

## Association between number of cell phone contracts and brain tumor incidence in nineteen U.S. States

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**Abstract** Some concern has arisen about adverse health effects of cell phones, especially the possibility that the low power microwave-frequency signal transmitted by the antennas on handsets might cause brain tumors or accelerate the growth of subclinical tumors. We analyzed data from the Statistical Report: Primary Brain Tumors in the United States, 2000–2004 and 2007 cell phone subscription data from the Governing State and Local Sourcebook. There was a significant correlation between number of cell phone subscriptions and brain tumors in nineteen US states ( $r = 0.950$ ,  $P < 0.001$ ). Because increased numbers of both cell phone subscriptions and brain tumors could be due solely to the fact that some states, such as New York, have much larger populations than other states, such as North Dakota, multiple linear regression was performed with number of brain tumors as the dependent variable, cell phone subscriptions, population, mean family income and mean age as independent variables. The effect of cell phone subscriptions was significant ( $P = 0.017$ ), and independent of the effect of mean family income ( $P = 0.894$ ), population ( $P = 0.003$ ) and age (0.499). The very linear relationship between cell phone usage and brain tumor incidence is disturbing and certainly needs further epidemiological evaluation. In the meantime, it would be prudent to limit exposure to all sources of electro-magnetic radiation.

**Keywords** Brain tumor · Cell phone

Cell phones were introduced to the U.S. in 1984 but were not widely adopted until the mid-1990s. By early 2000, the number of subscribers to cell phone services had grown to an estimated 92 million in the United States and 500 million worldwide. Some concern has arisen about adverse health effects, especially the possibility that the low power microwave-frequency signal transmitted by the antennas on handsets might cause brain tumors or accelerate the growth of subclinical tumors. Inskip et al. performed a case control study and concluded that their data did not support the hypothesis that the recent use of cell phones causes brain tumors, but the data were not sufficient to evaluate the risks among long-term, heavy users [1]. Hardell et al. performed a meta analysis of two cohort studies and 16 case–control studies and reported that long-term use (10 years or more) of cell phones long term use has been associated with increased risk of brain tumors [2]. Myung et al. found possible evidence linking mobile phone use to an increased risk of tumors from a meta-analysis of low-biased case–control studies [3]. A World Health Organization study has shown a significantly increased risk of some brain tumors related to use of cell phones for a period of 10 years or more [4]. The Interphone Study Group found no overall increase in risk of glioma or meningioma with use of mobile phones; but there were suggestions of an increased risk of glioma at the highest exposure levels, though biases and error prevented a causal interpretation [5].

In the current study we examined the relation of cell phone subscriptions to brain tumor incidence by US state.

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## Methods

The following sources were used:

Reports of brain tumor incidence 2000–2004 and population from 19 U.S. states: Az, Co, Ct, De, Id, Ma, Me, Mn, Mt, NC, ND, NM, NY, RI, SD, Tx, Ut, Va, WV, data from Table 9 of Ref. [6]. These 19 states were chosen because their cancer registries responded to the request of the Central Brain Tumor Registry of the United States for brain tumor data. Brain tumor types are shown in Table 1, which is derived from Table 1 of Ref. [6].

**Table 1** Types of brain tumors included in analysis (Information from Table 1 of reference 6)

Tumors of neuroepithelial tissue
Pilocytic astrocytoma
Protoplasmic and fibrillary astrocytoma
Anaplastic astrocytoma
Unique astrocytoma variants
Astrocytoma, not otherwise specified
Glioblastoma
Oligodendroglioma
Anaplastic oligodendroglioma
Ependymoma/anaplastic ependymoma
Ependymoma variants
Mixed glioma
Glioma malignant, not otherwise specified
Choroid plexus
Neuroepithelial
Non-malignant and malignant neuronal/glial, neuronal and mixed
Pineal parenchymal
Embryonal/primitive/medulloblastoma
Tumors of cranial and spinal nerves
Nerve sheath, non-malignant and malignant
Other tumors of cranial and spinal nerves
Tumors of meninges
Meningioma
Other mesenchymal, non-malignant and malignant
Hemangioblastoma
Lymphomas and hemopoietic neoplasms
Lymphoma
Germ cell tumors and cysts
Germ cell tumors, cysts and heterotopias
Tumors of sellar region
Pituitary craniopharyngioma
Local extensions from regional tumors
Chordoma/chondrosarcoma
Unclassified tumors
Hemangioma
Neoplasm, unspecified
All other

2007 Cell phone subscriber data from the *Governing State and Local Sourcebook* (<http://sourcebook.governing.com>).

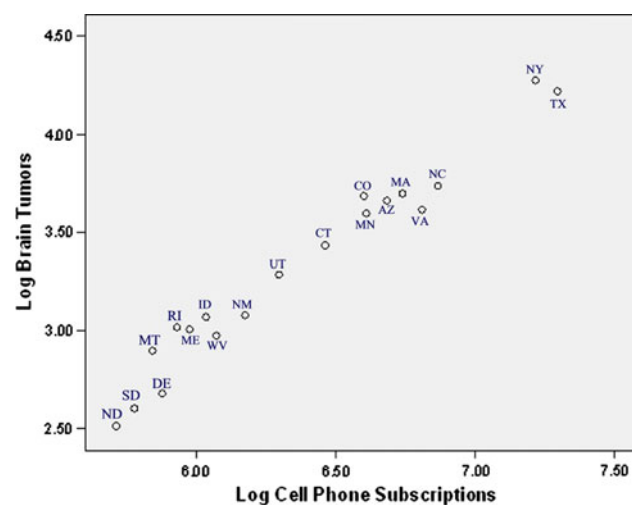
Mean population age and income by state 2004–2006 from [www.census.gov](http://www.census.gov).

## Results

There was a significant correlation between number of cell phone subscriptions and brain tumors ( $r = 0.950$ ,  $P < 0.001$ , Fig. 1). Because increased numbers of both cell phone subscriptions and brain tumors could be due solely to the fact that some states, such as New York, have much larger populations than other states, such as North Dakota, multiple linear regression was performed with number of brain tumors as the dependent variable, cell phone subscriptions, population, mean income (i.e. socioeconomic status) and mean age as independent variables. The effect of cell phone subscriptions was significant ( $P = 0.017$ ), and independent of the effect of mean income ( $P = 0.894$ ), population ( $P = 0.003$ ) and age (0.499).

## Discussion

The association of cell phones and brain tumors remains controversial. The only documented adverse effect from cell phones is an increased risk of automobile crashes when the phones are used while driving. Moreover, the lack of ionizing radiation and the low energy level emitted from cell phones and absorbed by human tissues have led many investigators to doubt that these devices cause cancer [7].



**Fig. 1** Log US cell phone subscriptions 2007 versus log brain tumors reported to the Central Brain Tumor Registry of the United States (2000–2004) in 19 U.S. states. There is a significant correlation ( $r = 0.950$ ,  $P < 0.001$ )

However, several animal studies have shown dysfunction of the blood–brain barrier caused by radiofrequency fields [8, 9]. Leakage of albumin into the brain has been demonstrated. The blood brain barrier consists of endothelial cells and the end-feet of astrocytes. Thus, one mechanism might be that microwaves induce blood brain barrier dysfunction so that carcinogenic substances may leak into the brain; the astrocytes especially might be exposed. There is some support for this mechanism in the study of Hardell and Carlberg, who found an increased risk for astrocytoma but not other types of malignant brain tumors [2]. An interaction with microwaves themselves might exist, since microwaves have been shown to induce several non-thermal effects in experimental studies, including free radicals [10, 11].

A weakness in the analysis that we have presented here is that tumor type was not taken into account. Indeed, Ahlbom et al., suggest that the risk associated with cell phone use may differ with tumor type [12]. Similarly, a meta-analysis by Khurana et al. demonstrated a significant cell phone effect when gliomas and acoustic neuromas were considered, but the observed effect did not extend to meningiomas [13].

It would be worthwhile to see if a linear relationship exists between cell phone subscriptions in each state and brain tumor incidence. Also, it might be possible to identify the type of tumors that have increased with cell phone subscriptions. Moreover, the cell phone-brain tumor relationship would be strongly supported if the numbers from each individual state showed similar linear relationships (thus ruling out, for example, that the increased number of brain tumors might be a disproportionate and disparate increase in the state of NY only).

Increased cell phone subscriptions may be a consequence of more and more children using these devices, while the number of adult users may not have increased at all. Indeed, Hardell and Carlberg found that the highest risk of astrocytoma and acoustic neuroma was in persons with first cell phone use under 20 years of age. This result is of biological significance, since a developing organ is more sensitive to carcinogenic agents, and the brain continues to develop until age twenty [2].

The linear relationship between cell phone usage and brain tumor certainly needs further epidemiological evaluation. In the meantime, it would be prudent to limit exposure to all sources of electro-magnetic radiation.

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