



## Taking a Breath...

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### Editorial

As a teen in the 70s, I would give my father a hard time about smoking in the house: The World War II Bronze Star Medal recipient who had once forced an enemy to abandon strongly fortified positions in Normandy would be 'forced' by his daughter to abandon a warm, comfortable position in our kitchen to smoke on our cold, poorly insulated, enclosed (I'm not a monster) Chicago porch. You see, studies were just coming out from the government regarding the dangers of second hand smoke, and I didn't want to breathe that stuff [1]. During my senior year in med school, I took what I considered the coolest elective out there: A 6-week rotation at the then Centers for Disease Control (CDC). There, I co-drafted a chapter in the 1989 U.S. Surgeon General's Report which examined trends in the public's beliefs, attitudes, and opinions about smoking since the first such report on smoking in 1964 [2]. The 1964 report had stated that cigarette smoking is a cause of cancer and other serious diseases based on over 7,000 publications, some originating in the 1950s [2]. Although the level of public knowledge regarding smoking hazards had grown since 1964, we found that many Americans still did not know and/or believe the health risks of smoking. For example, 15% of smokers in 1986 did not believe smoking increased the risk of lung cancer [2]. In terms of secondhand smoke, it was around the same time that the surgeon general finally concluded that involuntary smoking is a cause of disease in non-smokers [3]. It wasn't until 2006 that the surgeon general concluded that there is no risk-free level of exposure to secondhand smoke [4].

The awareness of ionizing radiation and its maleffects has had a similar evolution to that of smoking. For example, today, no sane person would agree to setting up an X-ray machine for casual public use in a local mall. Yet that's exactly what they did in the 60s in my Midwest hometown. As children, my siblings and I would have our feet X-rayed to ensure proper shoe fit. This shoe-fitting fluoroscope had been in use by shoe stores across America since the 20s [5]. Concerns about fluoroscope radiation had been published in the medical literature as early as 1948 [6]. Regarding the fluoroscopes, a 1949 JAMA editorial noted "Nevertheless, the injury of even one person in ten thousand could not be condoned if the chance taken yields but small reward [7]." Yet there we were, children wiggling our toes around, enjoying the new perspective of our feet with this new toy. About ten years prior, in 1950, Lewis et al. stated: "Yet, because of the latent period between cause and effect in low dosage radiation, it is impossible at present to determine merely by clinical examination whether or not deleterious influences have been produced by this device. It is also difficult to estimate the probability of harmful effect [5]."

The then American Standards Association (currently The American National Standards Institute) had recommended a limit of 0.1 roentgen per day of "general stray irradiation" and 2 roentgen per exposure to feet for shoe fitting machines [7]. Per Lewis, this "arbitrary" limit was vastly exceeded in practice. He goes on to conclude: "The growing probability of increasing use of ionizing radiations warrants vigorous governmental control or possibly elimination of procedures of questionable merit which involve public risk... The early history of the use of diagnostic X-irradiation without precaution and the subsequent appearance of skin and neoplastic changes after years of latency should provide adequate warning against careless exposure to any source of ionizing radiation [5]." These safety concerns of the late 40s to early 50s were eventually acknowledged over time. Still, by 1960, only 33 states had either banned these fluoroscopes or adopted strict regulation of their use [8].

In "On a New Kind of Rays," published in 1895, Wilhelm Roentgen had described how he measured the absorption of X-rays: "Thick blocks of wood are permeable. Boards of pinewood, 2 cm to 3 cm thick absorb very little. A sheet of aluminum with a thickness of 15 mm did not make the fluorescence vanish completely but reduced the effect markedly [9]." Today's recommended dose limits for ionizing radiation are still, in part, based on energy absorption by a given mass, now using tissue instead of wood. But because the biological effect of ionizing radiation is now also considered, various factors such as organ type, age of exposure and type of radiation are all

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factored in [10]. The risks of ionizing radiation are either a tissue reaction (severity determined by dose) such as a skin burn, or a stochastic effect (probability of occurrence, rather than severity, determined by dose) such as radiation-induced cancer. Tissue reactions have a dose threshold above which effects occur, while stochastic effects may not have an apparent threshold dose. Much like Roentgen's 1895 experiments, current radiation safety guidelines for radiofrequency (RF) radiation (a type of non-ionizing radiation used in wireless technology) are based solely on energy absorption: thermal effect is measured [11]. In a Report and Order adopted in 1996, the Federal Communications Commission (FCC) last established a set of guidelines for evaluating the environmental effects of RF exposure [12]. "These [24-year-old] guidelines remain in effect today and include limits for specific absorption rate (SAR, the present metric for highly-localized, close-in exposure at commonly-used frequencies) and maximum permissible exposure (MPE, the measure for more-distant, whole-body exposure and for whole-body exposure at higher frequencies) [13]." The MPE limits are based on exposure criteria quantified in terms of SAR, a measure of the rate of RF energy absorption (much like in 1895) [12]. Yet there is an overwhelming body of evidence in the international scientific community demonstrating the biological effects of wireless radiation as "clearly established to occur with very low exposure levels (non-thermal levels) to electromagnetic fields and radiofrequency radiation exposures [14]". As just one example, like the indirect effect of ionizing radiation on DNA, wireless radiation can cause DNA damage *via* free radical (oxidative effects) [14,15].

We're all familiar with the 200-foot (60.69 meter) macrocell towers that serve an entire city for wireless communication. Their lower-frequency waves travel miles, and, if we're fortunate, the towers are stationed miles away from our homes. Also, there are "tricks" we can use to avoid unwanted wireless radiation exposure, such as using a wired internet setup. Soon, due to a federal mandate, the simple lamppost you see outside your window today may well become a Small Wireless Facility ("small cell site") to deploy 5G [16]. Unlike macrocell towers, the higher frequencies associated with 5G will require small cell sites to be located more closely together, i.e., your street [17]. Per the FCC, 5G stands for the fifth generation of mobile communications. 5G uses millimeter (MMW) waves, "a higher-frequency band than 2G, 3G, or 4G ever used [17]." Joel Moskowitz, PhD, School of Public Health, and University of California, Berkeley states: "Millimeter waves are mostly absorbed within a few millimeters of human skin and in the surface layers of the cornea. Short-term exposure can have adverse physiological effects in the peripheral nervous system, the immune system and the cardiovascular system. The research suggests that long-term exposure may pose health risks to the skin (e.g., melanoma), the eyes (e.g., ocular melanoma) and the testes (e.g., sterility) [18]." Also, "Unfortunately, few studies have examined prolonged exposure to low-intensity MMWs [millimeter waves], and no research that I am aware of has focused on exposure to MMWs combined with other radiofrequency radiation [19]." Some of the most interesting millimeter wave research was performed by the U.S. military. Back in 1998, Pakhomov et al. concluded: "Such MMW effects as alterations of cell growth rate and UV light sensitivity, biochemical and antibiotic resistivity changes in pathogenic bacteria, as well as many others are of potential significance for safety standards, but even local and short-term exposures were reported to produce marked effects." And, "Many reported MMW effects could not be readily explained by temperature changes during irradiation [20]"

In their study of the Active Denial System, a non-lethal, directed-energy weapon using millimeter technology, the U.S. Department of Defense concluded that there was minimal risk of injury. This clean safety profile was apparently due to "Normal, innate, self-protect behaviors such as eye blink, head turn and aversion response... The sensation immediately ceases when the individual moves out of the beam [21]."

In December 2018, Senator Richard Blumenthal stated "the health hazards [of 5G] are unknown and unstudied. And that is a sign of neglect and disregard on the part of the Federal Communications Commission [22]." In a February 2019 senate hearing on the future of 5G wireless technology, in response to his question to the wireless industry about safety studies, the industry representative responded "...we rely on the expert agencies, we rely on the findings of the FDA and others as to the requirements to keep all of us safe. There are no industry-backed studies to my knowledge right now [23]." In January 2019, Representative Anna Eshoo introduced bill H.R. 530, "To provide that certain actions by the Federal Communications Commission shall have no force or effect [24]."

What does it take for the public, a scientist, or a government official to "believe" in and act on the science? I'm not sure. I just know that I was able to discern and act, based on the science, decades before my government, with just an 8<sup>th</sup> grade education. I don't want this piece cited decades from now, recounting our early history of the use of wireless radiation "without precaution" and reporting on the subsequent morbidity and mortality "after years of latency." We can do better than accepting the "boards of pinewood" experiments measuring only the thermal effects of non-ionizing radiation. Let's halt 5G and small cell site deployment until the safety profile of both is fully understood. Let's take a breath.

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