

An Empirical Exploration to Impact of Wi-Fi (Wireless Fidelity) on Human Health

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Abstract— Internet of Things (IoT) is ideas that can visualize all things (objects) those are available around us as the part of Internet. The Internet of Things (IoT) is going to change each and everything including our day-to-day life. This time we can see the uses of the IoT nearby us like in shopping malls, communication, education, science, business, government, and humanity. Clearly, the Internet is one of the most important and powerful creations in all of human history. This time the wireless devices have become the essential part of our everyday life. The purpose of this paper is to investigate the effects of IoT wireless devices on human body. In IoT all devices will be connected via RF (radiofrequency) or Wi-Fi. These devices will emit the harmful radiations which will cause the diseases like male infertility, hearing impairment, brain tumor, fetus, effect on eyes, etc. Besides, these radiations of wireless system severely affect various parts of human body. Although there is limited scientific evidence of harm, suggestions are given as to how to reduce personal exposures to RF and Wi-Fi radiations.

Keywords- Radiation, Wi-Fi, Human Health, Radio Frequency, Cellphones, RF-emitting

1. INTRODUCTION

The word IoT (Internet of Things) was first time used by British technology Pioneer Kevin Ashton in 1999 to explain a system in which all objects in the world could be connected to the Internet/network by sensors. [2] Ashton coined the term to illustrate the power of connecting Radio-Frequency Identification (RFID) tags [3] used in corporate supply chains to the Internet in order to count and track goods without the need for human intervention. While the Internet has conventionally only connected computers and people, IoT carries composed all kinds of connected devices into a comprehensive network of allocated information. The capacity of information being collected and accumulated, allows the growth of big data with machine learning, systematizing the procedure of increasing meaningful perceptions. Acquiring the IoT is one of the big obstacles to IoT attainment its full prospective [1]. IoT has the potential to touch every domain, and almost every aspect of human life. Given below numbers indicate the impact IoT is expected to have:

- 70 percent a year growth through 2018 in total sales of clothing and accessories incorporating computer technology, rising from \$3 billion today to \$42.5 billion
- 8 billion mobile broadband access points by 2019
- 3.5 connected devices per person by 2015 and almost 7 by 2020
- 50 billion devices connected to the Internet worldwide by 2020
- 4.5 million IoT jobs by 2020
- \$14.4 trillion of value over the next decade
- \$97 billion additional revenue in Medical device industry by 2024
- \$3.3 trillion market for 'Smart City' applications and services by 2025

The IoT is the growing relationship between humans and things a relationship that is being redefined through technology, narrowing the divide between the two. [4]

2. WHAT ARE THE RADIO FREQUENCIES (RF) RADIATIONS?

The electromagnetic radiation combination of an electrical field and a magnetic field, which each oscillate perpendicular to one another as they travel through the space. [7] The electromagnetic spectrum (img.1) is having two characteristics propagated waves and of particles these are based on wavelength and energy carried. The electromagnetic (EM) spectrum is divided into two parts ionizing and non-ionizing regions. The electromagnetic waves, which fall inside the "Ionizing Radiation" area, have sufficient energy to remove tightly bound electrons from atoms, thus generating charged particles or Ions. This generated EM energy usually people thinking as 'Radiation'. [5] Rays with shorter wavelengths can carry more information and more energy.

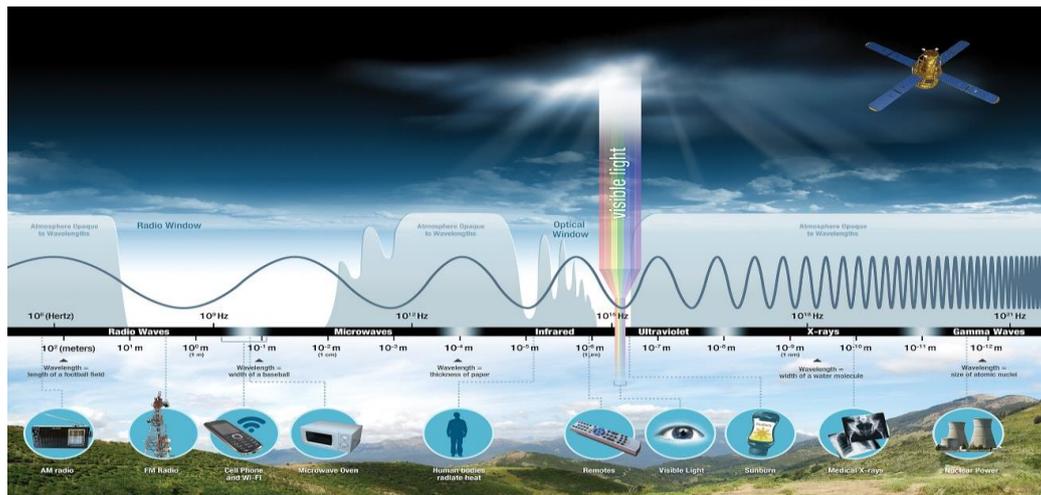


Fig. 1. Source: Science NASA [6]

Radiofrequency (RF) radiation is generated naturally during lightning and through discharges of the sun, stars and other astronomical groups. This time, man-made RF sources such as radio, cell phones, television, cordless (DECT) phones, wireless internet/network routers and home monitors are widespread and contribute to RF exposure depending on the technology uses, and distance from the sources. Radiofrequency based technologies are used in industries, houses, workplaces, universities, public spaces, and in public transportation (e.g., trains, flights, buses, mass transit, cars, cruise ships, and most recently airplanes). [5]

3. IMPACT OF RADIATIONS FROM VARIOUS DEVICES

The several types of radiation are being used for connecting the wireless devices and each type of radiation has different wavelength and frequency, the frequency of radiation is from 3 kHz to 300 GHz. There are different wireless devices, which are hand free, wireless router, tablet pc, Cell phone tower, Mobile phone [23].

3.1 Impact of Mobile phones Radiations

The effect of mobile phone radiation on human health is a subject of interest and study worldwide. The power output of older cell phones was as high as 2 Watt. Currently cell phones transmission is continuous at lower maximal power outputs of up to 250.0 mW. For near-field exposures from devices, such as cell phones, held close to the body, power density measures do not apply and instead, SAR is calculated. The SAR due to cell phone exposure is generally in the order of 1 W/kg, but can be slightly lower or higher depending on the cell phone model. When the cell phone is in use, its distance from the head is an important factor to consider. The absorbed power for a cell phone placed 10 cm from the head is more than 10 times lower than when it is held close to the ear, and about 100 times lower than when held 40 cm from the head, such as when texting. SAR can also increase if cell phones are used in enclosed areas such as offices due to signal dampening, thus requiring higher cell phone power output to reach the nearest router, or near metallic walls such as inside elevators, where waves reflecting off the walls can increase exposure. In general, as technology has improved, the RF energy emitted from individual cell phones has decreased. As the cell phone network is enlarged with more antennas installed, cell phones require less power to connect to the network, thereby lowering the user's exposure to RF waves. [6]

3.2 Impact of Cordless (DECT) phones Radiations

DECT (Digital Enhanced Cordless Telecommunication) phones are cause for concern in that the base station is usually kept in a convenient spot close by such as on a bedside table, or on your desk, or in the kitchen. The base stations of all older and most current models continually emit radiation even when not in use. When a handset is in use mode, the unit continuously radiates at high power from handset to base station. Even handset power will be down when close by a base station. The DECTs are always on high power when in use. There are two factors to be aware of in regard to wireless technologies [13].

1. There is the radiation between handset and base station.
2. There is the information-carrying radio wave (ICRW).

Microwave radiation always carries the voice/data information by means of modulations. Most of the Scientists are now trying to observe that pulsed information transfer by



Fig. 2. Cordless (DECT) phones [19]

The Wireless technologies radiation is in an organized fashion, these pulses interfere with the various biochemical processes going on in the body. We are Electromagnetic/ Electrochemical creatures, as can be knowledgeable when hooked up to an Electrocardiogram Electroencephalogram or an (ECG or EKG, a test which checks the heart related problems with the electrical activity). [7]

3.3 Impact of Cell phone base stations Radiations

The cellular phones first time introduced in the United States in the 1990s, after that these are increasing dramatically. The base stations of all older and most current models continually emit radiation even when not in use. The well-known use of cell phones has led to cell phone towers being placed in many communities and areas. These towers, also known as base stations, these are having electronic equipment and antennas that receive and transmit radiofrequency (RF) signals. [8]

In 2004 a series of power density measurements were conducted in British Columbia, by a BCCDC team at 20 different locations across the county using a dedicated RF survey unit mounted on a vehicle. The power density readings collected in the survey result showed that the base stations were largely compliant with Safety Code 6 (SC6) guidelines with exposures 3000 to 1,000,000 times lower than SC6 limits for uncontrolled (public non-workplace) environments. The detailed results of the surveys for all visited British Columbia locations are available online. [9] In 1998 to 2000 the United Kingdom conducts a survey for cell phone base stations at 118 locations. The measured power densities ranged from 0.01 mW/m² to 1 mW/m², equivalent to 0.0002% to 0.02% of ICNIRP public limits. [10]

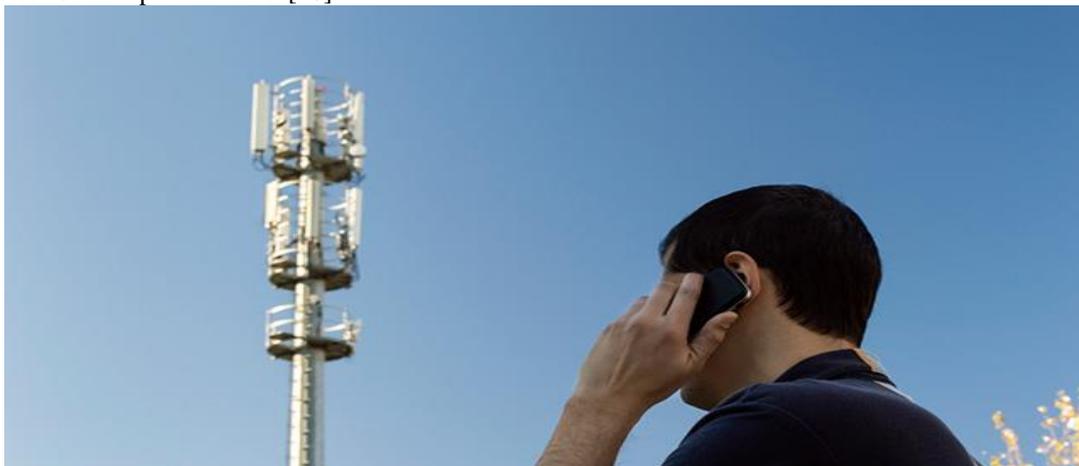


Fig. 3. Cell phone base stations Figure [18]

3.4 Impact of Wi-Fi computer networks Radiations

Wi-Fi is an acronym for "wireless fidelity" and it refers to a wireless network for computers that use radio frequency radiation for communication just like cell phones and two-way radios do. The World Health Organization (WHO) classified electromagnetic radiation (those are emitted by cell phones or Wi-Fi

transmitters) as a Class 2b carcinogen [18]. Thousands of research and studies have also confirmed many other negative biological effects of electromagnetic radiations, long before cancer has a chance to develop. This time the uses of cell phone, Wi-Fi and Wi-Fi hotspots are very common. Most of the people nowadays are exposed to cell phone and Wi-Fi radiation 24 hours a day, 360 days a year. Now days if you just standing at the mall exposes you to at least many different Wi-Fi signals at any given moment. Maximum hotels, restaurants and coffee shops offer free Wi-Fi while you eat or drinking. It is very less possibilities to find a hotel without Wi-Fi signals even in the rooms [15]. As a result, our living and sleeping in "electro smog" created by the constant exposure to electromagnetic fields has become the norm. A person no longer knows what it feels like to not be surrounded by electromagnetic radiation. The person cannot see it, feel it, hear it or taste it everyone assumes that we are not being affected by these radiations. Wi-Fi Dangers Made Worse by Cumulative Effect. At home and at work, dozens of wireless networks are streaming invisible radio waves through your space and body. Mobile phone and Wireless Network are the part of our daily life throughout the world. The Wi-Fi device allows the exchange data through wirelessly and Wi-Fi devices emit radio waves. Devices that use Wi-Fi are tablet pc, cell phone, audio player, PC and digital camera [14].

Many countries have done countless independent studies for health effects, damage to DNA, and the genetic material in every cell of our bodies. As per to Dr. Devra Davis in her book Disconnect, "More than a dozen different studies from highly respected researchers showed that radio frequency signals could damage DNA, alter the ability of cells to repair themselves, or cause them to die off at unusual rates." [11]

3.5 Impact of Smart Meters Radiations

Many studies link biological effects to Radio Frequencies radiation exposure, including increased cancer risk, cause of damage to the nervous system, adverse reproductive effects, DNA damage, and many more. One of the report published in Santa Cruz County California, confirmed Smart Meters pose a health risk. The AAEM (American Academy of Environmental Medicine) sent this report to the CPUC calling for a halt to wireless smart meters. Also this report from Dr. Carpenter, endorsed by 50+experts [12].



Fig.4. Smart Meters Radiations

The smart meter health complaints, which include sleep problems, nausea, heart palpitations, headaches, anxiety, and ear pain, focused and memory problems, immune, dizziness, nervous and hormonal system impacts. [16]

3.6 Impact of Baby monitors

Maximum baby monitors are working on wireless technologies and transmit information either over an analog frequency or digital frequency. Analog frequency can transmit over an FM radio band at 40 Mhz while digital uses one of several technologies such as Wi-Fi, Bluetooth and Digital Enhanced Cordless Communication (DECT) to transmit at different strength frequencies. Analog frequency are considering safer than digital, the concern is that it's wireless [13].

All wireless baby monitors produces and emit non-ionizing radiation (NIR). This non-ionizing radiation has two kinds of effects on our bodies:

- (1) Thermal effect
- (2) Non-thermal effect

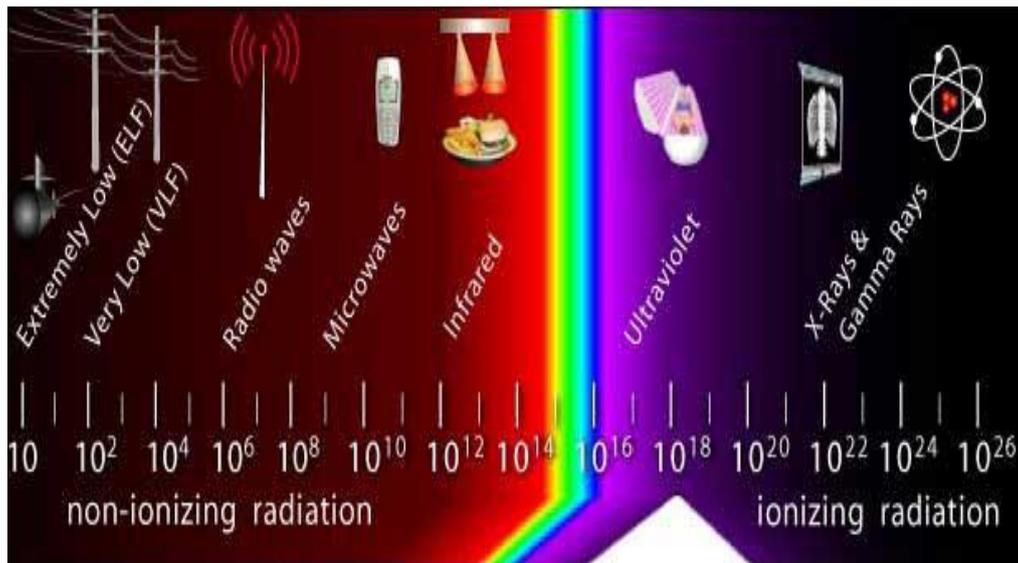


Fig. 5. Non-ionizing Radiation Frequency Figure: [20]

The World Health Organization told “To date, no adverse health effects have been established as being caused by mobile phone use.” With respect to the thermal effect, the WHO’s position is “at the frequencies used by mobile phones, most of the energy is absorbed by the skin and other superficial tissues, resulting in negligible temperature rise in the brain or any other organs of the body.” And regarding the non-thermal effect, they hold that “to date, research does not suggest any consistent evidence of adverse health effects from exposure to radiofrequency fields at levels below those that cause tissue heating.” [20]

4. THE POTENTIAL HEALTH EFFECTS FROM EXPOSURE TO RF WAVES

4.1 Risk of cancer

The main concern about the effects of exposure to RF is the development of cancer. Some studies have shown a connection between long-term and frequent use of cell phones and specific types of brain tumours, especially ipsilateral-tumours (on the same side of the head as the cell phone was used) [23]. Different types of radiation are being used for connecting the wireless devices and each type of radiation is having different-different wavelength and frequency. Normally frequency of radiation is in between from 3 kHz to 300 GHz. There are several types of wireless devices which are hand free, Wi-Fi router, tablets, mobile tower, Mobile phone, Bluetooth device, laptop connected with the wireless router and audio player [22].

Each and every wireless devices emit the harmful radiations, these cause of many diseases i.e., Brain Tumor, male Infertility, miscarriage risk, Ear Hearing Impairment, effect on fetus, increasing risk of cancer. . Radiations are also cause of some Heart disease, Parkinson’s disease, Alzheimer’s disease (20), asthma, insomnia, leukemia, high blood pressure, birth defects, rheumatoid arthritis, Immune system, sleep disturbance, headache etc. [21]

4.2 Reproductive effects

The focus of this studies on reproductive effects related with exposure to RF have major damage to sperm cells. This study is based on a mechanistic argument which hypothesizes that mobile phones exposure has a direct effect on sperm cells when it is positioned near the testes (carried on a belt or in pant pockets) or an indirect effect through reproductive hormonal changes. The balance of evidence is showing a relation between RF exposure and sperm abnormalities, these effects do not necessarily equate with infertility. [19]

5. HOW CAN ONE REDUCE PERSONAL EXPOSURE TO RF?

The intensifying use of RF devices for contact has postulated advantages of pragmatism, practicality, and transformation to society all together. The scientific suggestion to date propositions no clear indication of health effects related with community revelation to RF. As there are numerous causes of RF, decreasing or defecating one source may have controlled impact on entire personal contact to RF and possibly insufficient impact on exposure to EMF in customary. Expenditure of mobile phones has endorsed safety, with who saved uncountable lives through allowing remote communication [17]. Yet, mitigation strategies are to dispense an option for the concerned communal to decrease particular exposures to RF. In the case of reducing RF exposure to the general public, parallel strategies include nonuse, knowledge and design changes for RF-emitting expedients, distancing

and preventive use, and examination of shielding measures. In professional hygiene, the hierarchy for exposure reduction comprises substitution, administrative controls, engineering controls, and personal protective equipment [21].

RF Source	Substitution	Engineering Controls	Administrative Controls	Protective Equipment
Mobile Phones	Limit Use Use Landline Phones	Use phones with low SAR ratings Use phones that emit at lower output power in the real world scenarios	Keep phone at a distance from the head using handsets or speaker phone function Do not place in front of pocket or against body during use or when left on Limit duration of use Only use when connection with base station is good	Do not use shields
Cordless Phones	Use Landline Phones	Use models with a power-saving function that decrease output power when the connection is good Use models that do not produce beacon signals when placed in the base-station cradle	For some models, store the handset in base station cradle For some models, ensure base station maintains good connection with phone Keep phone base station at least 50 cm from area of use	Do not use shields
WLAN	Limit Use Use Wired Systems	Only use the antenna provided by the WLAN transmitter	Install access point at least 1m away from work area Position access point in central location so all devices have a good connection Do not hold device against body when in use Turn off WIFI when not in use	Do not use shields

Fig. 6. Mitigation strategies for reducing personal exposure to RF (Source: <http://www.bccdc.ca/resource-gallery/Documents/Guidelines%20and%20Forms/Guidelines%20and%20Manuals/EH/EH/Section14Final06062013.pdf>)

There are a number of options to reduce RF exposure from cell phones and RF headsets:

- Follow manufacturer's safety instructions.
- Switch off the cell phone when not in use.
- Spend less time on cell phones; use a wired landline telephone when you have the option.
- Disable accessory FM and Wi-Fi options when not in use.
- Limit the use of wireless earpieces such as Bluetooth headsets as these devices also use RF radiation for transmission.
- Use the text option.
- Keep the phone away from the body; when the phone needs to be powered, but is not in active use. Use the speaker option or headsets to increase distance between the head and phone.
- Use phones with low SAR ratings and which emit at lower output power.

6. CONCLUSION

The use of RF-emitting devices has increased dramatically over the years with the evolution of wireless technologies. There is wider availability of a variety of wireless devices including cell phones, Wi-Fi, laptops, tablets, and Bluetooth. Given their ubiquity and their proximity to users, cell phones are the greatest single source of overall population RF exposure. Ongoing research regarding the potential health effects of RF has not demonstrated clear evidence of impacts on cancer, reproduction, and development; however, at question is whether there are effects of aggregate and ongoing RF exposure on the population's health. Carefully conducted

studies on the relationship of acute and chronic health effects with measured aggregate exposures to radiofrequency waves from multiple devices, particularly for children, are needed to better understand whether everyday exposure to these RF sources has the potential to cause harm. It can be expected that exposure to the many different RF sources will increase over time. Wireless communication technology is changing and with it how, where, and how much people are exposed to RF. Regulatory measures do limit total population exposure to RF; however, individuals can choose to apply appropriate measures to reduce their own and their family's exposure to RF radiation, particularly from their use of cell phones.

ACKNOWLEDGMENT

We would like to thank my friends and colleagues, who provided us an efficient support to work on this atmosphere and good infrastructure. We would also like to thank to all the previous researchers who worked very hard and helped others to comprehend the subject of Wi-Fi and human health.

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