasons that include the absence of accurate date-of-onset data, underreporting, misdiagnosis, myriad potential exposures and surveillance limitations. The high proportion of sporadic infections relative to total annual cases in Ireland, and their association with environmental exposures, has made the spatiotemporal occurrence of VTEC and cryptosporidiosis particularly important in public health. Moreover, a notable urban–rural divide exists with respect to the prevalence, frequency and severity of both infections, with the burden of disease disproportionately borne by rural communities, placing a significant strain on public health infrastructure in Ireland. Similarly, the burden of both infections is markedly more prevalent among young children (< 5 years) and older people (> 65 years), leading to reduced productivity and increased economic burden among caregivers and the Health Service Executive.

National, regional and local planning and investment decisions pertaining to healthcare, infrastructure and climate resilience must be based on robust scientific evidence, and must account for the characteristic spatiotemporal diversity of Ireland.

Developing solutions

The STEP_WISE project investigated spatiotemporal patterns of laboratory-confirmed primary cases of VTEC enteritis and cryptosporidiosis in Ireland using, and subsequently developing, multiple statistical tools. Three analytical approaches were employed, as follows:

1. Focusing on "event based" meteorological impacts on infection, the STEP_WISE project focused on a 6-week period in November and December 2015, when a series of Atlantic storms caused widespread pluvial and fluvial flooding. An ensemble of statistical and time-series analyses were used to quantify the influence of flood hydrometeorology on the incidence of confirmed infections. Excess cases of VTEC enteritis were geographically associated with the midlands, while cryptosporidiosis clusters were widespread. Models showed a clear association between rainfall, surface water discharge, groundwater levels and infection incidence, with lagged associations from 16 to 20 weeks particularly strong. All three hydrometeorological variables were associated with the increase in cryptosporidiosis during April 2016, while only surface water discharge was associated with VTEC enteritis.
2. Random forest classification was used to identify associations between individual components of a national deprivation index and spatially aggregated cases of VTEC enteritis and cryptosporidiosis. VTEC incidence was (negatively) associated with mean number of persons per room and percentage of local authority housing in both urban and rural areas, in addition to lower levels of educational attainment in rural areas, while lower unemployment rates were associated with both infections, irrespective of settlement type. Lower levels of third-level education were associated with cryptosporidiosis in rural areas only.
3. Entirely novel "space–time cluster recurrence" indices and a decompositional clustering approach were developed for the study of waterborne infections, with recurrent clusters of both infections identified in three distinct geographical regions in the west and mid-west, all primarily rural, and characterised by high reliance on private groundwater sources and on-site domestic wastewater treatment systems.

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