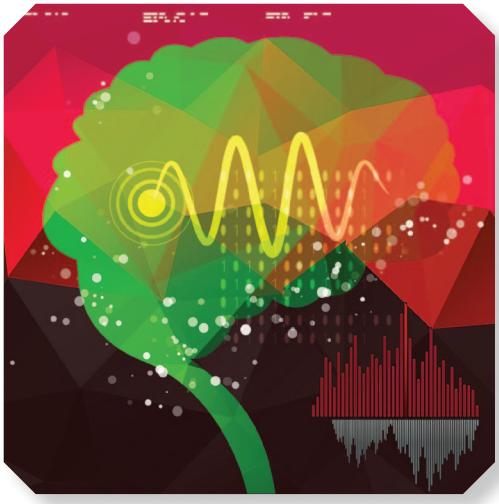
Health Matters

Human Exposure to RF, Microwave, and Millimeter-Wave Electromagnetic Radiation

■ **James C. Lin**

Current world population (the total number of human beings living on Earth) is about 7.4 billion, according to estimates by the United Nations Department of Economic and Social Affairs, Population Division [1].

Statistics and forecasts suggest the total number of mobile phone users worldwide will reach 4.8 billion by 2017 and is expected to pass the 5 billion mark by 2019 [2]. In 2014, ownership of mobile phones reached 60% of Earth's population. Mobile phone penetration is likely to continue to grow to 67% by 2019.



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Mobile Phones and Radiation

Mobile phones and other wireless devices and systems rely on RF or microwave radiation to function. They use RF or microwave radiation to send and receive text and voice messages, along with many other kinds of data. In addition to RF and microwaves, millimeter and terahertz waves are increasingly enlisted to support the rally toward ubiquitous, round-the-clock wireless connectivity.

Wireless applications of RF and microwave radiation are found nearly everywhere: on city streets and at other outdoor locales, within public transportation and automobiles, inside homes and workplaces, even worn on and embedded into human bodies. Besides mobile phones, wireless devices and gadgets show up as intelligent sensors, smart meters, security monitors, and various types of controllers in homes, offices, factories, health-care facilities, gyms, sports arenas, and elsewhere—often supported by such platforms as the Internet of Things, among other burgeoning technologies.

Today, many medical professionals rely on mobile information-access and messaging tools to improve communication, provide immediacy, and enhance decision-making capabilities associated with delivery of health care. Handhelds and wearables are commonly used for mobile tracking during fitness activities, monitoring vital signs, and conducting sleep research. They are also found as implantable and ingestible medical devices with integrated RF antennas for wireless communication (telemetry) supported by remote monitoring and control functions in many diagnostic and therapeutic procedures.

These applications and others are enabled by wireless technologies such as Wi-Fi, Bluetooth, and ZigBee and underpinned by networks, routers, base stations, repeaters, and satellite systems operating in the RF and microwave range.

RF and microwave electromagnetic radiation is the lifeblood of wireless systems. Once primarily an urban phenomenon in industrialized countries, in recent years demand for wireless access has seen rapid growth in virtually all parts of the world—growth

James C. Lin (lin@uic.edu) is with the University of Illinois at Chicago, United States.

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that is projected to continue for years to come. Meeting this demand will translate into exponentially greater human exposure to RF and microwave radiation.

Now, for the first time in its history, a ubiquitous source of RF radiation is being placed directly next to the heads (and bodies) of a large portion of the human race; in fact, the percentage of all people being exposed to RF electromagnetic radiation is rapidly approaching the percentage exposed to polluted air. (In 2013, 87% of the world's population lived in areas with pollution exceeding the World Health Organization's air-quality guidelines [3].)

Research and Warnings About Health Risks

Scientific research on the biological effects and health risks of RF radiation began in the 1940s, and guidelines for limiting exposure to RF electromagnetic fields were published in the 1960s with the objective of providing protection against the then known adverse health effects. In the interim, these guidelines have been periodically revised and updated.

Current guidelines regarding the RF range, for example, impose basic restrictions and limits on the specific absorption rate (SAR) from general public and occupational exposures so as to avoid both whole-body heat stress and excessive localized tissue heating, specifically to prevent any biological and health effects resulting from a body temperature rise of 1 °C or more over an average duration of 6 min [4], [5]. This level of temperature increase results from exposure of individuals, under moderate environmental conditions, to a whole-body SAR of approximately 4 W/kg for about 30 min. A whole-body average SAR of 0.4 W/kg has been determined as the limit to provide adequate protection for occupational exposure. An additional reduction factor of five was introduced for public exposure, giving an average whole-body SAR limit of 0.08 W/kg.

However, questions persist about safe long-term human exposure to low-level RF radiation. There is a general consensus that scientific knowledge is lacking in regard to long-term exposure beyond the existing basic restrictions on short-term exposure, for which there is an abundance of reliable data or evidence.

Since the initial research investigations, thousands of scientific studies have been published on RF biological effects and health risks. Many of them took place after the introduction of—and so were associated with—mobile telephony. A survey of these—regardless of their experimental design, quality, merits, limitations, flaws, or methodological weakness—suggests that more report no effects than report effects. However, few studies have been subjected to extant independent replication of results. Thus, the subject remains controversial, and considerable uncertainty remains due, in part, to constraints on research funding, as government-funded RF biological-effect science has dwindled, especially in the United States.

That said, since the late 2000s, a "secretive" five-year project has been single-sourced through a contract with the Illinois Institute of Technology Research Institute (IITRI) in Chicago to investigate whether long-term exposure to cell-phone-type wireless RF radiation can cause cancer in rats and mice [6]. This project is the largest animal cancer study ever undertaken by the National Toxicology Program and the National Institute of Environmental Health Sciences (NIEHS), with a price tag in excess of $25 million to U.S. tax payers [7]. Although years overdue and with huge budget overruns, the project appears not yet to have been completed. (Note that the life spans of rats and mice are about two years.) Staff members at IITRI remain mum about the work. To date, in contrast to the norm in science, they have not discussed any results or made any presentations of their findings at scientific meetings. The NIEHS has refused to release any progress reports or project documents.

An international panel of experts convened by the World Health Organization's International Agency for Research on Cancer (IARC) concluded in 2011 that exposure to RF electromagnetic fields, including those used by mobile phones, is "possibly carcinogenic" to humans [8]. The panel assessed available scientific papers and concluded that—while evidence was incomplete and limited—published epidemiological studies reporting increased risks of 40–200% for gliomas (a type of malignant brain cancer) and acoustic neuromas (a nonmalignant tumor of the auditory nerve on the side of the brain) among heavy and/or long-term users of mobile phones are sufficiently strong to support a classification of these devices as possibly carcinogenic to humans in terms of exposure to RF electromagnetic fields [9], [10].

Note that other scientific groups, such as the International Commission on Non-Ionizing Radiation Protection's Standing Committee on Epidemiology [9], evaluating the same data or evidence have concluded that any increased risk was entirely explicable by various biases or errors, believing that there is little possibility that mobile-phone use could increase risk of glioma or acoustic neuroma in users.

Nevertheless, Belgium responded by adopting new regulations to promote mobile phone RF radiation safety and banned the sale of mobile phones to children [11]. The French Health Agency recommended that children and vulnerable groups should take measures to reduce their mobile phone RF exposure [12].

The U.S. Federal Communications Commission (FCC) states that no scientific evidence currently establishes a definite link between wireless device use and cancer or other illnesses—but does note that some parties have recommend taking measures to reduce exposure to RF energy from mobile phones [13]. While the FCC does not endorse the need for these practices, it provides information on some simple steps that can be taken to reduce personal exposure to RF radiation from mobile phones. For example, it notes that wireless devices only emit RF energy when they are in use and that the closer the device is to the user, the more RF energy the individual absorbs.

The U.S. Food and Drug Administration (FDA) advises that "if there is a risk from being exposed to RF radiation from mobile phones—and at this point FDA does not know that there is—it is probably very small." But, the FDA continues, individuals concerned about avoiding even potential risks can take a few simple steps to minimize RF exposure, such as reducing the amount of time spent using mobile phone and using speaker mode or a headset to place more distance between the head and the mobile phone [14].

An "Ounce of Prevention"?

Full recognition of a public health risk takes time. The paradigm of "an ounce of prevention is far better than a pound of cure" seems to have fallen by the wayside many years ago. And it now often evokes strong responses, with monumental resistance from those who have profited from the mass marketing of mobile devices.

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Antibiotics save lives and remain a vital tool in the fight against bacterial infection in modern medicine. However, antimicrobial resistance has become a major challenge. The number of bacterial pathogens that have become resistant to antibiotics is increasing as a result of widespread and inappropriate use of antibiotics in health care and food production. Today, some 70 years since Alexander Fleming's 1945 Nobel Prize for the discovery of penicillin and its curative effects in various infectious diseases [15], too many of the hundreds of thousands of people who get infected worldwide with pathogens die each year, and much more needs to be done to curb inappropriate use of antibiotics.

Fleming had cautioned about antimicrobial resistance in his acceptance lecture, telling this story (and I paraphrase): "A Mr. X who suffers from a sore throat takes some penicillin. The dose is not sufficient to eradicate the streptococci but enough to make them resistant to penicillin. His wife picks up the bug, and she comes down with pneumonia. Mrs. X is treated then with this wonder drug, penicillin. As the streptococci are now resistant to penicillin, the treatment fails, and, unfortunately, Mrs. X dies."

No until 1986 did the IARC classify active tobacco smoking as carcinogenic in humans, announcing that there was sufficient evidence to conclude that tobacco smoking caused cancers not only of the lung but also of the upper digestive tract including the oral cavity, pharynx, larynx, and esophagus; the pancreas; and the lower urinary tract including the bladder and renal pelvis [16].

However, evidence of the harm done by tobacco smoking had been accumulating for more than 200 years prior—at first, with regard to cancers of the lip and mouth and, then, to vascular disease and cancer of the lung [17]. The evidence was generally ignored until several epidemiological studies linking smoking to the development of lung cancer were published in 1950. These studies stimulated more research that supported an association between smoking and lung cancer. However, the question of whether smoking was connected with lung cancer and various diseases was vigorously debated for many years, and general acceptance for the link to lung cancer came about only in the late 1960s—and, eventually, for other diseases in subsequent decades.

Given their growing ubiquity, is the promise of an "ounce of prevention" for mobile devices so far out of the question?

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