

ORIGINAL ARTICLES

Urban and Rural Risks of Lyme Disease in the Scottish Highlands

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Abstract

Background

This paper investigates the pattern of Lyme disease testing and infection within the Highland region of Scotland.

Methods

Data from all Highland samples tested during 2004-2006 were analysed according to result and patient's residence in relation to the eight fold Scottish Executive's urban/rural classification, and distance from woodland.

Results

In total, 1602 patients were tested for Lyme disease, 0.71% of the Highland population. From these, 104 (6.5%) were seropositive. There were more patients tested, and seropositive patients from rural than urban locations, 1113 vs 489, and 79 vs 25 respectively. There were also significantly more seropositive patients per patients tested from rural locations (χ^2 , $p < 0.0001$). The number of patients tested and seropositive patients increased as the rural areas become more remote. The likelihood of being tested for Lyme disease also increased as the distance between a patient's residence and woodland decreased. The relative risk of being tested elevated by 74% for those patients living within 200 metres of woodland.

Conclusions

Those living in the most rural areas of Highland and those living closest to woodland have an increased risk of being tested and having Lyme disease.

Key Words

Lyme disease, Scottish Highlands, Risks, Woodland, Rural

Introduction

Lyme disease is considered to be endemic in the Highlands of Scotland.¹ Although we test samples from all of Scotland for Lyme disease, 50% of samples tested are from the Highlands. There has been a large increase in Scotland's tick population in recent years.² As a consequence, there may be more human

cases of Lyme disease due to tick-borne *Borrelia burgdorferi* infection. The number of cases of Lyme disease in Scotland reported to Health Protection Scotland rose from 56 in 2004 to 130 in 2006.^{3,4}

The risk of acquiring Lyme disease has been associated with tick infection rates, tick population dynamics and human behaviour.^{5,6,7} The sheep tick (*Ixodes ricinus*) is the vector of *B. burgdorferi* infection in Scotland.² Its population dynamics are determined by a complex interaction of climate, soil type, vegetation type and density of animal host vectors.⁶ Ticks tend to be abundant in shaded areas with high precipitation such as long grass/scrub/woodland that have dense populations of birds, small and large animals to feed on.^{2,6} Our aim was to determine who were tested for Lyme disease and those with the highest risk of developing the illness.

Methods

Data from all Highland samples tested for Lyme disease by the National Lyme disease testing service at Raigmore Hospital, Inverness from April 2004 to March 2006 were analysed. Result category and patients' postcodes were determined. All samples were screened using a *B. burgdorferi* total antibody enzyme-linked immunoassay (EIA) (Zeus). EIA equivocal/positive samples were confirmed using an in-house *B. burgdorferi* IgG Western blot.⁸ EIA negative samples with clinical information suggestive of Lyme disease (e.g. erythema migrans) were also tested by Western blot. Samples that were Western blot positive were classed as seropositive. Using the Scottish Executive's eight fold urban/rural classification⁹ (Table 1) and a bespoke Geographical Information System, it was possible to assign each patient's postcode to either urban or rural. Similarly, it was possible to determine the distance, in metres, between each patient's postcode and the nearest area of woodland or forest using Ordnance Survey forest data.

Table 1: Scottish Executive Urban Rural Classification 2003-2004 (8-fold)⁸

1 Large Urban Areas	Settlements of over 125,000 people.
2 Other Urban Areas	Settlements of 10,000 to 125,000 people.
3 Accessible Small Towns	Settlements of between 3,000 and 10,000 people and within 30 minutes drive of a settlement of 10,000 or more.
4 Remote Small Towns	Settlements of between 3,000 and 10,000 people and with a drive time of between 30 and 60 minutes to a settlement of 10,000 or more.
5 Very Remote Small Towns	Settlements of between 3,000 and 10,000 people and with a drive time of over 60 minutes to a settlement of 10,000 or more.
6 Accessible Rural	Settlements of less than 3,000 people and within 30 minutes drive of a settlement of 10,000 or more.
7 Remote Rural	Settlements of less than 3,000 people and with a drive time of between 30 and 60 minutes to a settlement of 10,000 or more.
8 Very Remote Rural	Settlements of less than 3,000 people and with a drive time of over 60 minutes to a settlement of 10,000 or more.

With an appropriate population denominator, analysis by urban/rural and proximity to woodland was undertaken. The population denominator used was the Community Health Index (CHI), which contains details of all residents of Scotland registered with a General Practitioner and provides the unique patient identifier used throughout Scotland. Data was analysed using the χ^2 test for significance, and the calculation of relative risk. Relative risk is the ratio of the disease rate in exposed persons to that of people who are unexposed.¹⁰ A score of 100 suggests no added risk, a score of 150 suggests 50% more risk.

Results

Samples from 1602 patients residing in Highland were sent for Lyme disease testing from April 2004 to March 2006. The Highland CHI population was 225,519, meaning that 0.71% of the Highland population were tested during this period. Of the patients tested, 6.5% (104) were seropositive. When the Scottish Executive's extended eight fold urban/rural classification was applied to this population (Table II) there were no large urban areas (class 1). Inverness City was the only area classed as 2, whereas Nairn, Culloden, Smithton, Dingwall were classed as 3. Tain, Invergordon, Alness were all area 4 and Thurso, Wick and Fort William area 5. All other areas were in classes 6, 7 and 8. The classification designates areas within classes 1-5 as urban, and 6-8 as rural. There were more patients tested from rural locations than urban locations, 1113 (classes 6-8) vs 489 (classes 2-5) (Table II).

Table II – Comparison of the urban/ rural distribution of Highland residents (CHI population), patients tested and seropositive patients from 2004-2006.

Urban rural classification	CHI population	No. patients tested	No. seropositive patients	% seropositive patients
2	47492	223	14	6.3
3	22210	51	2	7.8
4	13595	130	6	4.6
5	25685	85	3	3.5
6	34994	263	17	6.5
7	24015	313	29	9.3
8	57528	537	33	6.1
Total	225519	1602	104	6.5

There were also more seropositive patients from rural locations, 79 vs 25, and significantly more seropositive patients per patients tested from rural locations (χ^2 , $p < 0.0001$) (Table II). Figures I and II demonstrate the urban/rural distribution of the seronegative and seropositive patients with the Highland population. The urban distribution patterns of the seronegative and seropositive patients were very similar for populations in classes 2-5. However, the proportion of seronegative and seropositive patients increased disproportionately to the population as the classes became more rural from 6 to 8.

Table III uses relative risk to show the cumulative difference between the total population of Highland and residents of the study population living in Highland by distance from woodland. Whilst 35% of the Highland population live within 700 metres of woodland (i.e. 65% live beyond 700 metres), 50% of the study population were within 700 metres of woodland. This table shows that the relative risk of being tested for Lyme disease is 141% higher if residency is within 700 metres of woodland compared with the total population. This likelihood increases as the distance between residency and woodland decreases with the relative risk of being tested rising to 174% if one's place of residence is within 200 metres of woodland (Table III).

Table III – Difference between Highland population (CHI population) and study population (patients tested) in relation to distance of residence from woodland.

Distance from woodland	Cumulative CHI population	Cumulative study population	% CHI population	% study population	% Risk
200 metres	26814	334	12%	21%	174%
300 metres	39034	469	17%	29%	168%
400 metres	50228	568	22%	35%	158%
500 metres	60774	658	27%	41%	151%
600 metres	70303	738	31%	46%	146%
700 metres	78938	800	35%	50%	141%
Total populations	225519	1602			

Discussion

Exposure to ticks is much greater in the Highlands than the rest of Scotland and therefore the pattern of testing is important.¹¹ The rural areas of Highland had significantly more seropositive patients than urban areas, and seropositivity increased as the area became more rural. The fact that most infections were found in the most rural areas of Highland is unsurprising as it represents the largest proportion of the Highland population, and the largest geographical area. The classifications used by the Scottish Executive are based on population size and drive time, with rural areas containing less than 3,000 people, and remote areas with a drive time of over 30 minutes to a settlement of 10,000. We found that the extended eight fold classification was more suitable for Highland than the standard six fold classification as it further distinguishes between remote and very remote small towns and rural areas, based on drive time (Table I). It was more suitable for our study because it removes any preconceived misconceptions of which areas are considered urban or rural. A case-control study in Pennsylvania, USA found that the incidence of Lyme disease in a rural setting was three times the incidence in an urban setting.¹² Other American literature suggests Lyme disease occurs primarily in suburban and rural areas.^{13,14} However, Maetzel et al, 2005 concluded that the risk of acquiring Lyme disease after a tick bite in urban/suburban areas around Bonn, Western Germany was as high as in woodlands outside of the city.¹⁵ Another German study found the incidence in city dwellers and inhabitants of rural areas was not significantly different.¹⁶ Explanation of these diverse findings is the different definitions for urban/rural. We believe that the eight fold classification applies a standard well-structured classification to a geographically diverse population.

Risk of tick bite can be determined by gardens, parkland and forested areas as well as urban/ rural areas.^{1,6,12,14,15,16,17,18} We found patients were most likely to be tested for Lyme disease if they lived within 200m of woodland, therefore nearby woodland can be seen as a significant risk factor. This is understandable as woodland provides ticks with optimal climate and abundance of animal vectors. One limitation of our study was that it is based on patient's residence and not where they may have acquired the tick bite. Whilst popular opinion is that outdoor occupations and hillwalking are 'at risk' activities several studies have implied that infection is often acquired near the home, with gardening and dog walking associated with increased risk.^{12,19}

Over the last 15 years there has been intense education of the Highland population and medical profession about Lyme disease, which may partly account for the increases in sample numbers and cases. The National Lyme disease testing service is based in Inverness, and this is reflected in an aware clinical and local population and appropriate testing to identify at risk groups. This study provides good evidence that living in the most rural areas and within 200m of woodland represents a significant risk of Lyme disease in the Highlands.

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Fig. 1 – Comparison of the urban/ rural distribution of seropositive Highland residents (-▲-) with the Highland population (—■—), 2004-2006.

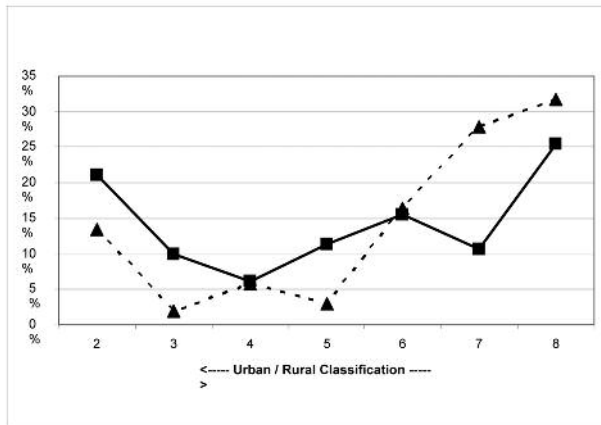
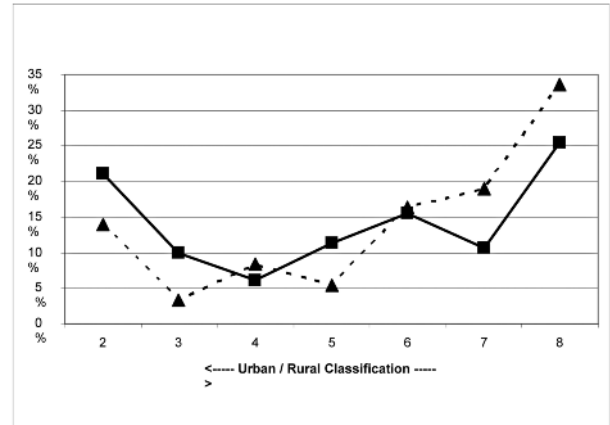


Fig. 2 – Comparison of the urban/ rural distribution of seronegative Highland residents (-▲-) with the Highland population (—■—), 2004-2006.



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