Intracranial tumors comprise approximately 95% of the estimated 17,200 brain and other nervous system malignancies projected to occur in 2001 in the US. Most brain cancers cannot presently be attributed to known risk factors. Recent media attention has focused on a possible link between cellular phone use and brain cancer. Network news programs ran their own tests of mobile phones, reporting to the public that some mobile phones exceed the maximum level of emitted radiofrequency (RF) energy allowed by the Federal Communications Commission. In the year 2000, it was estimated that there were 92 million cell phone users in the US, a number growing by one million every month. This report summarizes what we now know about the carcinogenicity of using cellular phones, as this is clearly a topic of wide concern.

Cellular Phones and Risk of Brain Tumors

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BACKGROUND

Intracranial tumors comprise approximately 95% of the estimated 17,200 brain and other nervous system malignancies projected to occur in 2001 in the US. Most brain cancers cannot presently be attributed to known risk factors. Recent media attention has focused on a possible link between cellular phone use and brain cancer. Network news programs ran their own tests of mobile phones, reporting to the public that some mobile phones exceed the maximum level of emitted radiofrequency (RF) energy allowed by the Federal Communications Commission. In the year 2000, it was estimated that there were 92 million cell phone users in the US, a number growing by one million every month. This report summarizes what we now know about the carcinogenicity of using cellular phones, as this is clearly a topic of wide concern.

WIRELESS TELEPHONES

Cellular (cell) phones operate with radio frequencies, a form of electromagnetic energy located on the electromagnetic spectrum between FM radio waves and the waves used in microwave ovens, radar, and satellite stations. Cell phones do not emit ionizing radiation, the type that damages DNA.

Cellular phone technology works on a system of geographically separated zones called “cells.” Each cell has its own “base station” that both receives and emits radio waves. When a call is placed from a cellular phone, a signal is sent from the cell phone antenna to that cell’s base station antenna. The base station responds to the cellular phone signal by assigning the phone an available radio frequency channel. When the RF channel is assigned, modulated radio signals are simultaneously received and transmitted, allowing voice information to be carried between the cell phone and the base. The base station transfers the call to a switching center, where the call can be transferred to a local telephone carrier or another cell phone.

There are four types of wireless telephones—cordless, transportable, mobile, and
portable phones. Cordless telephones, commonly used in homes, have base units that are plugged into telephone jacks and wired to local telephone service; these are not considered “cellular” phones. The question of health risks associated with cordless phones, which operate at 1/600th the power of cellular phones, has not been raised.6

Transportable, mobile, and portable phones are all considered “cellular” phones. Transportable phones are also known as “bag phones.” These operate with equipment stored in a small carrying case; the antenna of the bag phone usually extends from the carrying case. Because they are most commonly stored inside the car with the phone user, or carried by the phone user, bag phones can be a greater source of RF exposure than mobile phones. Transportable telephone use is declining as portable phones become more popular.

Mobile phones, also called “car phones,” usually have an antenna mounted on the outside of a car—on the window, fender, roof, or trunk. The antenna of a cellular phone is the phone’s primary source of radio frequency. The metal surface of a car provides a shield between the mobile phone user and the energy associated with the antenna. The physical distance between the mobile phone user and the antenna also serves as protection against RF energy. Because of these two obstacles—the metal car surface and the physical separation—users of mobile phones are thought to have little exposure to RF energy.6

The antenna of a portable phone is integrated into the body of the phone. Because the antenna of a portable phone is close to the phone user’s head, portable phones pose greater RF exposure than the other types of cordless phones.

Cellular phones are an important source of RF exposure for those who use them. The amount of RF to which a person is exposed depends on a number of factors. The number of “cells” in a geographical area depends upon the cellular phone traffic in that area. For example, large cities may have many cells per square mile, whereas a less-populated, rural area may have a single cell stretching over several square miles. The farther away a cell phone antenna is from its base station, the higher the power level needed to maintain the connection. Very small cells are therefore associated with much lower exposures.5

Each geographical cell has a different number of available channels. Cellular phones operate ideally with the least amount of interference from neighboring channels. To help achieve optimal operation, cellular phones automatically step down to the lowest power level available that still maintains a connection with the base station. On the other hand, any physical obstacle, such as buildings or trees, interfering with the connection between base station and cell phone forces the base station to increase the power sent to that phone. Therefore the amount of power sent from a base station to a particular cellular phone can vary, even within a single call.5

Manufacturers are required to report the specific absorption rate (SAR) of their product to the FCC. The SAR is the amount of RF energy absorbed from the phone into the local tissues. The upper limit of SAR allowed is 1.6 watts per kilogram of body weight.3 Exposure to RF also depends on the duration and frequency of cellular phone use, with more use implying more exposure. Finally, older cellular phones (analog models) involve higher exposure than newer, digital equipment.

EPIDEMIOLOGIC STUDIES

Because widespread cellular phone use is little more than a decade old, there has been limited opportunity to examine its long-term health effects. However, three recently published large case-control studies and one large cohort study have compared cell phone use among brain cancer patients and individuals free of brain cancer.

The first of the case-control studies
compared 233 brain cancer patients diagnosed between 1994 and 1996 in the Stockholm and Uppsala regions of Sweden, and 466 controls. The second study compared 469 brain cancer patients diagnosed between 1994 and 1998 in New York, Providence, and Boston, with 422 controls. The third and largest study compared 782 brain cancer patients diagnosed in Phoenix, Boston, and Pittsburgh between 1994 and 1998 with 799 controls. All three case-control studies had similar results:

- The brain cancer patients did not report more cellular phone use overall than the controls. In fact, most of the studies showed a tendency toward lower risk of brain cancer among cellular phone users, for unclear reasons.
- When individual types of brain cancer were considered, none was consistently associated with cell phone use. Although Muscat, et al. reported a nonsignificantly increased risk of neuroepitheliomatous tumors (odds ratio of 2.1 with a 95% confidence interval of 0.9 to 4.7), Inskip, et al. found a nonsignificant decrease (odds ratio of 0.5 with a 95% confidence interval of 0.1 to 2.0).
- When specific locations of tumors within the brain were considered separately, no associations with cell phone use were observed.
- None of the studies showed a “dose-response relationship” between cell phone use and brain tumor risk.
- None of the studies showed a clear link between the side of the head on which the brain cancer occurred and the side on which the cellular phone was used. Hardell, et al. found a nonsignificant but intriguing increase in ipsilateral temporal lobe tumors (the site of highest RF exposure). However, Muscat, et al. found a marginally significant (p = 0.06) trend for concordance of laterality of cerebral hemisphere tumors but not of temporal lobe tumors. Inskip, et al. found no relationship between laterality of phone use and location of tumors.

Results of the cohort study, which linked data on all of the 420,095 cellular telephone users in Denmark between 1982 and 1995 to the Danish Cancer Registry are in agreement with the findings of the case-control studies. Cellular phone use was not associated with an increased risk of developing brain tumors overall; nor was there an association with any brain tumor subtypes or with tumors in any anatomical location within the brain. As in the case-control studies, there was no correlation between brain tumor risk and RF dose, as assessed by duration of cellular phone use, date since first subscription, age at first subscription, or type of cellular phone used.

In summary, there is now considerable epidemiologic evidence that shows no consistent association between cellular phone use and brain cancer.

**ANIMAL STUDIES**

Most laboratory studies have reported a lack of RF-induced DNA damage.
No increase in spontaneous brain tumors or in intracranial tumors induced by transplacental exposure to nitrosourea was observed in two studies of Fischer 344 rats exposed to RF. The incidence of lymphoma was increased following whole-body RF irradiation in a transgenic animal model.

**WHAT PUBLIC HEALTH AGENCIES SAY**

Based on animal and human evidence like the examples cited here, several public health agencies have evaluated the carcinogenicity of cell phone use.

In October 1999, the Center for Devices and Radiological Health (CDRH) of the US Food and Drug Administration responded to increased media focus on cell phones and brain cancer by issuing a Consumer Update on Mobile Phones (including cellular phones). In that update, the CDRH stated, “the available science does not allow us to conclude that mobile phones are absolutely safe, or that they are unsafe. However, the available scientific evidence does not demonstrate any adverse health effects associated with the use of mobile phones.”

The FCC issued a statement in October 1999 in response to media assertions that some mobile phones exceed the maximum level of emitted radiation permitted. Claiming support from the Food and Drug Administration, the Environmental Protection Agency, the National Institute for Occupational Safety and Health, and the Occupational Safety and Health Administration, the FCC stated that its guidelines “already incorporate a large margin of safety between allowed levels of exposure and exposure thresholds that have been identified with known adverse health effects.” The excess levels of exposure reported by the media were “well within that safety margin, and, therefore, there is no indication of any immediate threat to human health from these phones.” The FCC is currently undertaking new research to verify the safety of RF levels emitted from mobile phones.

In the United Kingdom, the National Radiologic Protection Board Advisory Group on Non-ionizing Radiation concluded in May 1999 “…there was no human evidence of a risk of cancer resulting from exposure to radiations that arise from mobile phones.” The United States Environmental Protection Agency, National Toxicology Program, and the International Agency for Research on Cancer, have not evaluated the carcinogenicity of cell phone use.

**ASSOCIATION WITH OTHER HEALTH PROBLEMS**

The only documented adverse effect from cell phones is an increased risk of automobile crashes when the phones are used while driving. To date, there have been no claims made that cell phones are responsible for any other health problems. A small epidemiologic study from Germany found an association between uveal melanoma and exposure to mobile phones and RF-transmitting devices, but this has not yet been examined in other studies. The large Danish cohort study found no significant association with salivary gland tumors, leukemia, eye tumors, or any of 22 other cancer types.

**SUMMARY**

As cellular telephones are a relatively new technology, we do not yet have long-term follow-up on their possible biological effects.
However, the lack of ionizing radiation and the low energy level emitted from cell phones and absorbed by human tissues make it unlikely that these devices cause cancer. Moreover, several well-designed epidemiologic studies find no consistent association between cell phone use and brain cancer. It is impossible to prove that any product or exposure is absolutely safe, especially in the absence of very long-term follow-up. Accordingly, the following summary from the Food and Drug Administration Center for Devices and Radiological Health offers advice to people concerned about their risk:

If there is a risk from these products—and at this point we do not know that there is—it is probably very small. But if people are concerned about avoiding even potential risks, there are simple steps they can take to do so. People who must conduct extended conversations in their cars every day could switch to a type of mobile phone that places more distance between their bodies and the source of the RF; since the exposure level drops off dramatically with distance. For example, they could switch to: a mobile phone in which the antenna is located outside the vehicle, a hand-held phone with a built-in antenna connected to a different antenna mounted on the outside of the car or built into a separate package, or a headset with a remote antenna to a mobile phone carried at the waist. Again the scientific data do not demonstrate that mobile phones are harmful. But if people are concerned about the radiofrequency energy from these products, taking the simple precautions outlined above can reduce any possible risk.4

In addition, people who are concerned might choose digital rather than analog telephones, since the former use lower RF levels.

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