is that, for all causes, the 2485 deceased individuals had an overall mortality rate of 71% of the norm for the U.S. population as a whole. From this, you might conclude that holding an amateur license is definitely healthy! (Milham speculates that this is due to a lower rate of cigarette smoking among radio amateurs, but cites no statistics for this). Some of his categories also have lower than normal mortality rates: All circulatory diseases, all respiratory diseases, all accidents, all cancers (when grouped together) have mortality rates below 100% of the norm. However, two of the specific ICD categories had mortality rates exceeding the norm: Code 202 (other neoplasms of lymphoid tissue) and Code 203 (multiple myeloma) taken together had 43 deaths when only 26.6 would be expected in the normal population, for a mortality rate of 162% of the norm. Milham gives a $p < 0.05$ significance for this rate, implying a "one out of 20" probability that it is caused by chance alone. However, since Milham divided his original data into several different categories of cancer for analysis, it is much more likely than "one out of 20" that *at least one* category would exceed the norm by this much through chance alone. Thus, his 162% rate is not all that convincing about cause and effect. The proper conclusion from the Milham study would be that additional statistical studies of these cancers in larger or different populations of radio amateurs may be warranted. It is interesting that such studies were evidently not undertaken.

Next, let us consider some observations about amateur radio. The frequency range specifically cited by King, i.e., 50–60 MHz, does, indeed include a range assigned to radio amateurs. Before Wold War II (WW II), it was 56–60 MHz, i.e., the "5 meter band." In its infinite wisdom, the FCC changed this assignment to 50–54 MHz, i.e., the "6 meter band," following WW II in order to assign TV Channel 2 to 54–60 MHz, thus placing Channel 2 right on top of the harmonics from all the lower frequency amateur bands and creating endless grief for amateurs and TV viewers alike! Contrary to the impression given by King's statement that 50–60 MHz is ". . .a principal amateur-radio frequency. . .," the present 6-m band is arguably one of the least popular of all the amateur bands between 1.8–460 MHz. It is in only the last few years (a decade after Milham's mortality study) that this band has been included in the popular "made-in-Japan 100 Watt high-frequency transceiver" now used almost universally by amateurs. In the years before the Milham study, 5- or 6-m gear was home built and low power. It is likely that only a handful of amateurs the country possessed a 1-kW 6-m transmitter.

What is the impact of this on the Milham study? Milham could say nothing about the operating habits of the licensees he studied, beyond citing a survey of 8895 members of the American Radio Relay League in 1981 [2] that gave the "average amateur" as a 46 year-old male who was first licensed in 1963 and spent a total of 6.1 h a week on his hobby. Certainly nothing regarding whether or not the typical amateur used a 1-kW transmitter on 50 MHz. Thus, we are reduced to guess work about the operating habits of the individuals in the Milham study. You may make your own guesses; as an active radio amateur for 51 years (licensed 1949 as W6GEB, 1976 as W6FA), mine are as follows: 1% or fewer ever used 6 or 5 m, 0.1% or fewer used it as a significant part of their operating time, and fewer than 0.01% ever used 1 kW of power. If correct, this would put 678, 68, and 7 as the number of amateurs in the sampled population in these three categories. Thus, the overlap between King's physics and Milham's statistics seems nearly zero.

It is usually not worth the effort to comment on "unwarranted conclusions" in the technical literature. If the subject is unimportant, who cares? If the subject is important, further work will yield the truth. However, with a subject so "loaded" as electromagnetic radiation and human health, coupled with a tabloid press that exaggerates dangers, or even makes up new dangers, the possibility of a headline "Noted Harvard Professor Proves Amateur Radio Causes Cancer" cannot go unchallenged.

References

[1] S. Milham, Jr., "Increased mortality in amateur radio operators due to lymphatic and hematopoietic malignancies," *Amer. J. Epidemiol.*, vol. 127, no. 1, pp. 50–54, 1988.

[2] Amer. Radio Relay League, *Amateur Radio Survey 1980; A Look at Ham Radio as We Enter the Eighties*. Newington, CT: Amer. Radio Relay League, 1981.

Author's Reply

Ronold W. P. King

1) The claim that use is made of "simple dimensional scaling to show that 2.45 GHz for a mouse scales to 100 MHz for a man" is not correct. It is stated on the right-hand-side column of page 1537 of the above paper:[1] *"If scaling is assumed to be valid* according to the formulas $f_r h_r = f_m h_m$, $f_r a_r = f_m a_m$, where f is the frequency, h the half-length, and a the mean radius, these results could be significant for humans. Specifically, with $f_m = 100$ MHz, h_m, and a_m for a man, and f_r, h_r, and a_r for a rat or mouse, the frequency $f_r = 2450$ MHz gives $2h_r = 2h_m f_m / f_r = 100 \times 1.75/2450 = 0.071$ m or 7.1 cm. This is a reasonable length for a rat or mouse. The validity of such scaling is examined as part of this study." Later, on page 1540 at the end of Section IV of the above paper, it is stated: "An examination of (3) for z^i and (27) for $J_{1z}(\rho, z)$ shows that the radius a occurs in a^2 and in $k_1 a$, not only as $k_2 a$ as required for frequency scaling. It follows that *scaling as described in the introduction and as used by Gandhi [21] is not quantitatively valid in the frequency range 50–200 MHz.*"
2) The author is grateful to Dr. Bridges for his detailed information about the Milham study. Actually, it is irrelevant to the analytical determination of the electric fields and currents induced in the human body in the 50–200-MHz range. It seemed to provide an additional motivation for studying this range. However, the facts should have been looked into more closely or the reference omitted. Actually, in the more recent detailed study in [1], no mention is made of the Milham study until the very last sentence where it is stated: "Although no direct correlation is possible, the fact that statistical evidence found by Milham [17] indicates an increase in malignancies in some radio amateur operators over that of the general population should not be ignored."
3) Dr. Bridges' detailed information about frequencies used by amateur radio operators is interesting, but not particularly important with reference to the complete analysis in [1] of one actual amateur radio setup. Reference [1] provides detailed formulas

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The author is with the Division of Engineering and Applied Science, Gordon McKay Laboratory, Harvard University, Cambridge, MA 02138-2901 USA.

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[1] R. W. P. King, *IEEE Trans. Microwave Theory Tech.*, vol. 48, no. 9, pp. 1537–1543, Sept. 2000.

for distances and relative locations so that the interested reader can apply them to other similar setups and calculate approximate fields induced in the operator's body and cells. Other frequencies can be inserted in the formulas. The power level of 1 kW is convenient since, by multiplying it and the field induced in the body by any desired fraction, the formulas give the correct result. There are no "unwarranted conclusions" in [1]. A really unwarranted statement is the concluding sentence in Dr. Bridges' long discussion, viz., "Noted Harvard Professor Proves Amateur Radio Causes Cancer."

REFERENCES

[1] R. W. P. King, "Electric fields induced in the cells in the bodies of amateur radio operators by their transmitting antennas," *IEEE Trans. Microwave Theory Tech.*, vol. 48, pp. 2155–2158, Nov. 2000.