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Background. Gliomas are important because they affect disproportionately high numbers of people of working age and have a poor prognosis. Neurosurgeons were concerned about a possible recent cluster of glioma cases in a northwestern region in England.

Methods. All patients aged 18–89 years in Lancashire and South Cumbria with a histologically confirmed glioma diagnosed at the Royal Preston Hospital between January 1, 2006, and December 31, 2010, were ascertained. Clinical information was extracted from hospital records. Completeness of case referral to Royal Preston Hospital was checked against the National Cancer Registry and National Brain Tumour Registry records for the same period. For a comprehensive assessment of regional incidence, age-standardized incidence rates of all gliomas diagnosed in adults (aged 15 years and older) in the study area were then compared with those for the North West region and England as a whole. Rates for the North West region in defined small area-units (“Middle Super Output Areas”) were also investigated to assess any small-area variation in the region during the decade to 2010.

Results. There were 435 glioma patients from Lancashire and South Cumbria diagnosed at the Royal Preston Hospital between 2006 and 2010, with case ascertainment verified to be complete by the National Cancer Registration Service. The age-standardized incidence rate of gliomas in the study area was 7.10 per 100 000 in 2006–2010, which was minimally different from the rate for all cancer networks in England over the 10 years from 2001. Small-area analysis confirmed lack of major variation in glioma rates in the North West region of England.

Conclusion. Glioma incidence rates in England have remained stable by region and over time during the last decade.

Keywords: brain tumors, England, glioma, incidence, regional variation.
to be 7.7 per 100,000.\textsuperscript{7} In the second survey, a review of all CT scans with contrast and magnetic resonance imaging of the head was performed for the population of Devon and Cornwall from April 1992 to March 1997 in order to define the incidence of brain tumors and assess case-finding methods.\textsuperscript{8} This gave an age-standardized incidence of neuroepithelial tumors of 9.8 per 100,000, of which 69\% were histologically verified.

Incidence data also allow assessment of possible disease clusters, and indeed there was concern among neurosurgeons about a possible regional focus of glioma in a region of northwestern England, namely Lancashire and South Cumbria, that led to the present study. Our primary aim was to assess whether there was a higher than average incidence of glioma in this defined region of England. We therefore performed a detailed investigation of newly diagnosed and confirmed glioma cases in Lancashire and South Cumbria in the previous 5 years by review of hospital-based histological records for the region concerned, with verification by the National Brain Tumour Registry. We then extended this investigation to explore the variability of incidence of gliomas in recent years in all small districts in the North West region and across England.

Materials and Methods

All patients aged 18–89 years living in Lancashire and South Cumbria who had a glioma newly diagnosed and histologically confirmed at the Royal Preston Hospital (the regional center) between January 1, 2006, and December 31, 2010, were ascertained. Gliomas that were presumptively diagnosed by radiology and grade I gliomas were excluded from the hospital-based study. Clinical information was extracted in standard format from hospital records including each patient’s National Health Service number, date of birth, sex, postcode of residence, date of pathological diagnosis, histological subtype, grade of tumor, and location in the brain. Chi-square tests were used to assess differences in distributions of age and sex of patients and differences in the histological subtypes, grades, and location of the tumors.

In order to verify completeness of referral and ascertainment of eligible glioma patients in Lancashire and South Cumbria through Royal Preston Hospital records, the hospital’s data were compared with the corresponding records of gliomas diagnosed in Lancashire and South Cumbria as registered by the National Cancer Registry Service, North West Office, and compiled by the National Cancer Registry Service, Eastern Office, Cambridge, England. To more comprehensively examine the overall incidence of gliomas in the study area and compare this rate with rates in the rest of the country, we considered all gliomas diagnosed with and without histological verification and calculated incidence rates of gliomas in adults (aged 15 years or over) diagnosed in the Lancashire and South Cumbria Cancer Network, in the North West region of England, and in England as a whole for the period 2001–2010, using data from the National Cancer Data Repository.\textsuperscript{9} All rates were age-standardized to the European Standard Population, and their 95\% confidence intervals were calculated.

Age-standardized incidence rates for the North West region of England from 2001 to 2010 were further analyzed at the level of middle super output area (MSOA) to look for small-area differences in glioma incidence. MSOAs are stable geographic areas derived from 2001 census data comprising approximately similar-sized populations of 5,000 to 15,000.\textsuperscript{10} They are thus sufficiently large for at least one tumor to be diagnosed in the majority of areas in the 10-year period. Small-area analysis of incidence at MSOA level was undertaken for the period 2001–2010 on a year-by-year basis and on a 10-year aggregation of cases. We used Joinpoint regression software version 4.04\textsuperscript{11} to calculate average annual percentage change (AAPC)\textsuperscript{12} over the period. Age-standardized incidence rates for each MSOA in the North West region for 2001–2010 are presented as a funnel plot.\textsuperscript{13} To take account of the large number of geographical areas being tested and the subsequent increased risk of generating positive findings

<table>
<thead>
<tr>
<th>Location</th>
<th>n (%)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal ganglia</td>
<td>3 (0.7)</td>
<td></td>
</tr>
<tr>
<td>Brainstem</td>
<td>2 (0.5)</td>
<td></td>
</tr>
<tr>
<td>Cerebellar</td>
<td>3 (0.7)</td>
<td></td>
</tr>
<tr>
<td>Corpus callosum</td>
<td>6 (1)</td>
<td></td>
</tr>
<tr>
<td>Frontal</td>
<td>113 (26)</td>
<td></td>
</tr>
<tr>
<td>Frontoparietal</td>
<td>23 (5)</td>
<td></td>
</tr>
<tr>
<td>Frontotemporal</td>
<td>11 (3)</td>
<td></td>
</tr>
<tr>
<td>Frontotemporoparietal</td>
<td>2 (0.5)</td>
<td></td>
</tr>
<tr>
<td>Intraventricular</td>
<td>1 (0.2)</td>
<td></td>
</tr>
<tr>
<td>Occipital</td>
<td>14 (3)</td>
<td></td>
</tr>
<tr>
<td>Parietal</td>
<td>112 (26)</td>
<td></td>
</tr>
<tr>
<td>Parieto-occipital</td>
<td>19 (4)</td>
<td></td>
</tr>
<tr>
<td>Temporal</td>
<td>76 (17)</td>
<td></td>
</tr>
<tr>
<td>Temporoparietal</td>
<td>29 (7)</td>
<td></td>
</tr>
<tr>
<td>Thalamic</td>
<td>5 (1)</td>
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<tr>
<td>Missing/unspecified</td>
<td>23 (5)</td>
<td></td>
</tr>
<tr>
<td>Missing/unspecified</td>
<td>16 (4)</td>
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due to chance\textsuperscript{14} we applied a Bonferroni correction\textsuperscript{15} and considered areas with incidence rates more than 3 standard deviations above the North West region’s average to be statistically significant. Finally, we examined the potential for spatial-temporal clustering of higher than expected incidence at MSOA level over the period 2001–2010 using the software Satscan version 9.1.1.\textsuperscript{16,17} We applied a discrete Poisson model, with age as a covariate, using MSOA centroid Cartesian coordinates and a maximum reporting cluster size of 50% of the population at risk. For secondary clusters, we specified “no geographical overlap”.

Results

In the overall study period from January 1, 2006, to December 31, 2010, there were 435 patients aged 18–89 years living in Lancashire and South Cumbria who were newly diagnosed with a grade II to IV glioma at the Royal Preston Hospital. Of these, 65% were male, and 61% were aged 60–79 years (Table 1). The majority (86%) of these gliomas were histologically classified as glioblastoma (Table 1). Of the 60% of tumors whose location was recorded, there was no dominant laterality, and the main affected lobes were frontal and parietal (both 26%) (Table 1).

Practically all (97%) of the cases had been registered by National Cancer Registration Service, North West Office, and the number of cases identified for the Lancashire and South Cumbria geographic area was very similar (442), confirming the close to complete capture by Royal Preston Hospital of glioma cases diagnosed in the Lancashire and South Cumbria catchment area. As a corollary, the corresponding National Cancer Registry data were considered entirely representative of the underlying cancer rates in the Lancashire and South Cumbria Cancer Network.

The age-standardized incidence rate of glioma in the Lancashire and South Cumbria Cancer Network for the period 2006 to 2010 was 7.10 per 100 000 (95% CI, 6.47–7.80). This was similar to the age-standardized incidence rates for the North West region of England at 7.19 per 100 000 (95% CI, 6.89–7.50) and England as a whole at 6.93 per 100 000 (95% CI, 6.82–7.04). In the Lancashire and South Cumbria regions (AAPC = −1.54 [−4.3–1.3]), the North West region of England (AAPC = 0.92 [−1.2–3.1]), and in England overall (AAPC = 0.24 [−0.3–0.8]), there was no statistically significant trend in standardized incidence rates over the 10-year period at \( P < .05 \).

Age-standardized incidence rates for 7 MSOAs (none geographically adjacent) were more than 2 SDs above the North West regional average (Fig. 1), but no MSOA had an incidence rate more than 3 SDs above the North West regional average. These results were confirmed by spatial-temporal cluster analysis, with no MSOA clusters significantly higher or lower than expected.

Discussion

We found no evidence of any material variation in incidence rates of glioma within Lancashire and South Cumbria in the North West region of England including after fine-area investigation by MSOA. Moreover, the incidence of glioma in the Lancashire and South Cumbria Cancer Network was in no way anomalous in comparison...
with other cancer networks in England. Trends in gliomas over the last 10 years appear to be stable for this region and throughout all cancer networks in England. This stability and consistency are confirmed by published reports of regional incidence of glioma across England and Scotland during the last 2 decades. Indeed, the observed lack of any increase in rates is in line with trends of gliomas in Nordic countries and in the United States. These stable trends are interpreted as evidence of a lack of association between mobile phone use, which has risen rapidly in this period, and the occurrence of malignant brain tumors.

The demographic characteristics of glioma patients in the Lancashire and South Cumbria region are similar to those of glioma patients in other populations, with significantly more males than females affected and onset often in middle adulthood in men and women of working age. Predominance of glioblastomas is seen universally, and the site distribution within the brain is similar to that reported in other series with respect to frontal and parietal lobe dominance, although some differences are noted in comparison with a detailed single-center study in Finland, which may not have been a representative series.

The strengths of this study are the population-based nature of the primary data and their recency. Such small-area analyses of glioma incidence in England are uncommon and grounding the results in the context of the national incidence of glioma and comparing incidence in the study area with that in other small areas of North West England for the immediate past, and against longer-term trends, give further reassurance of the validity of the findings. Study weaknesses include a proportion of tumors in small areas of North West England for the immediate past, and the occurrence of malignant brain tumors.

In summary, we have investigated in detail a clinically suspected cluster of gliomas in Lancashire and South Cumbria in the North West region of England and found no evidence of variation in the region itself or when compared with other regions of England over the last 10 years.

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Conflict of interest statement. None declared.

References