

# The Effect of Electromagnetic Radiation due to Mobile Phone Use on Thyroid Function in Medical Students Studying in a Medical College in South India

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## Abstract

**Background:** Enormous increase in mobile phone use throughout the world raises widespread concerns about its possible detrimental effect on human health. Radiofrequency waves are emitted by cell phones. They are non-ionising and the effect on the thyroid gland is part of their non thermal effects. The thyroid gland may be particularly vulnerable to this effect because of its normal anatomical position. **Materials and Methods:** The study was done to explore the association between radiation exposure and thyroid dysfunction among mobile phone users. It had an exploratory design and unit survey method to collect information from all medical students in a medical college in South India. Inclusion criteria included active use of mobile phone prior to and during the study period. Criteria for exclusion was presence of pre-existing thyroid disease, thyroid nodule, thyroid goitre/nodule and altered thyroid function. **Results:** The sample size was 83 undergraduate students. 71% of respondents had no family history of thyroid illness. Among the remainder, 20.5% had a first degree relative with thyroid dysfunction, 8.4% had a second degree relative affected. Clinical examination revealed that 79.5% of the respondents were normal, 13.6% had thyroid swelling, 3.6% had symptoms of thyroid dysfunction and 3.6% had both thyroid swelling and symptoms of thyroid dysfunction. 53% of the respondents spent 0.5 hrs on an average talking on the phone daily, 28.9% spent 1.5 hrs daily and 10.8% of respondents spent over 3.5 hours. We found there was a significant correlation between total radiation exposure and an increase in TSH among both groups – in those with and without family history of thyroid illness. **Conclusion:** In our study there was a significant correlation between total radiation exposure and increasing TSH values among both all respondents.

**Keywords:** Mobile phone use, nonionising radiation, radiation exposure, radiofrequency waves, thyroid dysfunction, thyroid gland

## INTRODUCTION

The enormous increase in mobile phone usage throughout the world raises widespread concerns over its possible detrimental effects on human health.<sup>[1-5]</sup>

Electromagnetic radiation in radiofrequency (RF) region is emitted by cell phones. The Radiofrequency waves (RFW) are nonionizing in nature and cannot ionize molecules in our body. The effects of RFW caused by the rise in temperature are called thermal effects and the changes in metabolism without a rise in temperature are called the nonthermal effects.

Cell phone radiation is said to affect thyroid gland metabolism as a part of its nonthermal effects. These RF waves emanate from the antenna, which is part of the body of a handheld phone. The waves are strongest at the antenna and lose energy

quickly as they travel away from the phone. The body tissues closest to the phone such as the thyroid and brain absorb more energy than tissues further away.<sup>[4,6]</sup>

The possibility of induction of any significant physiological effects in humans by RF radiations emitted by mobile phones is an active area of ongoing research. The cell phone radiation emitted from a phone is measured quantitatively using an index called specific absorption rate (SAR). According to federal communications commission (FCC), the SAR is a measure of

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the rate of RF energy absorption by the body from the source being measured – in this case, a cell phone.<sup>[7]</sup>

Every cell phone model has a different SAR which is determined by tests and is published. It is mandatory for the cell phone companies to conform to the set standards while manufacturing cell phones, and as such, they are not supposed to manufacture and market sets which cross these published values.<sup>[8]</sup>

Various governments have defined maximum SAR levels for RF energy emitted by mobile devices. In the United States (US), the FCC requires that phones sold have an SAR level at or below 1.6 W/kg taken over the volume containing a mass of 1 g of tissue that is absorbing the most signal. In the European Union (EU), CENELEC that for mobile phones, and other such handheld devices, the SAR limit is 2 W/kg averaged over the 10 g of tissue absorbing the most signal. India switched from the EU limits to the US limits for mobile handsets in 2012.

This study aims to investigate the effects of electromagnetic fields (EMFs) induced by the global stem for mobile communications mobile phones on the thyroid-stimulating hormone (TSH) in active cell phone using medical students, in the age group of 18–25 years, with the research question, “Is there a relationship between electromagnetic radiation derived from SAR values and thyroid function indicated by TSH levels in active cell phone users.”

### Objectives

1. To assess the thyroid status of the study participants using clinical examination
2. To measure the extent of radiation exposure of the study participants
3. To find out whether there is any relationship between radiation exposure and thyroid dysfunction.

### METHODOLOGY

This is a cross-sectional to examine the relationship between radiation exposure and thyroid dysfunction among active cell phone using medical students who are studying in a medical college in South India.

Prior approval was obtained from the Institutional Review Board and Ethics Committee. The details of the study were explained to all the medical students and volunteers were recruited to participate in the study after they gave written informed consent. The criterion for inclusion of subjects in the sampling frame was the active use of cell phone prior to and during the study period and age between 18 and 25 years. Students were excluded from the sampling frame if there was a history of preexisting thyroid disease, thyroid nodule or goiter, or altered thyroid function.

Radiation exposure (in joules) of every participant was found out by taking the product of the SAR values of the phone model as published by the EU (the amount of radiation absorbed per m<sup>2</sup> of the body in W/m<sup>2</sup>) and the duration of cell phone usage (in hours on an average) by the participant.

The sample size was calculated using nmaster Sample size calculation software.<sup>[9]</sup> Using the mean values of the study by Mortavazi *et al.*,<sup>[10]</sup> the sample size estimated for a power of 80% and alpha error of 5% was 82 participants.

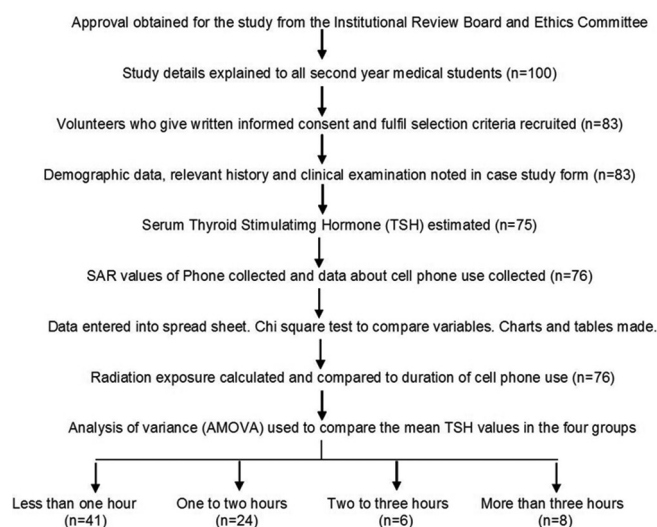
A structured questionnaire was used for collecting data from participants. Demographic data, family history of thyroid disease in the first-degree and second-degree relatives, symptoms of thyroid dysfunction, type and SAR of mobile phone, and the duration of cell phone usage were reported by the participants. The participants underwent a clinical examination to exclude clinical signs of thyroid disease, and the results were recorded. Finally, all the participants were subjected to laboratory investigation to determine the level of TSH.

All data were recorded without any identifying features to preserve confidentiality. All participants who have deranged thyroid function were offered medical advice regarding future management.

Figure 1 shows the study flowchart – the protocol used to recruit and then record historical, clinical, and biochemical data from them.

### RESULTS

The gender distribution of the medical students who participated in this study was almost equal with 49.4% of males and 50.6% of females. The mean age of the participants was 20.29 with a standard deviation of 0.863. Of the 83 students who participated, 62.7% were 20 years of age or less while 37.3% were over 20 years of age. No family history of thyroid disease was reported by 71% of participants, whereas 20.5% reported thyroid disease in the first-degree relatives and 8.4% in the second-degree relatives. Sixty percent of the relatives of participants with a positive family history of thyroid dysfunction had hyperthyroidism and 36% had hypothyroidism.



**Figure 1:** Study flow chart

The clinical examination showed that 79.5% of the participating medical students had clinically normal thyroid function while 13.3% had a palpable thyroid swelling, 3.6% had symptoms of thyroid dysfunction, and another 3.6% had both thyroid swelling and symptoms of thyroid dysfunction.

This is given in the form of a table in Table 1 and represented as a pie chart in Figure 2.

Of the 17 participants who were found to have clinical findings of thyroid dysfunction, 14 had a palpable thyroid swelling.

Figure 3 shows the distribution of TSH (in µg/dl) among the participants.

The mean value for the 75 participants for whom TSH levels were available was  $1.12 \pm 0.506$  µg/L.

Figure 4 shows the duration of mobile phone use in hours.

As many as 53% of the medical students who participated, reported spending ½ h on an average speaking on their mobile phone daily while 28.9% reported spending 1½ h daily and 10.8% reported talking over the cell phone for 3½ h.

The mean radiation exposure of this group of participants was 4423.23 J/kg with a standard deviation of 3482.391 J/kg.

The mean number of calls made per day by the participants was  $3.89 \pm 2.824$ . The minimum number of calls made per day was one and the maximum number of calls made per day was 15 while 66.3% of participants reported making three or less than three calls per day.

It is mandatory that the SAR value of every cell phone model is published by the respective manufacturer. As such, information on the SAR value of the cell phone model used by the respondents was collected from various websites maintained by the cell phone manufacturers. The box plot in Figure 5 presents information on the SAR values of the various mobile phones used by the participants.

The exposure to radiation energy for each respondent was calculated by finding out the total radiation exposure. The total radiation exposure of each respondent (J/kg) = SAR value of the cell phone (in W/kg) X duration of time spent talking on

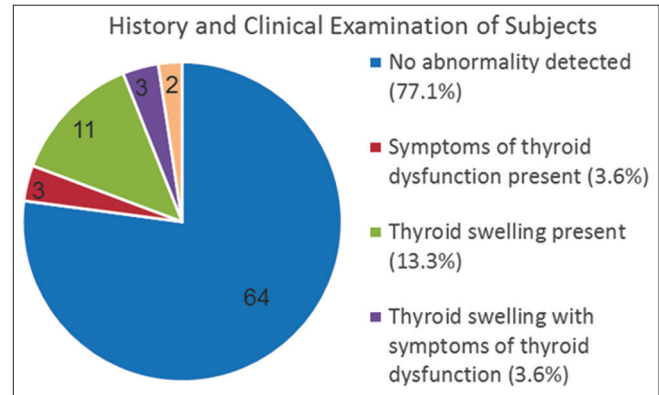


Figure 2: Clinical findings in the study participants

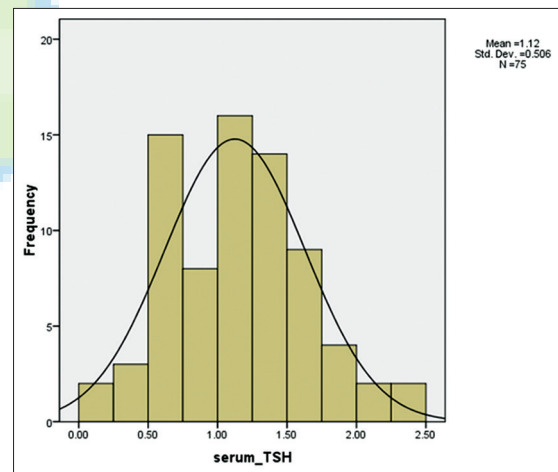


Figure 3: Serum thyroid-stimulating hormone levels in the study participants

Table 1: Demographic details and clinical findings of participants	
	n (%)
Gender (n=83)	
Female	42 (50.6)
Male	41 (49.4)
Age (n=83)	
Below 20 years	52 (62.7)
20 and over 20 years	31 (37.3)
Family history of thyroid disease (n=83)	
No history reported	58 (69.9)
In the first-degree relatives	18 (21.7)
In the second-degree relatives	7 (8.4)
Type of thyroid disease reported (n=83)	
No history reported	58 (69.9)
Hyperthyroidism	15 (18.1)
Hypothyroidism	9 (10.8)
Both hypo- and hyper-thyroidism	1 (1.2)
Clinical findings - symptoms and signs of thyroid disease (n=83)	
No abnormality detected	64 (77.1)
Symptoms of thyroid dysfunction	3 (3.6)
Palpable thyroid swelling	11 (13.3)
Symptoms of thyroid dysfunction with palpable thyroid swelling with	3 (3.6)
Missing data	2 (2.4)

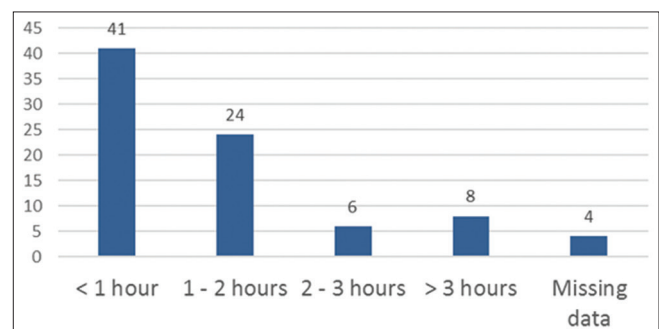


Figure 4: Duration of daily mobile phone use in hours

**Table 2: SAR values for commonly used Apple iPhones and Samsung Galaxy S Phones**

Model	SAR level
Apple iPhone 6 Plus	1.16
Apple iPhone 6	1.14
Apple iPhone 5	1.18
Apple iPhone 5c	1.18
Apple iPhone 4S	1.19
Apple iPhone 4 (GSM)	1.11
Apple iPhone 4 (CDMA)	0.87
Apple iPhone 3GS	0.67
Samsung Galaxy S6	1.25
Samsung Galaxy S6	1.47
Samsung Galaxy S4	1.18
Samsung Galaxy S3	0.82

SAR: Specific absorption rate, GSM: Global stem for mobile communications, CDMA: Code division multiple access

phone (in seconds). The mean radiation exposure for the group was  $4473.95 \pm 3413.719$  for the 76 participants for whom data were available.

This is represented in the form of a bar graph in Figure 6.

There is a significant correlation between the total radiation and the TSH values among both individuals with ( $P = 0.025$ ) or without ( $P = 0.0375$ ) a family history of thyroid dysfunction.

There was a significant 2-tailed Pearson's correlation between the radiation exposure and duration of cell phone use of 0.025 (Correlation is significant at the 0.05 level (2-tailed)). The regression equation is TSH value =  $0.961 + 0.00004 \times$  total radiation exposure. This means that for every one unit increase in total radiation exposure, there is 0.00004 unit increase in TSH value which is statistically significant ( $P = 0.025$ ).

Analysis of variance showed a significant correlation between the dependent variable serum TSH and the predictor, total radiation exposure ( $P = 0.025$ ).

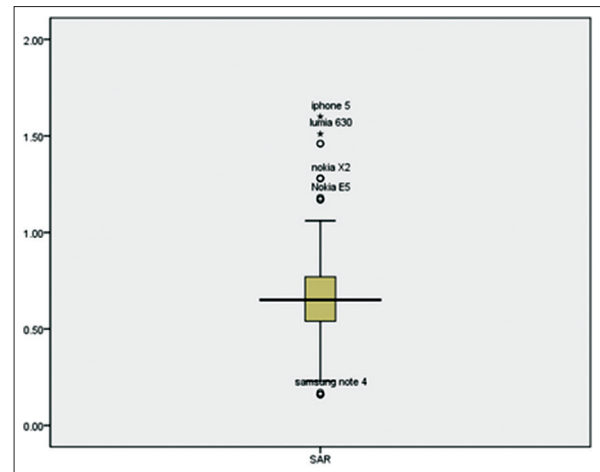
This is seen clearly in the scatter plot of radiation exposure versus serum TSH in Figure 7.

## DISCUSSION

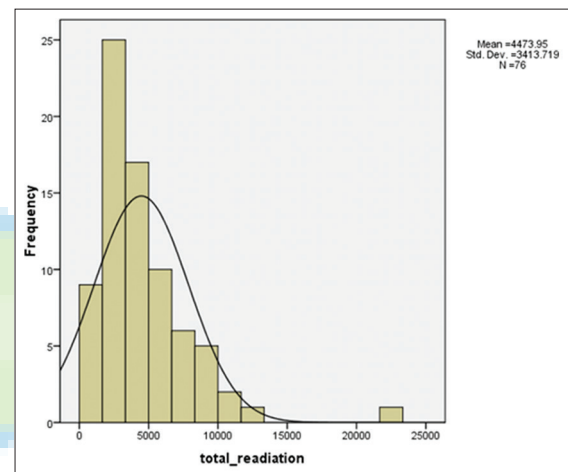
A search of published literature revealed a number of publications on the effects of EMF radiation on the endocrine system ranging from the pineal and pituitary gland to adrenal, testicular, and ovarian tissue in laboratory animals.<sup>[11-19]</sup>

In the endocrine system, the thyroid gland has vital and critical effects on practically all physiological processes in the human body. As the thyroid gland lies in the anterior aspect of the neck, it is particularly vulnerable to the deleterious effects of any EMF radiation.<sup>[6,20]</sup>

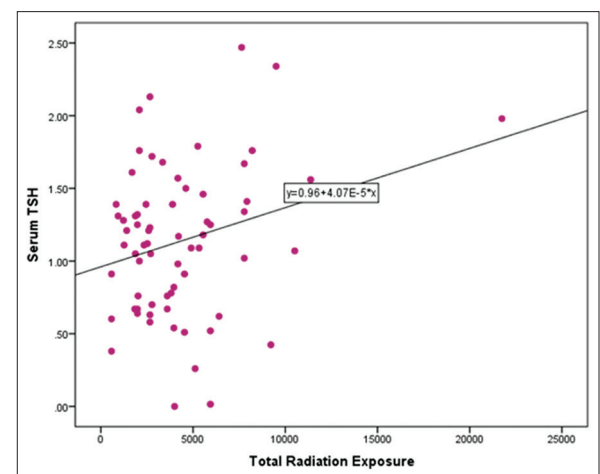
Work done by Amin *et al.* published from Egypt revealed that in a group of computer workers chronic exposure to computer monitor-emitted radiation caused a decrease in TSH, free T3, and free T4 which then improved with zinc supplementation.<sup>[21]</sup>



**Figure 5:** Specific absorption rate of cell phone models used by the study participants



**Figure 6:** Radiation exposure cell phone models used by the study participants



**Figure 7:** Scatter plot of radiation exposure versus serum thyroid-stimulating hormone levels of study participants

A study done by Rajkovic *et al.* investigating the effect of EMF exposure on rat thyroid cells found a predominant effect of

microfollicles with decreased colloid content with increased vascularity at both the light and electron microscope level.<sup>[22]</sup>

Sinha studied the effect of chronic non-thermal exposure of 2450 MHz microwave radiation on thyroid hormones of male rats. The study concluded that low-energy microwave radiation is sufficient to alter the thyroid hormones and emotional reactivity of irradiated animals as compared to control animals.<sup>[23-24]</sup>

Mortavazi *et al.* studied alterations in TSH and thyroid hormones in 77 healthy university students who were mobile phone users. They observed a higher than normal TSH level, low mean T4, and normal T3 concentrations in mobile users and concluded that minor degrees of thyroid dysfunction with a compensatory rise in TSH may occur following excessive use of mobile phones. It may be concluded that possible deleterious effects of mobile microwaves on hypothalamic–pituitary–thyroid axis affect the levels of these hormones.<sup>[10]</sup>

We had done some research on SAR values of different commonly used mobile phones, and we found the following interesting facts:

- Apple phones have SAR values ranging between 1.14 for iPhone 6S to 1.34 for iPhone 7 Plus
- HTC mobiles have SAR values as low as 0.358 for HTC Sensation and up to 1.59 for HTC Desire X, LG mobile phones SAR values vary between 0.56 for LG nerve 4 and 0.97 for LG G2
- Samsung, Nokia, and Motorola have much lower values for SAR varying between 0.337 (Samsung D830) and 1.03 (Samsung A 300), values between 0.29 (Nokia mobile N90) and 1.11 (Nokia X6), and 0.44 with Motorola V80-1.17 with Motorola V 66.

The following are the SAR values of commonly used commonly used Apple i phones and Samsung Galaxy S phones [Table 2].

## CONCLUSION

In this study, we found a significant correlation between the total radiation and the TSH values among both individuals with or without a family history of thyroid dysfunction.

## Limitations of the study

According to the American Cancer Society, the radiation energy to which a person is exposed to depends on many factors other than what we have considered in the present study. This study has not taken into account any of the following factors due to difficulties associated with measurement. These factors are the mode in which the cell phone is operated (whether handheld or hands-free), the distance and path to the nearest cell phone tower and the amount of cell phone traffic in the area at the time.

According to the FCC (US FCC), comparing SAR values between phones can be misleading because the SAR value is based only on the phone operating at its highest power

and not on what users would typically be exposed to with normal phone use. The actual SAR value during use varies based on a number of factors, so it is possible that a phone with a lower listed SAR value might actually expose a person to more RF energy than one with a higher listed SAR value in some cases.

## Future research directions

This study has raised some pertinent issues and questions regarding mobile phone use, subsequent radiation exposure and their possible effects on serum TSH and possible subsequent development of hypothyroidism.

The thyroid gland being externally placed may be particularly susceptible to the effects of electromagnetic radiation.

Ideally, the study needs to be repeated on a larger number of participants and the free T3, free T4 values need to be estimated in addition to serum TSH. Furthermore, the group of participants needs to be followed up over a period of at least 6 months to years to see how the clinical and biochemical picture evolves.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

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