

# Electromagnetic Radiation Due to Cellular, Wi-Fi and Bluetooth Technologies: How Safe Are We?

By [Naren](#) and [et al.](#)

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## Abstract

*The electromagnetic radiation (EMR) emitted out of wireless communication modules in various IoT devices (especially used for healthcare applications due to their close proximity to the body) have been identified by researchers as biologically hazardous to humans as well as other living beings. Different countries have different regulations to limit the radiation density levels caused by these devices. The radiation absorbed by an individual depends on various factors such as the device they use, the proximity of use, the type of antenna, the relative orientation of the antenna on the device, and many more. Several standards exist which have tried to quantify the radiation levels and come up with safe limits of EMR absorption to prevent human harm. In this work, we determine the radiation concern levels in several scenarios using a handheld radiation meter by correlating the findings with several international standards, which are determined based on thorough scientific evidence. This study also analyzes the EMR from common devices used in day to day life such as smartphones, laptops, Wi-Fi routers, hotspots, wireless earphones, smartwatches, Bluetooth speakers and other wireless accessories using a handheld radio frequency radiation measurement device. The procedure followed in this paper is so detailed that it can also be utilized by the general public as a tutorial to evaluate their own safety with respect to EMR exposure. We present a summary of the most prominent health hazards which have been known to occur due to EMR exposure. We also discuss some individual and collective human-centric protective and preventive measures that can be undertaken to reduce the risk of EMR absorption. This paper analyses radiation safety in pre-5G networks and uses the insight gained to raise valuable concerns regarding EMR safety in the upcoming 5G networks.*

## Introduction

The ever-increasing adoption of wireless communication has created a very complex situation of electromagnetic radiation (EMR) exposure. With new technologies such as 5G, the number of devices will increase exponentially and operate on a broader frequency spectrum. With this upcoming technology, the society will be more connected than ever before, and would witness huge economic growth. However, it is very important to identify beforehand, if any, harmful or adverse effects resulting from increased exposure of human beings.

Currently, there are about 15 billion wireless local area network (WLAN) devices ranging from Wi-Fi routers to Internet of Things (IoT) devices [1], 9 billion mobile connections, and

about 67% of the world population currently uses mobile phones [2]. Any unidentified or unaddressed health hazard due to the use of these devices or exposure to their radiation could impact the health of people globally.

Several organizations at both national and international levels have established guidelines for limiting EMR exposure in residential as well as occupational scenarios. Scientific research on EMR exposure-related biological effects began as early as the 1940s [3], but gained significant pace in the early 2000s with the widespread increase of EMR exposure due to cellular communications.

The International Commission on Non-Ionizing Radiation Protection (ICNIRP) has issued regulatory limits on EMR exposure for the general public and workers. ICNIRP's 1998 guidelines have been adopted by most of the countries in the world today [4]. But these limits only take into account the thermal effects of EMR and dismiss evidence on the biological effects of EMR exposure as unclear or unsatisfactory findings. In addition, there are several standards prescribed by medical bodies such as the Building Biology, BioInitiative, and Austrian Medical Association Standards. These limits have been arrived at after extensive scientific research of thermal, non-thermal, chronic exposure, and biological effects carried out by health experts from across the world. On comparing these limits with those prescribed by the ICNIRP, it can be seen that the limits prescribed by the medical bodies are several orders of magnitude lower than those prescribed by the ICNIRP. Therefore, a clear understanding of the differences between these limits, and an assessment of the current exposure levels in accordance with both kinds of exposure limits mentioned above is the need of the hour.

In the literature, many research studies have analyzed health hazards due to EMR exposure [5]. Numerous adverse health conditions such as cancer, infertility, damage to the auditory system, alteration of blood cells and blood flow, mental, cognitive and sleep disorders, and impaired childhood development have been identified in various studies. We have explored the literature in this area and presented a section describing various health risks associated with EMR exposure.

The major contributions of this paper are highlighted below.

- We analyse radiation levels of commonly used cellular, Bluetooth, and Wi-Fi devices to estimate how safe they are to human beings in terms of radiation.
- The procedure followed in this work serves as a tutorial for the general public who can arrive at a good estimate of their radiation exposure with minimal technical knowledge or expertise.
- We review several works which have identified various health hazards resulting from EMR exposure and presents the findings to highlight dangers of excessive EMR exposure.
- Then, we suggest techniques for people as well as societies/organizations to protect themselves from excessive EMR exposure and also presents ways to minimize ambient EMR levels in different environments like schools, hospitals, and homes.

The rest of this paper is organized as follows.

In Section II, we discuss the nature of EMR used in wireless communication devices and the need to analyze EMR from various common sources such as mobile phones, laptops and

other cellular, Wi-Fi, Bluetooth and IoT devices.

In Section III, we discuss a few important standards and guidelines for EMR exposure which have been determined by scientific organizations/commissions to avoid EMR related health hazards in humans.

In Section IV, we present our findings on the radiation levels present in common use cases of popular devices.

In section V, we summarize the important health hazards of EMR exposure that have been documented and reported. In section VI, we describe some measures to protect ourselves from EMR and also discuss ways to minimize ambient EMR in public places. In section VII, we recommend some proactive prevention techniques which can be immediately adopted at both individual and societal levels to prevent harmful EMR exposure. In section VIII, we discuss our findings from section IV in light of sections II, III, V and VI. We finally conclude the paper in section IX.

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