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Glioblastoma in England: 2007–2011

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Abstract ***Aims:*** Glioblastoma (GBM) is the most common and aggressive primary malignant brain tumour in adults, with a poor prognosis. Changing treatment paradigms suggest improved outcome, but whole nation data for England is scarce. The aim of this report is to examine the incidence of patients with glioblastoma in England, and to assess the influence of gender, age, geographical region and treatment on outcome.

Methods: A search strategy encompassing all patients coded with GBM and treated from January 2007 to December 2011 was obtained from data linkage between the National Cancer Registration Service and Hospital Episode Statistics for England.

Results: There were 10,743 patients coded with GBM in this 5-year period (6451 male, 4292 female), giving an overall national age standardised incidence of 4.64/100,000/year. Incidence increases with age. Median survival overall was 6.1 months. One, 2 and 5-year survivals, were 28.4%, 11.5% and 3.4% respectively. Age stratified median survivals decreased significantly ($p < 0.0001$) with increasing age from 16.2 months for the 20–44 year age group, to 7.9 months for the 45–69 years, and 3.2 months for 70+ years. In the maximal treatment subgroup, patients aged up to 69 years had a median survival of 14.9 months. Patients over 60 years were less likely to receive maximal combination treatment but median survival was better with maximal treatment at all ages.

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Conclusions: The overall outcome for patients with GBM remains poor. However, aggressive treatment at every age group is associated with extended survival similar to that described in clinical trials.

1. Introduction

Glioblastoma (GBM: World Health Organisation (WHO) grade IV glioma) is the most common and aggressive primary malignant brain tumour in adults [1]. The international estimated age adjusted incidence for all patients with primary malignant brain tumours (not exclusively GBM) is 5.3 per 100,000 population with higher rates in some western developed countries [2]. Few patients with GBM survive long term with reported median survivals of 6–9 months (Johnson, 2012, Darefsky, 2012).

In 2005 an European Organisation for Research and Treatment of Cancer and the National Cancer Institute of Canada Clinical Trials Group (EORTC/NCIC) phase III randomised trial showed the benefit of adding concurrent and adjuvant temozolomide, an oral alkylating agent that penetrates the blood brain barrier, to radiotherapy with a median survival of 14.6 months and 5-year survival of 9.8% [3,4]. Since publication, this protocol has become the standard of care for patients with GBM. Reports suggest an improvement in outcome since the widespread introduction of temozolomide after 2005, but complete whole country data for England is scarce. Only one previous national study examined the cancer journey of patients diagnosed with glioblastoma and treated in 2004–2005 in England and reported 21% 1-year survival [5]. The impact of the introduction of temozolomide on the combined patient outcome may be less than predicted as incidence peaks in the elderly, yet patients older than 70 years were not recruited to the EORTC/NCIC trial, and many may not receive temozolomide [3].

Between 2011 and 2013 English cancer registry data were centralised allowing ready exploration of national data on patients with brain tumours across the whole of England for the first time (approx 53.5 million people in 2012, Office for National Statistics 2013). These data are linked to data on hospital admissions (Hospital episode statistics: HES), which include treatment related to surgery, chemotherapy and pathology and radiology reports. In addition, multidisciplinary team meetings (MDTs; or tumour boards) feed diagnostic and therapy data directly to the National Cancer Registration Service (NCRS). This makes England uncommon in having detailed whole nation incidence and treatment data for all patients diagnosed with cancer. Here, we report the incidence and survival of patients with GBM in England 2007–2011 (Inclusive), and examine the relationship between age, sex, geographical region, treatment and outcome.

2. Methods

2.1. Patient cohort

We included all patients diagnosed with cranial glioblastoma (ICD10 site: C71, ICDO2 morphology 9440/3, 9441/3 and 9442/3) between 1st Jan 2007 and 30th Dec 2011, who were resident in England as registered by the NCRS. The NCRS holds data collated from electronic and paper-based reports, clinical notes, pathology reports and HES records (http://www.hscic.gov.uk/hes), which reports diagnosis as ICD-10 code and procedures using OPCS 4 (UK national classification of interventions and procedures version 4: http://systems.hscic.gov.uk/data/clinical coding/codingstandards/opcs4) for all patients admitted to hospital. Chemotherapy linked data describe treatment provision but not type, and company data provide unlinked temozolomide sales in England. Radiotherapy data are only complete from 2012 and were not used in this analysis. Data elements include age at diagnosis, tumour site, morphology, behaviour, WHO grade and treatment.

Vital status was checked using the NHS Personal Demographics Service (PDS) (http://systems.hscic.gov.uk/demographics/pds/). In this analysis, surgery encompasses all debulking procedures but not biopsy. HES data linkage were not complete but in eight of the nine regions were over 93%. The East of England (HES linkage 83%) used patient admission statistics (PAS) as the main source of hospital treatment data so would not normally match their data to HES. There was no significant difference between year of diagnosis, age and degree of linkage. Unlinked data between HES and NCRS were included in the analysis as other sources of treatment data including PAS, hospital notes and path reports could be used.

2.2. Statistical analysis

Annual European Age Standardised Incidence rates per 100,000 population were calculated for overall and age specific cohorts, using standard techniques. The standard population used is the 2013 European Standard Population (Annex F, http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-13-028/EN/KS-RA-13-028-EN.PDF) and the maximum age band is 85+.

Ninety five percent confidence intervals for the age standardised incidence rates were calculated using Dobson & Byar's method [6]. For comparison with the data from the US, the standard population used was the 2000 US Standard Population available from http://seer.cancer.gov/stdpopulations/stdpop.19ages.html [7].

Median survival in months and one, 2 and 5-year overall survival percentages were calculated using the stci and strs (www.pauldickman.com/rsmodel/stata_colon/) commands respectively in Stata version 12 SE (http://www.stata.com). A difference was considered statistically significant when the p-value was <0.05, or when the 95% confidence intervals did not overlap. Treatment analysis examined 2007–2010 inclusive because linked treatment data were currently available only for diagnosis up to the end of 2010. As those over 70 years of age were less likely to be given temozolomide, and their prognosis was poor, they were excluded from Fig. 6 and Tables 2 and 3 purely to allow a clearer comparison of the implications of treatment with less age effect.

3. Results

There were 10,743 patients registered with GBM in England from 2007 to 2011 (6451 male, 4292 female), giving an overall national age standardised incidence of 4.64/100,000/year (Table 1). Men had an incidence 1.66 times that of women. The frontal lobe was the most common site recorded (24.9%) followed by the temporal lobe (21.8%), parietal lobe (16.7%), occipital lobe (4.8%), cerebellum (0.5%), brain stem (0.4%) or was not specified/other (30.9%). There was no change in age standardised incidence or tumour site over the 5 years studied. Incidence increases with age, with a peak between 65 and 75 years of age (Fig. 1). More than 90% of patients had histological confirmation of their diagnosis, although this is less than 60% in the 70+ age group (Fig. 2). Median survival was 6.1 months overall, and 1, 2 and 5-year survivals were 28.4%, 11.5% and 3.4% overall (Table 1, Fig. 3). There was no difference between male and female outcome ($p = 0.22$). Survival worsens with increasing age band (Fig. 4). Median survival for patients age 20–44 was 16.2 months, for those aged 45–69 was 7.2 months, and for those age 70+ was 3.2 months (Fig. 5). Median survival by site showed that patients with tumours in the temporal (8.2 months), occipital (8.1 months), frontal (7.1 months) and parietal (6.6 months) lobes did better than those in the cerebellum (4.0 months), ventricle (4.3 months) or unspecified (3.8 months) ($p < 0.0001$).

There were significant differences in outcome between all treatment groups ($p < 0.0001$) (Fig. 6 and Table 2). To better examine the differences in outcome by treatment modality, only patients aged up to and including 70 years (2007–2010 inclusive; $n = 5995$) were included in this part of the analysis. The survival advantages of re-operation, re-irradiation or second or third line chemotherapy were not examined. Radiotherapy data are not complete, but it is likely that most patients who had surgery and chemotherapy also had radiotherapy (Johnson, 2012, Darefsky, 2012). Patients who had chemotherapy (Groups 3 and 4) lived longer than patients who did not (Groups 1 and 2), although the chemotherapy groups were of younger age. It is not possible to say exactly how many of these patients with GBM received temozolomide, but sales data suggest that most of the 660 patients per year under 70 who had chemotherapy had temozolomide. This calculation comes from company figures that 47,141 to 66,885 packs of five are sold per year (Source: IMS Health, IMS Health Hospital Pharmacy Audit by Country (HPAIC) MAT 2007–2011 Units: Total molecule usage through English hospital pharmacies based on projected sample data as interpreted by MSD Ltd). An 80 kg 170 cm male has a surface area of 2 m^2. The concomitant phase of 42 days of 75 mg/m^2 requires 150 mg/day which equates to 1×140 mg tablet and 2×5 mg tablets or 3×9 packs = 27 packs. The adjuvant phase of 150 mg/m^2 or 300 mg/day for 5 days for six cycles equates to 2×140 mg tablets and 1×20 mg tablets so a further 18 packs. Depending on the exact dose required, this means approximately 40–70 packs of five are required for treatment, so approximately 1000 patients per year. Some patients with anaplastic astrocytoma will be treated with temozolomide, but this still suggests most of the 660 patients who are reported to have had chemotherapy probably had temozolomide.

Table 1
Incidence and survival for patients with glioblastoma by sex: 2007–2011. ASR: Age standardised rate per 100,000 population. Median survival is in months. Figures in brackets are 95% confidence intervals.

	2007	2008	2009	2010	2011	Average 2007–2011
Male count	1243	1291	1287	1263	1367	1290
Male ASR	5.81 (5.49–6.15)	5.94 (5.62–6.28)	5.83 (5.51–6.16)	5.71 (5.40–6.04)	6.04 (5.72–6.38)	5.87 (5.73–6.02)
Male median survival	6.6 (5.9–7.1)	6.4 (5.7–6.9)	6.7 (6.0–7.2)	6.1 (5.6–6.6)	6.9 (6.4–7.6)	6.5 (6.2–6.8)
Female count	803	870	846	834	939	858
Female ASR	3.41 (3.18–3.66)	3.64 (3.40–3.89)	3.49 (3.26–3.73)	3.40 (3.17–3.64)	3.77 (3.53–4.02)	3.54 (3.44–3.65)
Female median survival	5.3 (4.7–6.1)	5.6 (4.8–6.1)	5.8 (5.3–6.3)	5.5 (4.9–6.1)	5.6 (5.0–6.2)	5.6 (5.3–5.8)
Persons count	2046	2161	2133	2097	2306	2149
Persons ASR	4.54 (4.34–4.74)	4.73 (4.53–4.94)	4.61 (4.41–4.81)	4.49 (4.30–4.69)	4.84 (4.65–5.05)	4.64 (4.56–4.73)
Persons median survival	6.0 (5.6–6.5)	6.0 (5.6–6.4)	6.2 (5.8–6.8)	5.8 (5.5–6.3)	6.3 (5.8–6.8)	6.1 (5.9–6.3)

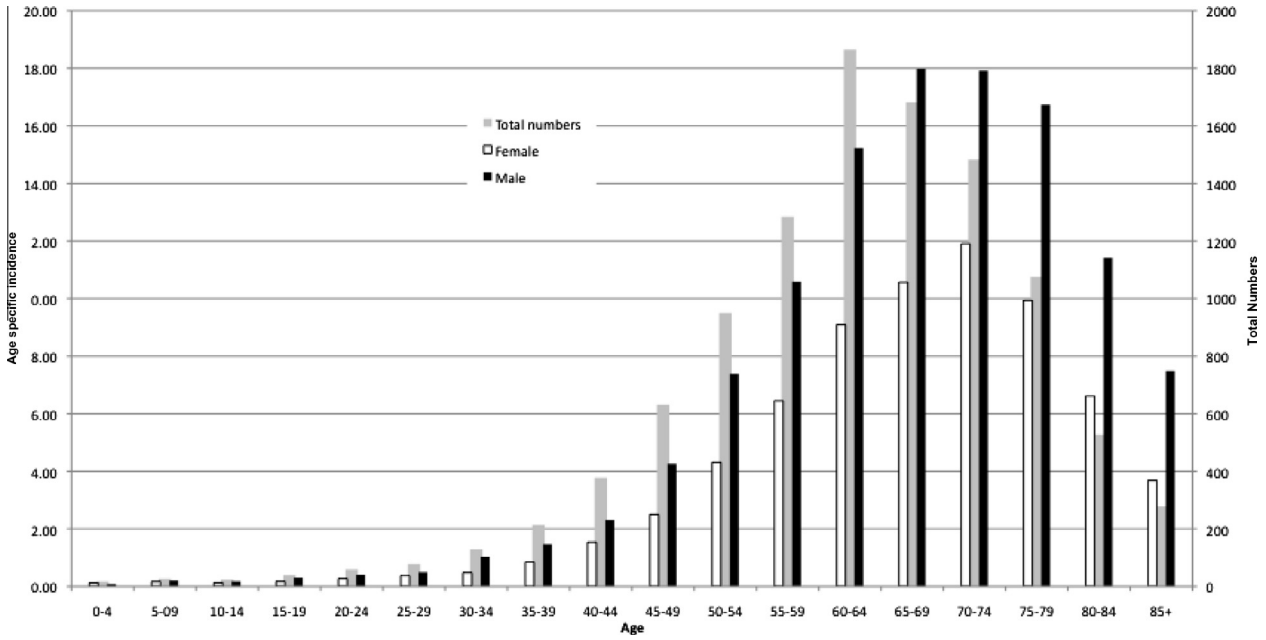

Fig. 1. Age specific incidence and total numbers of glioblastoma by 5 year age band between 2007 and 2011. Total numbers of patients presenting with glioblastoma between 2007 and 2011 by age (Right hand scale). Age specific incidence of patients by sex with glioblastoma per 100,000 population (left hand scale). Numbers peak between 60 and 70 years of age, whilst the incidence peaks between 65 and 75 years.

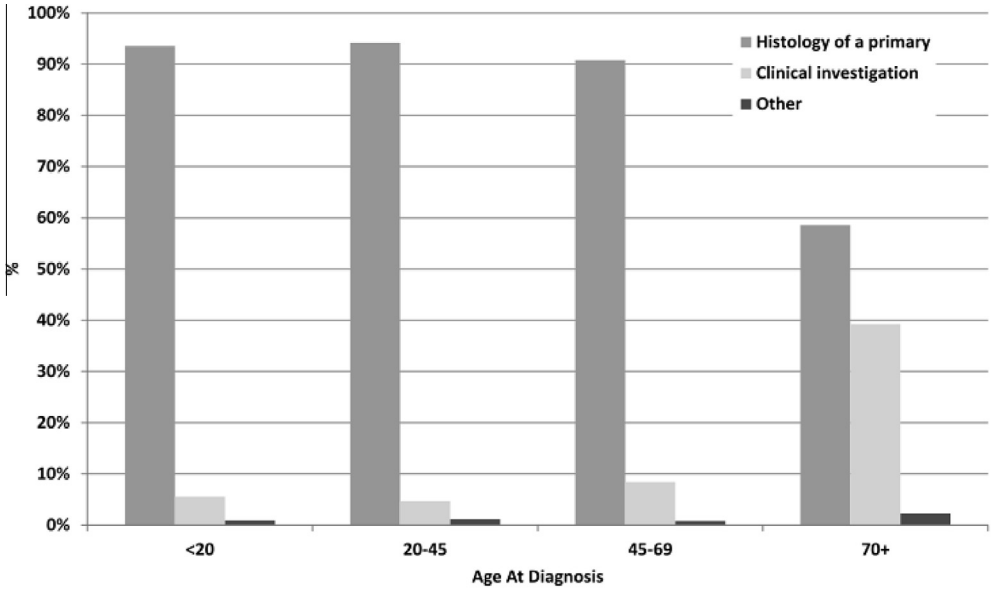

Fig. 2. Relative rates of basis of diagnosis by age. The Majority of diagnoses are based on histology, with only 0.85% based on the death certificate only, and these cases were included in the analysis. Histological verification rates were lower in the 70+ age range.

Patients who had debulking surgery, chemotherapy and probably radiotherapy, were defined as having maximal treatment (group 4). Thirty four percent of the total group had maximal treatment, although there was variation with age, including only 12% of the 70–74 year old group, 3% of the 75–79 year old group and just two patients of 577 (<1%) in the 80+ age group (Fig. 7). There was a longer median survival in the maximally treated group at all ages, but this did not abolish the stratified association with age (Fig. 8).

Regional variation appears to exist, although regional data quality issues may play a role (Table 3). Reported numbers for 'glioma or malignant brain tumour not otherwise specified' were high in the South West (36%) and low in the East Midlands (19%), and some of these patients are likely to have a GBM, affecting the reported incidence levels.

There were 135 patients age up to 18 years of age, with the cerebral hemispheres remaining the most common site (63%), followed by the brainstem (13%).

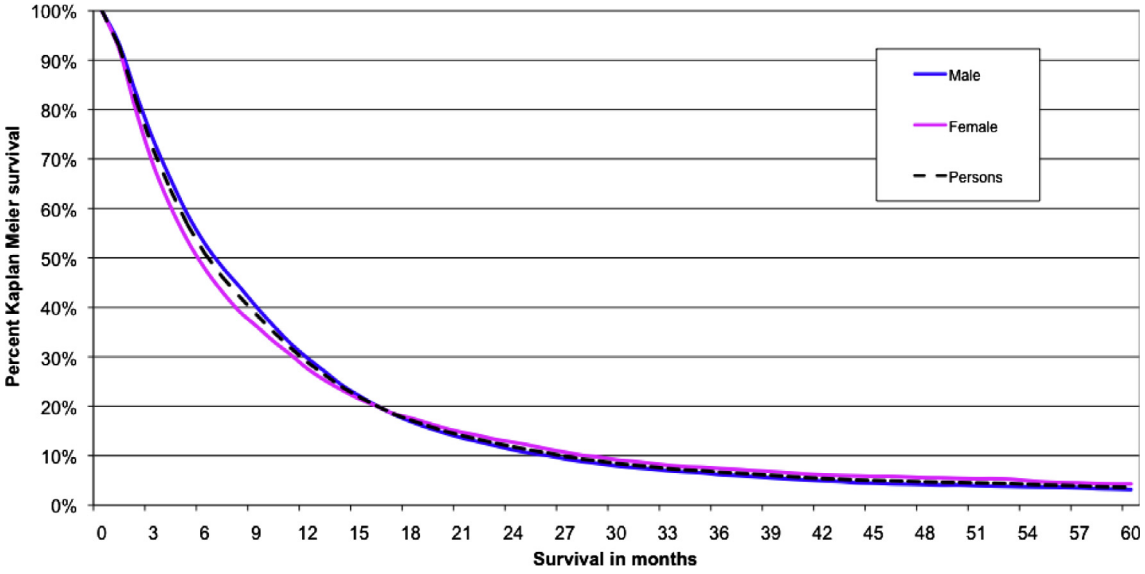

Fig. 3. Kaplan–Meier plot showing survival for patients with a glioblastoma. Median life expectancies are 5·6 months for women, 6·5 for men, and 6·1 overall. One, 2 and 5-year survivals were 29·2%, 10·9% and 3·0% for men, 27·3%, 12·5% and 4·1% for women, and 28·4%, 11·5% and 3·4% respectively overall.

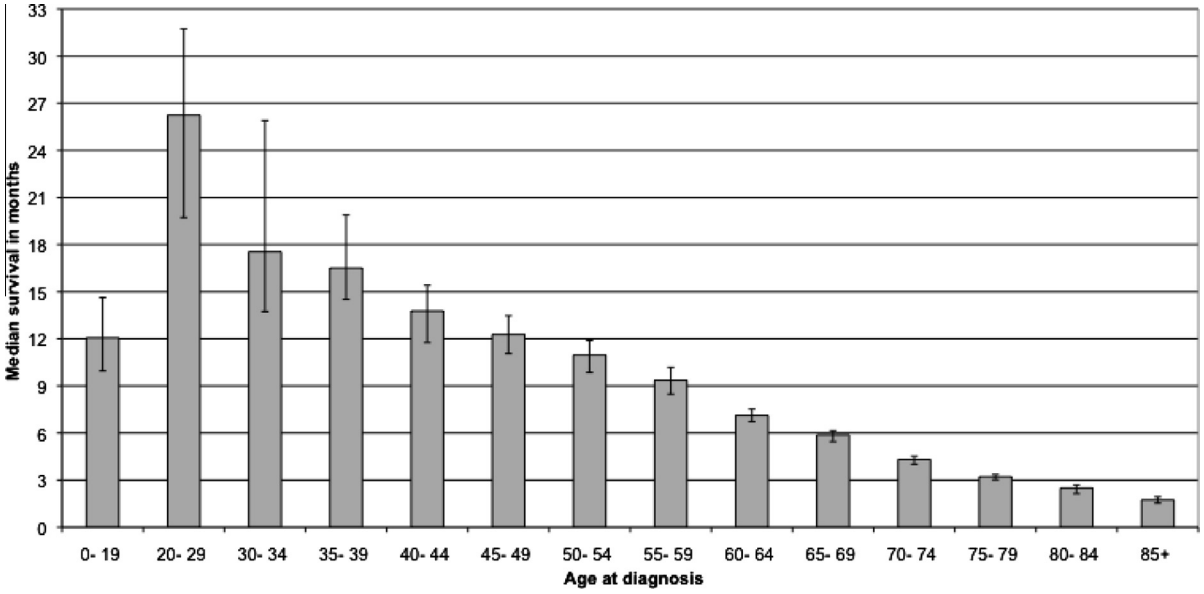

Fig. 4. Median life expectancy in months for patients with a GBM by age. There is a significant stepwise reduction in life expectancy with increasing age $\geqslant$20 years ($p < 0{\cdot}0001$). Bars denote 95% confidence intervals.

Median survival was 12 months for this group of patients, with one, two and five survivals of 50.5%, 25.8% and 15.4% respectively.

4. Discussion

Interest in the treatment and outcome for patients with glioblastoma has increased with better treatment paradigms and an improved understanding of the molecular subtypes [3,8,9]. In the US, the age standardised incidence for GBM is 3.19 [7]. Estimates for other countries are often lower [2]. Using the English incidence for GBM but standardised against the US population to allow direct comparison gives a figure of 3.43 per 100,000 population for England. Both this figure and the European age adjusted incidence of 4.64 per 100,000 population appear to place England amongst the higher rates in the world, but this may relate to international variations in coding and diagnostic practice rather than fundamental underlying differences. Although no alteration was found in glioblastoma incidence between 2007 and 2011, debate exists regarding changing prevalence, with some studies suggesting an increase and other model based estimates suggesting

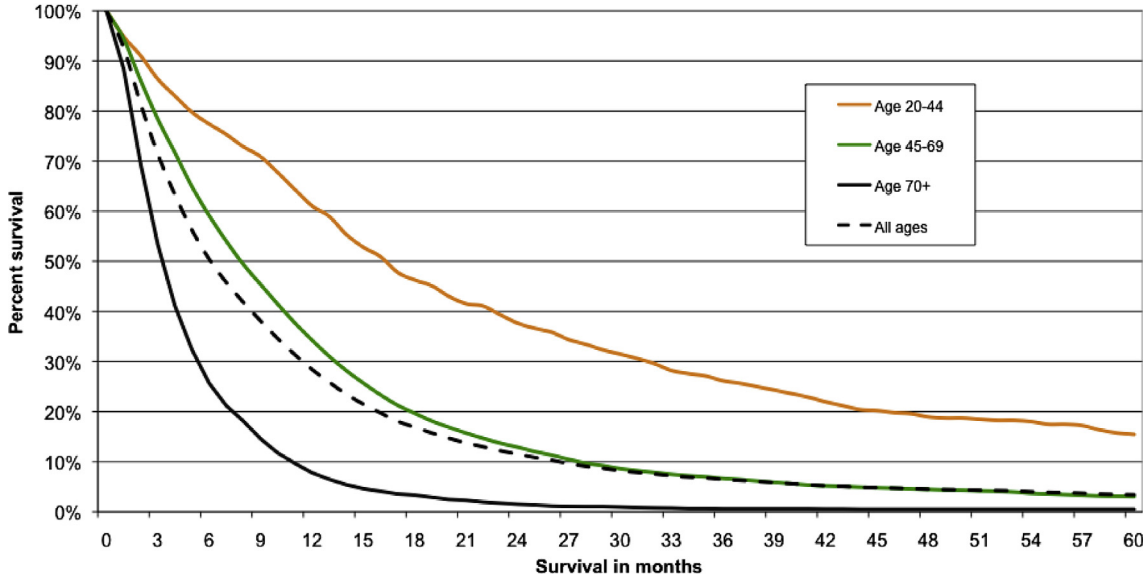

Fig. 5. Kaplan–Meier plot demonstrating survival by age. Survival decreases significantly ($p < 0{\cdot}0001$) for each increasing age band. Median survivals for age 20–44, 45–69 and 70+ were 16.2 months, 7.9 months and 3.2 months respectively. One, 2 and 5-year survivals for age 20–44 were 61·1%, 37·7% and 15·4%, for age 45–69 were 34·3%, 12·9% and 3·1%, and for age 70+ were 7·8%, 1·5% and 0·5% respectively ($p < 0{\cdot}0001$).

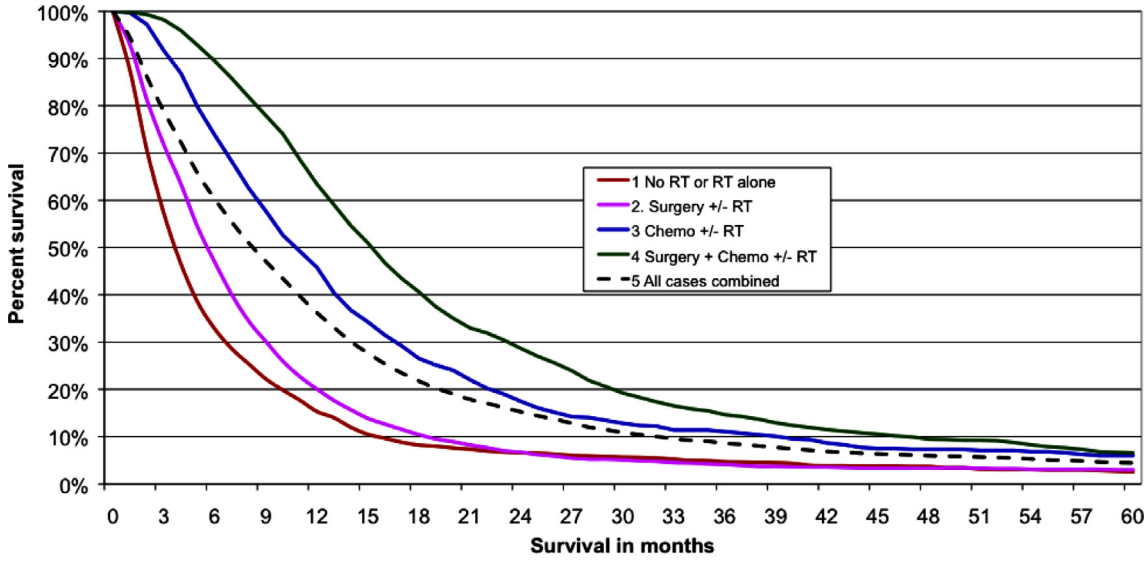

Fig. 6. Kaplan–Meier plot demonstrating survival by treatment type for patients with glioblastoma 20–70 years of age (2007–2010). RT: Radiotherapy. Radiotherapy data is not complete, but it is likely that most of the patients in groups 2–4 under 70 years of age received radiotherapy. Chemo: Chemotherapy. Surgery is any debulking procedure and does not include biopsy. There were significant differences between all treatment groups ($p < 0{\cdot}0001$).

stability [10,11]. A male preponderance of GBM is described previously, and the relative sex ratio is similar in England (1.66) to the US (1.56×) [2,10,12,13].

Regional variation in brain tumour patient incidence and survival has been examined previously. A study of 894 patients in Southern England in 1976 suggested an increased incidence in rural or smaller (<50,000) urban communities [12]. Incidence data presented in the current report are affected by different coding practices and age variations, limiting valid comparisons. These variations do not affect survival data, and poor survival in the Southeast of England may be related to the low percentage of patients having maximal treatment. The lowest maximal treatment rates were seen in London but did not correspond to low median survival rates. This discrepancy may be related to the younger aged population and poor data return for this item in London.

Outcome for patients with GBM is poor, in line with other western countries [11,14–16]. US data uses the SEER database, which covers 26% of the total population [7]. Published median survival rates in the US vary,

Table 2
Survival by treatment type for patients with glioblastoma aged 20–70 years of age (2007–2010). RT: Radiotherapy. Surgery: surgical debulking only. Chemo: chemotherapy. Bx: Biopsy. Figures following median, one, two and five-year survivals are 95% confidence intervals.

Group	Description	Number of patients	Average age	Median survival/ months	1 Year survival	2 Year survival	5 Year survival
1	No treatment or RT alone (minimal treatment)	1708	59.1	3.0 (2.8–3.1)	15.3% (13.6–17.1%)	6.6% (5.4–7.8%)	2.6% (1.8–3.5%)
2	Surgery ± RT (palliative surgery)	1645	59.0	5.2 (3.9–5.4)	20.1% (18.2–22.0%)	6.7% (5.6–8.0%)	3.0% (2.2–4.0%)
3	Bx + Chemo ± RT (non-surgical treatment)	634	54.7	10.1 (9.4–11.2)	45.8% (42.0–49.6%)	17.4% (14.6–20.5%)	6.0% (4.2–8.2%)
4	Surgery + Chemo ± RT (maximal treatment)	2008	55.1	14.8 (14.2–15.4)	63.4% (61.3–65.5%)	28.7% (26.7–30.6%)	6.6% (5.3–8.0%)
5	All cases combined	5995	57.3	6.0 (5.8–6.2)	36.2% (35.0–37.4%)	15.3% (14.4–16.2%)	4.5% (3.9–5.1%)

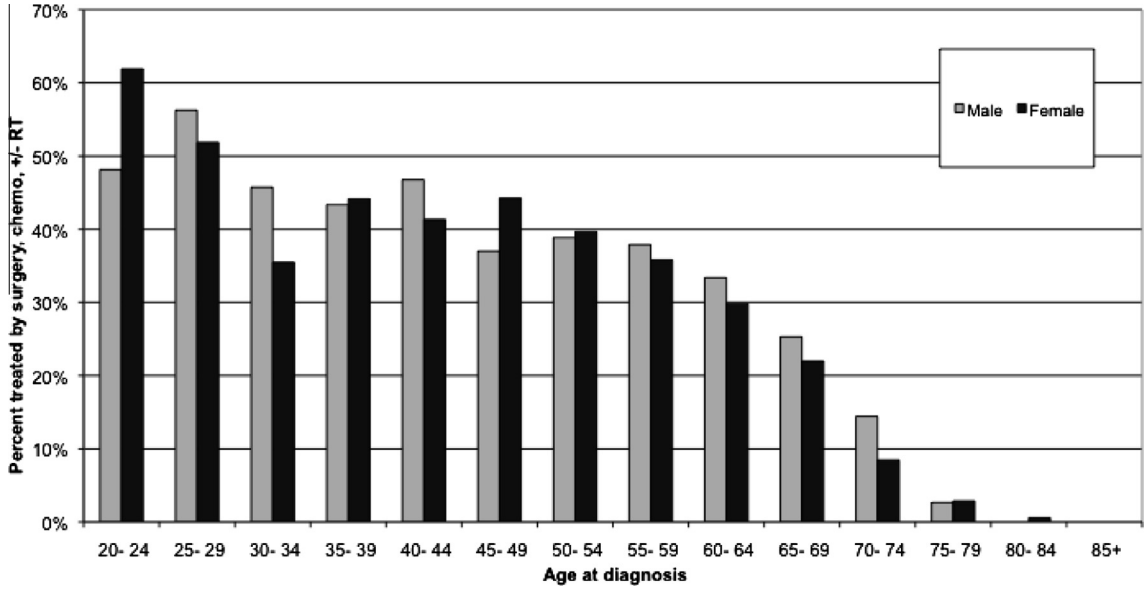

Fig. 7. Percentage of patients with GBM treated with Surgery, Chemotherapy, +/− radiotherapy (RT) by age: 2007–2010. Radiotherapy data is not complete, but it is likely that most of the patients in this group under 70 years of age received radiotherapy.

depending on the population and time frame observed, between 5.7 and 9.7 months [14–16]. One, 2 and 5-year survival rates in the US are quoted as being 35%, 13.7% and 4.7% rather than the English values of 28.4%, 11.5% and 3.4% respectively [7,14]. Because of the difference in populations, comparison of age range groups may be more accurate when comparing with US data. Age groups compare favourably between CBTRUS and English data for 1 and 2-year survivals, with better 5-year survival figures for England.

Increasing age is known as a poor prognostic factor for patients with GBM [7,16]. There is a stratified relationship between five year age increases between 30 and 85, and reduced median survival by 0.5–4.0 months for every age increment. This steady deterioration in overall survival does not take into account performance score, comorbidity, tumour biomarkers or the molecular variants of glioblastoma identified over the last few years that are found in different age ranges [8,9,17].

The absence of radiotherapy data and the failure to define linked chemotherapy type are weaknesses of this report. Studies using the SEER database show three quarters of US patients receive radiotherapy, and if no radiotherapy is given then median survivals are only 3 months [14,16]. As the current standard of care supports radiotherapy with other treatment options, and radiotherapy is relatively cheap to provide, is readily available, and median survival approaches the US figures, it is likely that English radiotherapy rates are similar to those seen in the US. The one quarter that did not receive radiotherapy are likely to be mainly within the elderly and minimal treatment groups, where survivals are poor. Temozolomide chemotherapy has been the standard of care since 2005, and other authors have assumed its use when describing unspecified chemotherapy provision [14,16]. Although only an estimate, the pack sales data suggest a substantial proportion of patients who received chemotherapy received temozolomide.

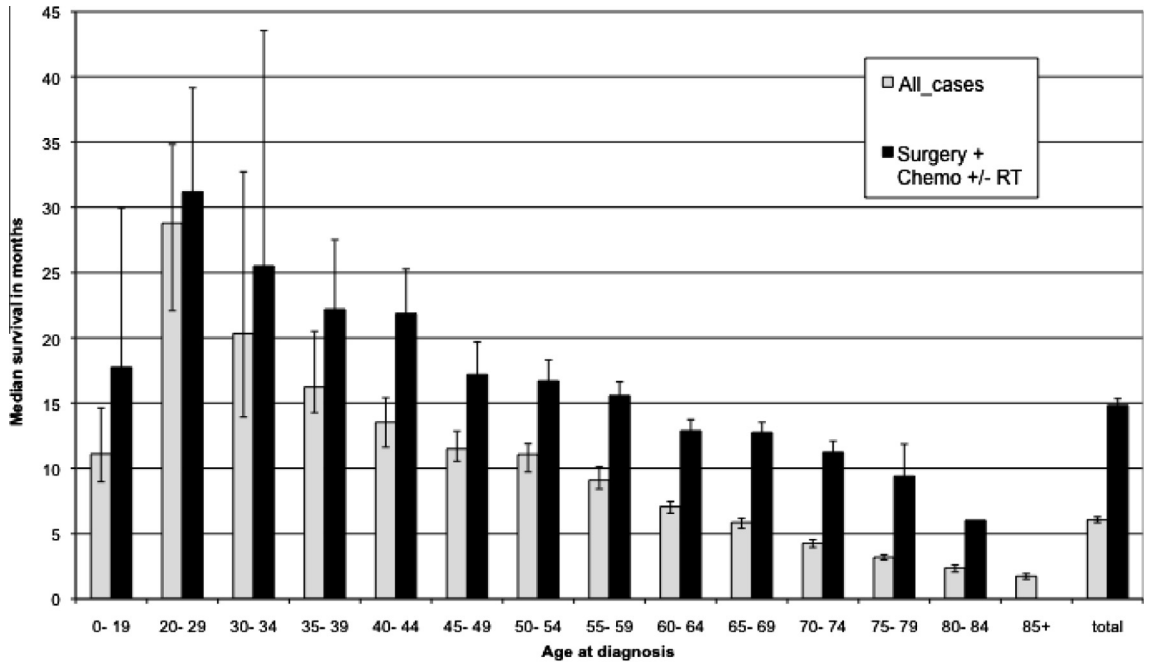

Fig. 8. Median survival of all patients by age compared to those treated with surgery, chemotherapy (Chemo), +/− radiotherapy (RT): 2007–2010. Radiotherapy data is not complete, but it is likely that most of the patients in this group under 70 years of age received radiotherapy.

Table 3
Regional variation in incidence, outcome and treatment 2007–2011. Incidence is per 100,000 population. Figures describe outcome as median life expectancy in months. Figures in brackets are 95% confidence intervals, except for Surgery + Chemo rates were brackets indicate absolute numbers. Surgery + Chemo are predicted rates for surgery, temozolomide and radiotherapy, for age 20–70 years inclusive, and are from the years 2007–2010 only. Lowest incidence, highest survival and surgery + chemo rates shown in shaded boxes, and highest incidence and lowest survival and surgical rates are shown in bold.

Area	Male incidence	Female incidence	Persons incidence	Male Survival/ Median	Female Survival/ Median	Persons Survival/ Median	Surgery + chemo rates
NORTH EAST	5.72 (5.10 to 6.38)	3.53 (3.08 to 4.02)	4.55 (4.17 to 4.94)	8.2 (6.7 to 9.2)	**5.0 (4.2 to 6.0)**	6.7 (5.7 to 7.9)	46.7% (143/306)
NORTH WEST	6.17 (5.77 to 6.59)	3.77 (3.48 to 4.08)	4.89 (4.64 to 5.14)	6.0 (5.4 to 6.8)	5.3 (4.7 to 5.9)	**5.7 (5.3 to 6.1)**	40.8% (351/861)
YORKSHIRE AND THE HUMBER	5.54 (5.11 to 6.00)	3.18 (2.87 to 3.51)	4.31 (4.05 to 4.59)	6.9 (6.0 to 8.0)	5.1 (4.3 to 6.1)	6.1 (5.6 to 7.0)	37.6% (232/617)
EAST MIDLANDS	**6.67 (6.16 to 7.21)**	**4.41 (4.02 to 4.83)**	**5.48 (5.16 to 5.81)**	**5.9 (5.3 to 6.8)**	6.0 (5.1 to 6.8)	5.9 (5.4 to 6.6)	37.0% (219/592)
WEST MIDLANDS	5.98 (5.54 to 6.43)	3.54 (3.22 to 3.88)	4.70 (4.43 to 4.98)	6.8 (6.1 to 7.6)	5.9 (5.1 to 7.4)	6.6 (5.9 to 7.3)	36.3% (241/664)
EAST OF ENGLAND	6.09 (5.66 to 6.54)	3.63 (3.32 to 3.96)	4.79 (4.53 to 5.06)	6.4 (5.6 to 7.0)	5.2 (4.4 to 5.9)	5.8 (5.3 to 6.4)	35.8% (246/688)
LONDON	5.50 (5.09 to 5.93)	3.30 (3.01 to 3.62)	4.32 (4.07 to 4.58)	6.9 (6.0 to 8.0)	6.2 (5.1 to 7.3)	6.7 (5.9 to 7.3)	**19.3% (130/673)**
SOUTH EAST	6.06 (5.71 to 6.43)	3.60 (3.34 to 3.87)	4.77 (4.55 to 4.99)	**5.9 (5.4 to 6.5)**	5.2 (4.7 to 5.8)	**5.7 (5.3 to 6.0)**	22.6% (231/1329)
SOUTH WEST	5.05 (4.66 to 5.47)	3.06 (2.77 to 3.37)	4.01 (3.77 to 4.26)	7.2 (6.3 to 8.1)	6.4 (5.2 to 7.6)	6.9 (6.2 to 7.7)	38.3% (215/562)
ENGLAND	5.87 (5.73 to 6.02)	3.54 (3.44 to 3.65)	4.64 (4.56 to 4.73)	6.5 (6.2 to 6.8)	5.6 (5.3 to 5.8)	6.1 (5.9 to 6.3)	33.5% (2008/5995)

In England, only 34% of patients overall received the maximal treatment, whilst a further 10% received chemotherapy with a biopsy. This means that less than half of all patients with GBM in England received the current standard of care. This may be due to significant numbers of elderly and poor performance patients not receiving this treatment. There is little population data available for comparison. The SEER database does not include chemotherapy data, so reports on US outcomes assume temozolomide use and do not provide comparable percentage figures [14,16].

There were relatively few paediatric patients in the time frame examined (1% of total). Brainstem glioblastoma was much more common in paediatric patients than adults, but this figure is probably an underestimate as diffuse pontine gliomas were not included. One, two and five year survivals were only slightly lower for England for age under 20 years than the US being 50.5%, 25.8% and 15.4% for England and 57.2%, 32.5% and 12.6% for the US respectively [7]. This age group did less well than the young adult [20–44]. This may relate to tumour position, as more brain stem tumours are seen in the paediatric population, difficulties with radiotherapy morbidity in the younger child, and a different paediatric genetic glioblastoma subtype [7,9].

English median survival figures for patients having maximal treatment (group 4, 14.9 months, 95% CI: 14.2–15.4) compare favourably with those from the EORTC trial (14.6 months) [3]. In the EORTC trial, 84% of patients had debulking surgery and this group had a median survival of 15.8 months as compared to 9.4 months for those that had a biopsy alone [3].

The elderly do poorly. Elderly patients are less likely to receive aggressive treatment, or get histological verification of the tumour type, and have poor median survivals [18]. Poor survival may be due in part to the variable underlying molecular genetics of the tumour group that is called GBM, in that older people tend to get less favourable subtypes [19–21]. The NOA-08 and Nordic phase III trials examined temozolomide treatment alone compared to radiotherapy alone and found no significant difference in outcome [22,23]. MGMT promotor methylation was associated with longer survival in patients treated with temozolomide alone, supporting its use in a decision pathway between temozolomide and radiotherapy [22,23]. Despite poor outcomes overall in the elderly, there appears a further survival advantage in those treated with combination surgery, chemotherapy, and radiotherapy, either due to careful patient selection or favourable molecular subtyping [18,24,25]. Quality of life data were not examined in the present study, and might mitigate slight increases in life expectancy. Outcomes in elderly patients treated without chemotherapy appear so poor that appropriately counselled patients may prefer palliative care rather than treatment regimes that will occupy much of the rest of their lives, and risk treatment related side-effects. The notion that a strict age cut off exists at age 65 or 70 cannot be supported by the steady decline seen in survival.

In conclusion, although median survival for patients with GBM in England is only 6 months, aggressive treatment at all ages is associated with extended survival similar to that described in clinical trials. Improved data quality currently being achieved will allow more searching analyses to be possible in the near future.

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Author contribution

All authors made a substantial contribution to the design of the paper, the interpretation of the results, and the final version of the paper. A Brodbelt wrote the paper, with the support and input of the other authors. D Greenberg, S Vernon, and T Winters also produced the data and most of the graphs, and provided the data for the tables. D Greenberg and T Winters provided the statistical analysis. All authors provided references used in the paper.

I confirm that I had full access to all data in the study and had final responsibility for the decision to submit for publication (A Brodbelt).

Conflict of interest statement

None declared.

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