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REPORT
IN BRIEF

FINAL ASSESSMENT OF POTENTIAL HEALTH EFFECTS FROM EXPOSURE TO RADIOFREQUENCY ENERGY FROM THE PAVE PAWS RADAR

A 2005 National Research Council report concluded that there is no expectation of adverse health effects to the population from continuing or long-term exposure to the U.S. PAVE PAWS radar system in Cape Cod, Massachusetts, and in particular, no evidence for an increase in total cancers or cancers of the prostate, breast, lung or colon. The conclusions and recommendations of that report remain unchanged following a review of an epidemiological study released by the International Epidemiology Institute in 2005.



Photo courtesy U.S. Air Force

The U.S. PAVE PAWS radar system located at the Cape Cod Air Force Station in Cape Cod, Massachusetts (see Figure 1) began operating in 1979 with the main purpose of detecting and tracking sea-launched and intercontinental ballistic missiles. The public raised concerns over the possibility of adverse effects from the PAVE PAWS facility even before the facility opened. These concerns have continued, fueled in part by the fact that incidence rates for some cancers, including colorectal, breast, prostate, and lung cancers, are elevated for residents of Cape Cod compared to residents in other parts of Massachusetts.

Some of the first concerns voiced in 1979 were about the possibility of thermal effects, disruption to implanted medical devices (such as pacemakers), and secondary radiation effects from improperly grounded structures exposed to the radar. Those concerns led in part to a 1979 National Research Council (NRC) report, *Analysis of the Exposure Levels and Potential Biologic Effects of the PAVE PAWS Radar System* (the 1979 report), which assessed the level of human exposure from the radar. The report concluded that at estimated exposure levels, there are no known irreversible effects, but recommended that the Air Force conduct additional research and surveillance to evaluate the potential exposure effects of PAVE PAWS. There is no evidence that the Air Force or others followed up substantially on the 1979 report recommendations.

Recent public concerns have focused on the possible biological relevance of the radar's waveform and the possible health implications of radiofrequency energy passing through human tissue. In response to those concerns, Senator Edward M. Kennedy asked the U.S. Air

Force to fund a follow-up study through the National Research Council to address the effects, if any, of the PAVE PAWS radar over its two-plus decades of operation. In 2005, the National Research Council released An Assessment of Potential Health Risks from Exposures to PAVE PAWS Low-Level Phased-Array Radiofrequency Energy (the 2005 NRC report).

The 2005 NRC report was reevaluated by its authoring committee following the release of a large epidemiologic study by the International Epidemiology Institute in late 2005. In a 2006 letter report, the committee concludes that the IEI study does not alter the conclusions and recommendations of the 2005 NRC report.

The PAVE PAWS Waveform

Public concern over the PAVE PAWS waveform arose in part because of the perception by some that the PAVE PAWS waveform is different from other radar waveforms. Based on a review of recently collected waveform-characterization data, the 2005 NRC report concluded that the PAVE PAWS narrow-band radiation is in fact similar to that from narrow-band reflectors or so-called “dish” antennas. Another concern was that there could be precursors (energy forms that may occur before, during, or after the signal waveform) that have the potential to produce health effects. The 2005 NRC report concluded that the existence of precursors is highly unlikely and would be too small to be measurable for the narrow-band PAVE PAWS system.

The Potential for Biological Effects

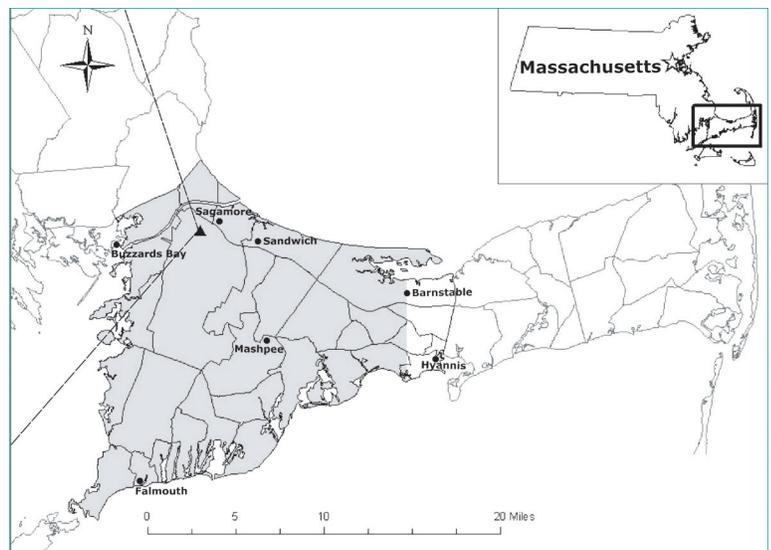
One way that scientists try to determine whether an environmental factor could lead to health effects is to look for possible mechanisms or pathways of biological change. At this time, there is no evidence of a mechanism shown to change biologic processes at power levels that are associated with the PAVE PAWS radar, although there are a number of possible mechanisms and pathways by which electric and magnetic fields could lead to changes at higher power-density levels. There are relevant data from experiments with animals and cells exposed under certain radiofrequency conditions that contribute to an understanding of the potential for human-health effects from PAVE PAWS. Based on a comprehensive review

of the animal studies and studies of other biological systems, the 2005 NRC report concluded there is no risk of cancer, reproductive or developmental effects, or neurobehavioral effects from exposure to radiofrequency energies. However, one study (Toler et al, 1997) demonstrated a significant and long-lasting effect on serum dopamine levels that support a biological effect that might result in an adverse health effect. The 2005 NRC report recommends that the Toler study be refined and repeated.

Estimating People’s Exposure

Based on 1990 census data, it was estimated that 12,773 of the total resident population (of which 11.8 % are children) were most likely receiving some exposure from the sidelobes of the PAVE PAWS radar beam (but not from the primary beam, which is angled upward). The 2000 census data estimated the population living in the area exposed to the PAVE PAWS radar-beam sidelobes to be 16,403. The measured data show that average power densities are consistently below 0.1 microWatts/cm², and generally in the 0.001-0.01 microWatts/cm² range at locations where the public would be expected to be exposed. Those levels of exposure are comparable to EPA studies of FM and TV broadcast bands (54-900 MHz) in the 1970s.

The potential for an individual’s exposure over time is determined by how long they reside at



The shaded area known as the “Upper Cape” is the area of concern. The PAVE PAWS radar (shown as a triangle near Sagamore) scans to the east within the dashed lines.

any possible point(s) where exposure might occur, and the level of exposure at that particular point, which will vary with time and other factors such as shielding from buildings and terrain. In spite of recent site-specific measurements and estimates of the PAVE PAWS power densities that now exist for a number of geographic locations, there are still no good data of a person's individual exposure to radiofrequency radiation from the PAVE PAWS radar.

Potential for Public-Health Effects

To date, observed elevated cancer-incidence rates among residents of upper Cape Cod compared to the rest of Massachusetts have not been adequately explained, although several environmental factors, including PAVE PAWS, have been studied. Another way that scientists try to understand the possible contribution of environmental factors to health effects is by comparing epidemiological studies that show distributions of disease. For PAVE PAWS, epidemiologic studies have been conducted for counties exposed to PAVE PAWS compared with counties that are similar but not exposed, for time periods both before and during the radar's operation, and for possible correlations between exposure and cancer incidence.

Lack of adequate human exposure data is the single biggest problem for most epidemiologic studies. The inability of investigators to explore the possibility of health effects from the PAVE PAWS radar was due principally to the lack of PAVE PAWS radiofrequency power-density information. Recent power-density models and measurements by the Broadcast Signal Laboratories enabled some epidemiological analyses by the 2005 NRC report committee and the IEI study.

Using power-density information from models provided by Mitre and recent power-density measurements and models provided by Broadcast Signal Laboratories, the NRC committee conducted a statistical analysis of reported occurrences of all cancers combined on the upper Cape as well as specific cancers, including colorectal, breast (female), prostate, and lung. The report found no increase in cancer risk with exposure to the PAVE PAWS beam using peak and average power-density estimates. The committee performed additional analyses to see whether some indicators of socioeconomic status might influence the results (an adjustment routinely made in health or epidemiologic studies). Socioeco-

omic status did not appear to influence results.

The 2005 NRC report compared the standard cancer-incidence rates, or SIRs, for total cancers, breast, colon, lung, and prostate cancer for the period of 1987-94 versus 1995-99 (which are the periods that the State of Massachusetts reports data). If radiofrequency energy were a contributor to cancer, the expectation would be an increase in cancers with increasing exposure. The analysis showed no consistent pattern of increase for the 5 towns in upper Cape Cod. During those two time periods, a decrease in SIR was observed in 15 out of 25 SIRs, an increase in 6 out of 25 SIRs and, no change in 4 out of 25 SIRs. These results indicate that increasing exposure to PAVE PAWS over time has not resulted in a detectable increase in cancer incidence.

International Epidemiologic Institute Study

The IEI study included a comparison of cancer mortality rates for periods of time before the radar was operational with periods of time during which the radar was operational. Their analysis showed no association between cancers and exposure to PAVE PAWS. The IEI study included analyses of county cancer mortality rates, surrogate dose-response analyses of mortality and hospitalization rates, cancer incidence rates, and birth weight.

The IEI study provided new information relevant to the assessment of potential health effects of the PAVE PAWS radar, including analysis of exposure to the radar and low birth weight, neurodegenerative disorders, and autoimmune disorders. In particular, the low birth weight analysis suggests that extensions of the present study are unlikely to find an association with exposure to PAVE PAWS radar.

The IEI study used census block group data and data at the zip code level in its analyses, which is the smallest geographic unit available thus improving the accuracy of the analyses. The 2005 NRC report had recommended that any future epidemiologic studies use census block group data in its analysis. However, the IEI analyses included some errors and methodological inconsistencies that make interpretation of the results difficult. One problem was the decision to include Worcester County in the comparison counties because it is a more urban county with many characteristics unlike those of the county under study (Barnstable County).

Conclusion

It is important to note that the IEI study, while well done for the most part, is just one additional study that supports the conclusion of no association between health effects and exposure to the PAVE PAWS Radar. However, because of some methodological inconsistencies, the NRC committee is reluctant to exclude the possibility of a difference in cancer mortality rates in the pre- and post-PAVE PAWS time periods.

Further studies might help to clarify some of the issues raised in the IEI report, although it is not clear that such studies would result in evidence sufficient to indicate that there are or are not adverse health effects resulting from the PAVE PAWS radar. If future studies are pursued, they should address new recommendations from the 2006 letter report and those in the 2005 NRC report not already addressed by the IEI study, including:

- more careful selection of comparison counties;
- personal exposure characteristics other than just residential location;
- additional known and potential confounders such as smoking, hospital admission

rates, pesticide exposures, occupational exposures, and other factors; and

- temporal trends based on annual changes in estimated disease rates rather than pre- and post-PAVE PAWS comparisons.

Based on the strength of the IEI birth weight study, the 2006 letter report recommends that no further studies of low birth weight be done. The 2005 NRC report also recommended that no future epidemiologic studies be conducted unless they are expected to have sufficient statistical strength, or so-called power, to be able to detect any possible health effects in the Cape Cod population.

It is extremely difficult, if not impossible, to prove ultimate safety. In the United States, various forms of safety or risk assessment are used along with regulatory guidelines to ensure that facilities, products, technologies, and other factors will not pose undue risk or harm to the public or environment. This committee has carefully evaluated the available scientific evidence and concluded that, at this time, there is no expectation of adverse health effects to the Cape Cod population from exposure to the PAVE PAWS radar.

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This report brief was prepared by the National Research Council based on the committee's reports. Permission granted to reproduce this brief in its entirety with no additions or alterations. For more information, contact the Nuclear and Radiation Studies Board at (202) 334-3066. *An Assessment of Potential Health Effects from Exposure to PAVE PAWS Low-Level Phased-Array Radiofrequency Energy* is available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu.

