

EFFECTS OF WIRELESS BLUETOOTH EARPHONES ON HUMAN

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ABSTRACT

We live in a wireless environment. A large number of our laptops, tablets, phones, and televisions are wirelessly linked to the internet. Security cameras can transmit photos from across town, while smart home devices may switch off lights from across the room. Other typical wireless gadgets used in homes are: Wireless headphones, Smart watches, Baby monitor, Cordless telephone, Routers and signal booster, Computer keyboard and mice. Since 2016, the expected total number of wireless devices in the globe has almost tripled to 22 billion. According to a survey by the consulting company Deloitte, there are up to 25 wirelessly connected devices in the typical American home. Certain physicians and researchers are worried that this spike could mean that people are always exposed to a range of electromagnetic signals that may increase in the risk of cancer. The development of wireless headphones hardware is examined, with an emphasis on advancements in Bluetooth communication, battery life, and audio quality. It is explained how conventional Bluetooth standards gave way to Low Energy versions, like Bluetooth 5.0 and later, emphasizing the gains in energy economy and data transfer speeds. One of the main issues with wireless devices has been addressed by the integration of improved battery technologies, such as lithium-polymer and fast-charging capabilities, which have greatly increased usage durations.

Keywords: Wireless Headphones, Ionizing Radiation, Non-Ionizing Radiation, EMF Technology, Cancer, Hear Loss, Gadgets, ADHD, Tinnitus, EMR.

I. INTRODUCTION

Technology is always changing, particularly in the area of hands-free and wireless devices like headphones. Concerns about those advances, including the safety of Bluetooth wireless headphones, also exist. [4]

A petition expressing "serious concern" about the possible health risks—such as cancer—associated with non-ionizing electromagnetic field (EMF) technology was signed by a number of scientists in 2015 [5]. EMF technology is used by every Bluetooth gadget.

Even though technology is always changing, we have always been cautioned about the dangers and health risks that come with using current technology and following trendy digital trends. The health concerns connected to using Bluetooth headphones is one of the most widely known [6]. Many investigations and assertions have shown that using Bluetooth headphones for extended periods of time may be extremely detrimental to your brain's health and may even be a cause of cancer. [7]

The scientist's states that there are several concerns related to electromagnetic fields, such as elevated cancer risk, cellular stress, genetic damages, structural and functional alterations in the reproductive system, deficiencies in learning and memory, neurological diseases, and detrimental effects on overall health. [8] [9]

The International Commission on Non-Ionizing Radiation Protection has published guidelines on electromagnetic field exposure levels, which WHO has urged countries to adopt. However, the appeal states that because these guidelines "do not cover long-term exposure and low-intensity effects, they are insufficient to protect public health." [10]

II. WHAT IS BLUETOOTH TECHNOLOGY

A popular wireless communication convention called Bluetooth allows devices within a short range to exchange data seamlessly. Bluetooth, which uses the 2.4 GHz frequency band, is a great way to create cable-free connectivity between compatible devices because it allows wireless connections over a distance of about 10 meters [11]. Bluetooth is especially useful for battery-operated devices, such as smartphones, wireless headphones, and peripheral devices. It is noteworthy for its low power consumption. Devices can quickly identify and connect to one another without the need for complicated manual settings because to the technology's user-friendly design [12]. Bluetooth reduces interference by using Frequency Hopping Spread

Spectrum (FHSS), which guarantees dependable connectivity in congested wireless situations [13]. Bluetooth technology has advanced through the use of many profiles that specify particular features like music streaming (A2DP) and hands-free communication (HFP).[14]



Fig 1: It shows how Bluetooth is connected to various gadgets.[15]

III. ELECTROMAGNETIC RADIATION

A fundamental property of the physical universe, electromagnetic radiation is a wide range of energy waves that travel through space [16]. The dual nature of these waves is evident in the way that both the electric and magnetic fields oscillate perpendicular to one another while they move [17] [18]. A wide range of frequencies and wavelengths, including radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays, are included in the electromagnetic spectrum [19]. Every part of this spectrum has a specific function and interacts with matter in a different way [21]. For example, visible light is the limited band that is visible to the human eye, whereas X-rays are used in medical imaging because of their tissue-penetration capability. In many technical applications, such as radio communication systems, electromagnetic radiation is essential [22].

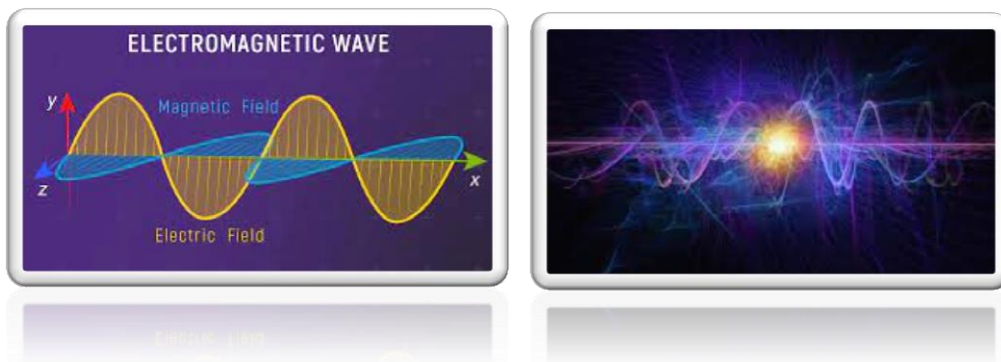


Fig 2: pictorial representation of electromagnetic wave.[20]

IV. RELATIONSHIP BETWEEN BLUETOOTH AND ELECTROMANGNETIC RADIATION

For devices to communicate wirelessly, Bluetooth technology depends on electromagnetic energy that falls into the radio frequency (RF) band. In particular, Bluetooth functions inside the electromagnetic spectrum's 2.4 GHz frequency band, which is a subset of radio waves [23]. This frequency range was carefully selected because it offers a fair trade-off between range, power consumption, and data transfer speed [24].

When it comes to Bluetooth, information is wirelessly sent between paired devices using electromagnetic radiation. Radio waves are used by Bluetooth-enabled devices, such laptops and smartphones, to establish

connections with other Bluetooth-enabled devices [25]. Antennas are used by Bluetooth-enabled devices to transmit and receive these radio waves, enabling the interchange of data, including files and audio for wireless headphones, files for file transfer or control signals for connected peripherals [26].

Bluetooth devices use a frequency-hopping spread spectrum (FHSS) technology to operate in the 2.4 GHz range [27]. In order to reduce interference from other devices using the same frequency range, FHSS rapidly changes the communication frequency between the devices. This method improves Bluetooth connection stability and dependability even in situations where there are several wireless devices present [28].

It is noteworthy that the electromagnetic radiation level linked to Bluetooth technology is deemed to be minimal and remains well within established safety boundaries. Regulations are followed in the construction of Bluetooth devices to guarantee safe operation and no damage to users or other nearby electrical equipment [29].

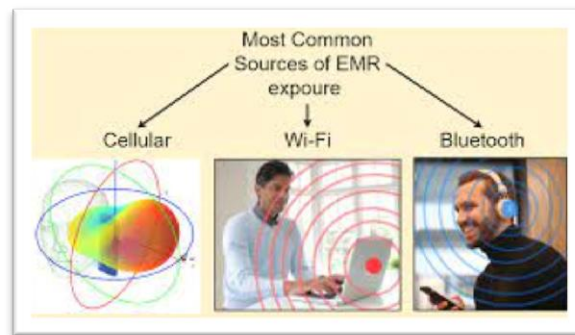


Fig 3: The relationship between Bluetooth and electromagnetic radiation [30]

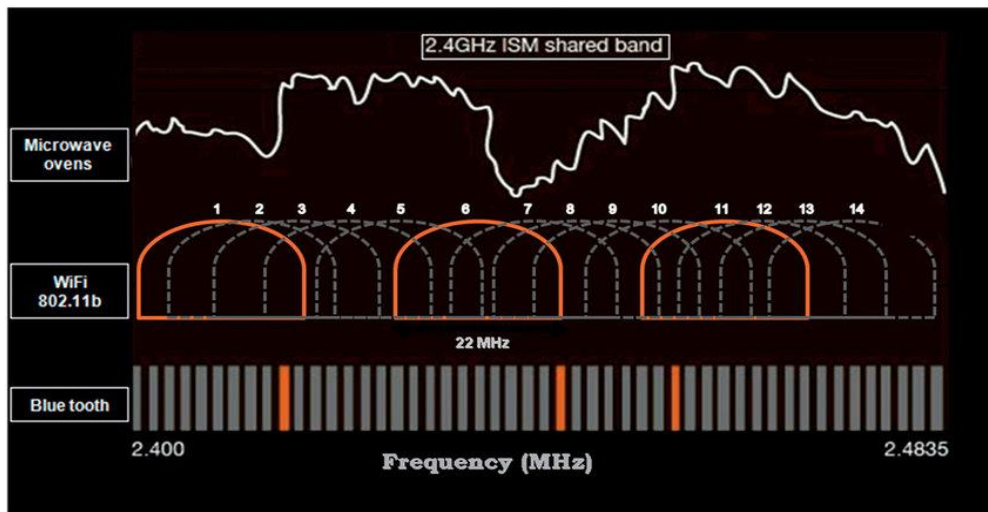


Fig 4: The frequency wave of Bluetooth

V. EVOLUTION OF WIRELESS HEADPHONES

In our life, headphones have become an essential accessory that we bring with us to the gym, the waiting room, or just anywhere we want to lose ourselves in music. Technological developments have changed headphones over time, turning them from large, corded gadgets into tiny, wireless marvels [31]. Let's explore the fascinating history of headphones, from their modest origins to their current status as contemporary icons.

The Unlikely History of Headphone Origins When they were first created in the 1880s, headphones were not intended for listening to music. Originally intended to be a tool for communication, operators used them to engage with clients [32]. But the first models, which weighed about ten pounds, were bulky and uncomfortable. Not until a French engineer submitted a patent application in 1891 for a lightweight and comfortable earbud-style headphone that the design started to resemble what we know today [33]. In 1895 the 1st civilian broadcast headphones emerged, allowing people to enjoy live music and information from the comfort of their homes.

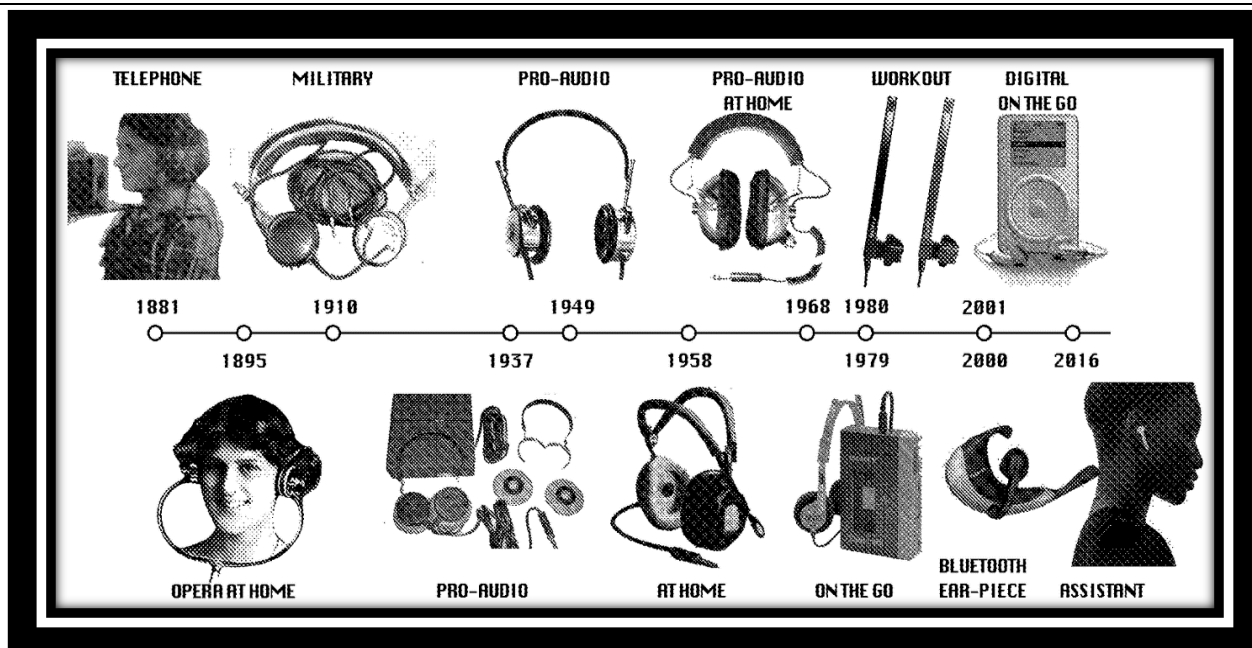


Fig 5: Evolution of headphones

From Dynamic Sound to Military Use The first contemporary headset was created in 1910 by the American corporation Baldwin and was intended for use by military intelligence operatives [34]. Excellent sound insulation was offered by this double over-ear headset, which served as the model for all subsequent headphone designs. The first dynamic headphones were introduced in 1937 by German scientist Eugen Beyer, and they had remarkable sound quality. The notion of active noise cancellation technology was created by the creator of BOSE in 1978, and as a result, commercial noise-canceling headphones were first introduced in 1989 [35].

Walkman and Beyond With the development of stereo headphones in the 1950s, which provided a more immersive listening experience, major breakthroughs were made. Sony's innovative Walkman turned headphones into a portable music player in 1979. People could now listen to music on the fly like never before thanks to foam ear cushions and portable sound equipment [36]. This completely changed the way we listen and paved the way for upcoming versions of portable headphones.

The Unbounded Potential of Headphones in the Future Bluetooth headphones have developed to satisfy a wide range of demands and tastes, and they are now considered a necessary item by many. Bluetooth headsets are always evolving, including capabilities like voice control, active noise cancellation, waterproof and dustproof construction, stereo audio, mono calls, and more. Headphones are set to undergo even more revolutionary changes with the emergence of virtual reality (VR) and augmented reality (AR), which promise a panoramic and immersive audio experience [37].

The development of headphones has been shaped by ongoing innovation, making their journey nothing short of extraordinary. One thing is certain as we look to the future wireless headphones have ingrained themselves into our daily lives, providing us with access to an endless array of options and sounds.



Fig 6: Evolution of headphones [38]

VI. TYPES OF WIRELESS HEADPHONES AND ITS SIDE EFFECTS

Wireless headphones come in various types, each with its own advantages and considerations. However, it's important to note that while wireless headphones provide convenience, they also have potential side effects associated with prolonged use. Here are some common types of wireless headphones and considerations for their usage:

1. **Bluetooth Earbuds and True Wireless Earbuds:** Advantages: Portable, lightweight, and suitable for active lifestyles. side effects: Prolonged use at high volumes may contribute to hearing loss. Earbuds that fit deeply into the ear canal can also increase the risk of earwax impaction or ear infections. [39][40]



Fig 7: True wireless earbuds

2. **Over-Ear Wireless Headphones:** Advantages: Immersive sound quality, effective noise isolation or cancellation side effects: Over-ear headphones can cause discomfort during extended wear, and the snug fit may contribute to heat and moisture buildup, potentially leading to skin irritation or acne. [39][40]



Fig 8: over ear wireless headphones

- 3. **On-Ear Wireless Headphones:** Advantages: Compact design, more breathable than over-ear headphones. Side effects: On-ear headphones may press against the ears, causing discomfort during prolonged use. They may also provide less effective noise isolation compared to over-ear options.[39][40]
- 4. **Neckband Headphones:** Advantages: Convenient design, stays in place during activities. Side effects: The constant pressure on the neck may cause discomfort for some users. Additionally, the proximity to the neck can lead to heat and sweat buildup.[39][40]



Fig 9: neckband headphones

- 5. **Bone Conduction Headphones:** Advantages: Leaves ears open, suitable for outdoor activities. Side effects: Sound quality may not match traditional headphones, and users may experience discomfort due to the vibration sensation on the bones.[39][40]



Fig 10: bone conduction headphone

- 6. **Sports Headphones:** Advantages: Sweat-resistant, designed for secure fit during workouts. Side effects :Intense physical activity may lead to increased moisture and potential for ear infections. Users should clean headphones regularly.[39][40]



Fig 11: sports headphone

- 7. **Noise-Canceling Headphones:** Advantages: Effective in reducing ambient noise for a better listening experience. Side effects: Prolonged use of active noise cancellation may contribute to ear fatigue. Users should be mindful of their surroundings, especially in potentially hazardous environments.[39][40]

VII. WIRELESS HEADPHONES

Both ionizing and non-ionizing radiation exist. Although non-ionizing radiation is capable of moving atoms, it is not able to extract electrons from them. Ionizing radiation, on the other hand, has the ability to do both. Because non-ionizing radiation carries less energy, there is a lower chance of health effects. Your tissues and DNA can be harmed by ionizing radiation, which includes radioactive waste and X-rays. If damaged cells are not properly repaired or eliminated by the body, they may develop into cancer [41]. Anything or anything exposed to something that can cause cancer is a carcinogen [42]. Certain medical procedures, such as radiation therapy, are examples of exposures that may be considered carcinogenic.

As a form of non-ionizing radiation, Bluetooth technology is safe and does not cause cancer [43].

Food and Drug Organization. Cell phones and radio frequency radiation. Conclusions about Bluetooth's association with an increased risk of cancer are yet lacking. Research has not been able to prove that radiofrequency radiation, particularly from cell phones, is harmful to one's health. However, more research is required [44].

Radiation safety regulations for the quantity of radiation released by consumer electronics are set by the US government. Even when pressed up on the skin, Bluetooth gadgets are much below that threshold. Foster made the observation that the Apple Air Pod antenna, which is used to receive and send radio waves, is not located inside the ear canal. Rather, the antenna is located in the portion that extends below the ear and stays outside. Even so, you can take off wireless gadgets from your head or ears when not in use to lessen your exposure.

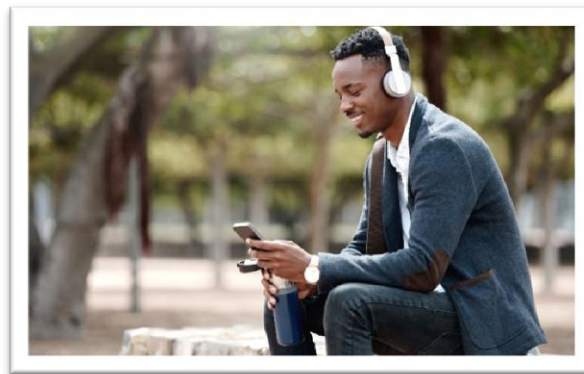
Department of Public Health in California. The CDPH publishes recommendations for minimizing exposure to cell phone radio frequency energy [45].

VIII. ARE WIRELESS HEADPHONES ARE SAFE?

It is important to be aware of health dangers that are more immediate than minute levels of radiation, regardless of the kind of headphones you wear.

"If you're walking around with your earbuds blasting, and you walk out in front of a car, that's a lot more dangerous than some theoretical tumor 20 years down the road," Foster said [46].

If you wear headphones carelessly, you risk damaging your hearing. Although hearing loss cannot be stopped, it can often be avoided. It is recommended to keep your headphone use to 60–90 minutes per day, with frequent pauses and a maximum volume of 60% to 80%. If you want to listen for longer than ninety minutes, turn the level down even more [47]. Foster said that if you want to be even more cautious, then avoid utilizing wireless technologies. Use wired headphones instead.



Noise-canceling headphones are recommended by the Centers for Disease Control and Prevention (CDC) to help prevent you from being tempted to turn up the volume to drown out other sounds [48]. hearing loss brought on by noise. If you are going for a stroll or are in any other circumstance where it could be dangerous to not be able to hear what is going on around you, noise-canceling headphones are not a suitable option [49].

IX. CONCLUSION

As of right now, there is not enough evidence to back up the claim that using Bluetooth headphones is risky. Scientists are unsure about the link between high exposure to nonionizing electromagnetic radiation (EMR) and harm, despite some data suggesting that it may be hazardous. It is imperative to bear in mind that cell phones generate far more Trusted Source EMR than Bluetooth headphones. However, experts are still unsure about how safe it is to wear Bluetooth headphones. Because of this, some people might find it best to avoid using Bluetooth headphones [50]. Reducing their usage of Bluetooth headphones and other wireless gadgets is one way they might achieve this.

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