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CLINICAL STUDY

Socio-economic characteristics of patients with glioblastoma multiforme

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Abstract The incidence of glioblastoma multiforme (GBM) varies across the world and also within subpopulations within each nation. Many cancers show correlation with socioeconomic status and we hypothesised that incidence of GBM also does the same. We performed a retrospective analysis of all patients treated with brain tumours at a single hospital over a 6-year period. For these patients we examined markers of socioeconomic status and reviewed their histopathological diagnosis. A total of 2859 patients had surgery between April 2006 and April 2012. Of these 880 had histological diagnosis of GBM. Records for all patients were reviewed. Based on postcodes, socioeconomic data was obtained at ward level from government sources. Markers were: average weekly household income, percentage unemployed, population density, indices of deprivation and percentage of households with no car. Data was analysed for trends between incidence per ward and socio-economic markers. Increasing incidence of GBM was associated with increasing wage ($p = 0.044$), less unemployment ($p = 0.0002$), Indices of Multiple Deprivation ($p = 0.05$), lower population density ($p = 0.0015$) and greater ownership of cars ($p = 0.0005$). There are unique socioeconomic characteristics for patients with GBM. Although a link to aetiology cannot be established from this limited epidemiological study, these results identify issues that these patients are more likely to face. These should be taken into account when planning support services and patient care following surgery.

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Introduction

Several publications have highlighted social inequalities in cancer incidence and mortality. For lung, stomach, and cervical cancer in western populations, a greater burden of disease rests with socioeconomically disadvantaged groups. It must be noted that this pattern is not evident with all types of cancer. Some show no socioeconomic trend (e.g., pancreas, uterine, prostate and ovarian cancer) whilst others are more common in the higher social strata (e.g., breast and colon cancer) [1].

For brain cancers some studies have shown a correlation between higher socioeconomic status and higher incidence [2–4], whereas other investigators conclude that there was no correlation [5].

As these trends reflect a complex mixture of environmental and genetic risk factors it is difficult to formalize causal relationships. However, an understanding of the socioeconomic characteristics of patient groups help promote awareness of disease in those populations and aid in the planning of provision allocation for treatment.

We conducted a retrospective study of the socio-economic characteristics of the patients treated at our institution to ascertain whether there is indeed a correlation and to better understand our patient population and their needs.

Methods

We conducted a retrospective review of all patients that were treated at our neurosurgical unit for glioblastoma multiforme (GBM) over a 6-year period and for each

Table 1 Summary of results

Socioeconomic indicator	Number of wards	R value	*p* value	Summary
Average weekly wage	265	0.0124	0.044	Statistically significant correlation between higher average weekly income and higher incidence of glioblastoma
Unemployed (%)	272	−0.224	0.0002	Statistically significant correlation between lower unemployment rate and higher incidence of glioblastoma
Population density	272	−0.191	0.0015	Statistically significant correlation between lower population density and higher incidence of glioblastoma
Population with no car (%)	272	−0.209	0.0005	Statistically significant correlation between lower percentage population not owning cars and higher incidence of glioblastoma
Indices of multiple deprivation (ranked score)	193	0.1398	0.05	Statistically significant correlation between lower levels of deprivation and higher incidence of glioblastoma

patient we established markers for their socio-economic grouping.

Using theatre logs, medical records and histopathology reports we identified all patients who had been diagnosed with WHO grade IV glioma (glioblastoma multiforme) between April 2006 and April 2012. These results were obtained following either biopsy or surgical resection. We did not categorize further according to histological subtype, location or radiological appearances. For patients who had previous surgery we only considered demographic data valid at the time of the first surgical procedure that obtained tumour samples leading to the histological diagnosis of glioblastoma.

For each patient we obtained the home address at the time of diagnosis, which allowed us to identify markers of socio-economic status and population size on a local council ward level (electoral districts at sub-national level). Socio-economic and population data was gathered from the UK Office for National Statistics. From the population data we were able to calculate the incidence of glioblastoma in each of the wards.

Several schemes for determining socioeconomic grouping exist. This can make interpretation of results and comparison between studies challenging. However most schemes use the following markers: household condition, unemployment rate, car ownership, occupation and wage [6].

To allow for easier and wider comparison to other studies and also in order to better understand the characteristics of our patient population we resorted to using these individual markers, rather than a generalised grouping scheme.

The set of socio-economic markers used were as follows: average weekly household income, unemployment rate and population density (number of people per square kilometre). Car ownership was recorded as the percentage of the population in each ward with no car. We also recorded the Rank of Indices of Multiple Deprivation score.

Indices of Multiple Deprivation is scored over several domains which include: income, employment, health deprivation and disability, education, skills and training deprivation, barriers to housing and services, levels of crime, and living environment. The results can be combined and sorted at council ward (electoral geographical divisions within the UK) level to give a Rank of Indices of Multiple Deprivation score where 1 represents the most deprived area and higher numbers represent less deprived areas in ascending order.

We also ranked wards for each of the other socioeconomic markers based on the level of affluence.

Using data on the population of the each local council ward (from UK National Census 2011 [7]), we calculated incidence rates for glioblastoma (per council ward) and examined for correlation with each of the socio-economic markers listed below.

Statistical analysis was performed using the statistics package SPSS v21. Bivariate correlation analysis (Pearson Coefficient) was used to examine the data.

Results

During the 6-year period, from April 2006 to April 2012, we performed surgical procedures at our neurosurgical unit, either by biopsy or resection, for 2859 patients with brain tumours. Of these, 880 patients were diagnosed WHO grade IV glioma (glioblastoma multiforme).

Our Neurosurgical unit serves a geographical area with a total of 272 local council wards. For each ward we

obtained data from the UK Office for National Statistics for population and socioeconomic markers as listed above. Our results are as follows:

Variation in GBM incidence with average weekly wage

Of the 272 council wards we were able to obtain data on mean weekly wage for 265 wards. Figure 1 shows, for each of the 265 wards, the weekly wage against in the incidence of glioblastoma in that ward. Bivariate correlation analysis (Pearson coefficient) revealed a correlation of $R = 0.124$, with $p = 0.044$. Hence there was a statistically significant correlation between higher average weekly income and higher incidence of glioblastoma.

Variation of GBM incidence with unemployment rate

Data on unemployment rates was available for all 272 council wards. Results are shown in Fig. 2. Using Pearson coefficient we found an inverse correlation of $R = -0.224$, with $p = 0.0002$. This shows a statistically significant correlation between lower unemployment rate and higher incidence of glioblastoma.

Variation in GBM incidence with population density

Data on population density, measured by number of people resident per square kilometre was available for all wards. Bivariate analysis with Pearson coefficient revealed $R = -0.191$ with $p = 0.0015$. Figure 3 illustrates these results. Incidence of glioblastoma was higher in areas with lower population density. It is assumed that areas with higher population density, such as inner city areas, have a population of a predominantly lower socioeconomic status, living in crowded areas. It is also assumed that subjects with a higher socioeconomic status and also wealth will reside in suburban regions, which have a lower population density.

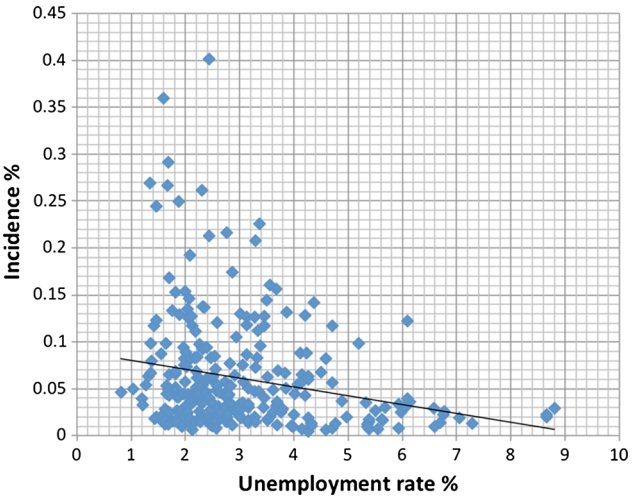

Fig. 2 Variation of GBM incidence with unemployment rate

Variation in GBM incidence and car ownership

Data was available for all 272 wards. We examined the percentage of the population that owned no cars. It is assumed that subjects from a lower socioeconomic group are less likely to own a car than subjects from a higher socioeconomic group. We found an inverse correlation with $R = -0.209$. This was statistically significant with $p = 0.0005$. Figure 4 shows these results.

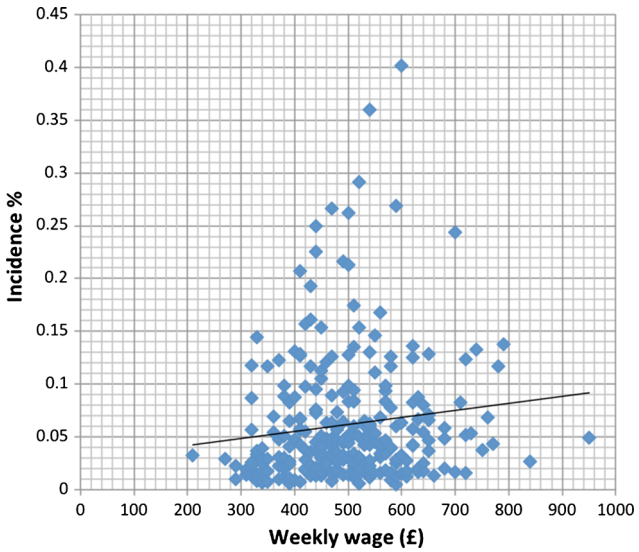

Fig. 1 Variation in GBM incidence with average weekly wage

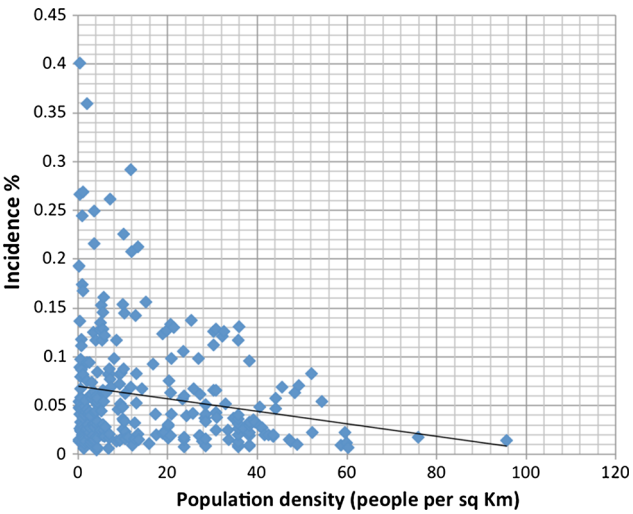

Fig. 3 Variation in GBM incidence with population density

Variation in GBM incidence with Indices of Multiple Deprivation ranked score

Data on indices of multiple deprivation was available for 193 of the 272 council wards. For these wards bivariate analysis showed a correlation with $R = 0.1398$ and $p = 0.05$. Wards with more deprivation had a lower incidence of glioblastoma compared to wards with less deprivation (Fig. 5).

Discussion

The often-quoted average incidence of glioblastoma multiforme is 3–4 cases per 100,000 population per year [8]. This is accurate for North American and Western European nations. However the incidence is notably lower in Asia and South America. This is the case for Central Nervous System (CNS) tumours in general [9].

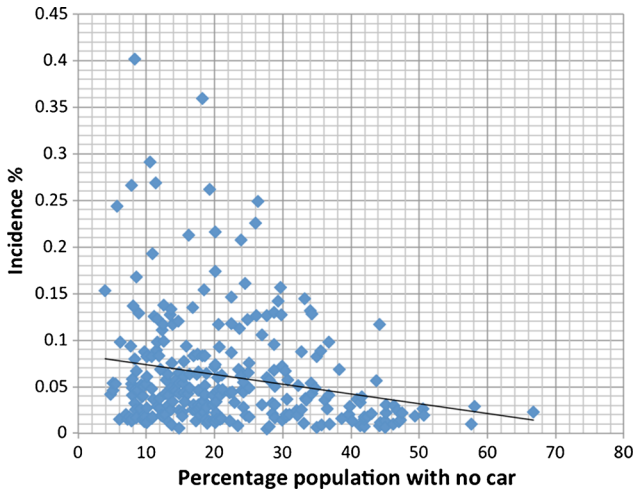

Fig. 4 Variation in GBM incidence and car ownership

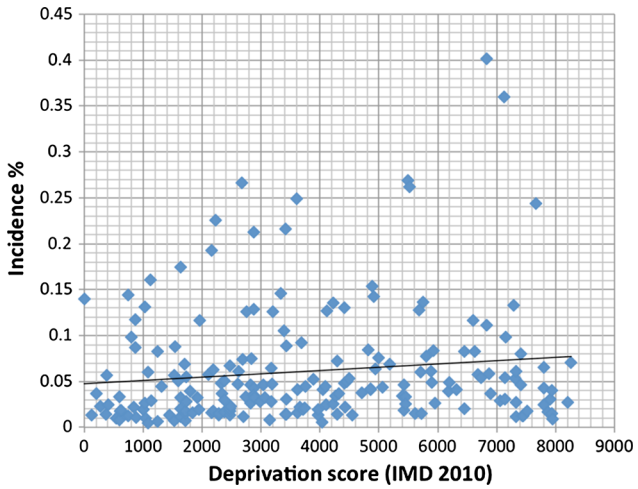

Fig. 5 Variation in GBM incidence with Indices of Multiple Deprivation ranked score. Table 1 shows a summary of the above results

This disparity may partly reflect difference in detection rates but this may also be due to variations in geographical distribution or ethnic (genetic) predisposition to glioblastoma. Even across the 'developed world' the incidence rate is not uniform; with population adjusted figures of 2.96 per 100,000 per year for USA and 3.55 per 100,000 for Switzerland.

However, further analysis reveals that this variation is not simply geographical. The Armed Forces Institute of Pathology (AFIP) tumour registry as well as the Central Brain Tumor Registry of the United States (CBTRUS) shows that glioblastoma incidence varies with race. It is twice as high in whites than blacks [10], whereas incidence rates are lowest in Asian populations [11, 12].

These racial differences may represent genetic predisposition to GBM. However, it should be noted that familial clustering, which accounts for only 5 % of glioma cases [13] and only approximately 1 % of glioblastoma cases are inherited in an autosomal dominant manner [14]. This apparently low level of heritability reflects the large number of gene mutation steps involved in the process to developing glioblastoma. As with many cancers perhaps the predisposing genetic characteristics are inherited but multiple external influences are necessary for the development of disease.

Our hypothesis is that the variability in GBM incidence across populations may be a reflection of diverse socio-economic factors. This link has been examined previously, although findings from studies have been mixed and an association between incidence and socio-economic status, measured with Castairs Index, car ownership, household overcrowding, social class, and unemployment rate has not been consistently shown across studies. Preston-Martin et al. [2] and Navas-Acien et al. [4] found that higher socioeconomic status was associated with higher incidence of all gliomas. However, Inskip et al. [5] found that low-grade gliomas were associated with higher levels of education, which correlates with higher socio-economic status; but they found no link for high-grade gliomas.

What is evident, as with most other non-CNS cancers, is that socioeconomic status has a marked effect on survival. Tseng et al. [15] examined survival data from Cancer Registry (Office for National Statistics) and compared to Deprivation (Castairs) Index; findings were, 30.8 % survival at 1 year in the most affluent group compared to 26.9 % in the most deprived. The reason for this may be due to differences in education or disease awareness which impacts on time taken to seek medical treatment, general health and presence of comorbidities, or because of variance in the support networks available. Understanding the socioeconomic distribution may therefore help in

equalizing these survival differences whilst improving survival rates overall.

Data from our study shows that there is higher incidence of glioblastoma in geographical areas where the population is of a higher socio-economic status. This trend was visible when examining each of the five socioeconomic markers used in our study (Table 1). The correlation between higher GBM incidence and higher average weekly wage, lower unemployment rates, lower population density and higher rates of car ownership, and Ranked Indices of Multiple Deprivation were all statistically significant (with $p \leq 0.05$).

As the trend in each of the five socioeconomic markers shows a correlation between higher socioeconomic status and higher GBM incidence we propose that this link is indeed true. It is not possible, nor was it the intention of this study, to establish causality. Our aim was to gain an understanding of the likely characteristics of patients with glioblastoma, leading to a better understanding of their needs.

One might consider the possible impact on a patient's life following surgery and a diagnosis of GBM. They will be unable to drive due to Driver and Vehicle Licencing Authority (DVLA) restrictions, and as they are more likely to be living in sparsely populated areas regular public transport access may be a problem for them. Having considered this, healthcare professionals will more readily appreciate the challenge faced by patients who are offered fractionated radiotherapy, requiring attendance to hospital (which are likely to be far from their homes, in urban areas) on a daily basis.

One might also consider that as the disease will eventually lead to disability and inability to work there will be a financial impact on daily living. Medical insurance and financial aid from government benefits may not be sufficient to maintain living costs, including mortgage and loan repayments. These financial worries may compound medical ones held by patients and their relatives.

In order to provide better, holistic care of patients it is imperative that healthcare professionals and cancer support workers consider the socio-economic impact of a diagnosis of glioblastoma and develop support networks to guide patients and their families through such hurdles. A better understanding of patient characteristics is the first step in this process.

Conclusions

The study shows a correlation between higher socioeconomic status and higher incidence of glioblastoma. Incidence is highest in groups that are employed, with a high wage, owning a car, living in more sparsely populated and less deprived geographical areas.

An appreciation of these patient characteristics and the problems faced by patients following diagnosis will aid in providing better support services and more holistic care.

Compliance with ethical standards

Conflict of interest None.

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