


Research Article

High Radiofrequency Radiation in the Surroundings of 10 Schools in Örebro, Sweden

Lennart Hardell^{*,1} and Mona Nilsson²

Abstract

In Sweden as well as in many other countries the fifth generation, 5G, for wireless communication is rolled-out since 2019/2020. This has caused increasing environmental exposure to radiofrequency (RF) radiation. Children and adolescents are especially vulnerable to RF radiation. Exposure sources in schools such as Wi-Fi routers, wireless connected mobile phones, and computers may cause high RF-exposure inside the schools but also outside sources, such as mobile phone base stations, may contribute significantly. In this study outside environmental exposure to RF radiation from 4G and 5G base stations was measured in October 2024 in close proximity to 10 schools in Sweden. The maximum levels ranged from 10,716 to 68,452 $\mu\text{W}/\text{m}^2$. These levels far exceed the EUROPAEM EMF guidelines for daytime RF radiation exposure 10-1,000 $\mu\text{W}/\text{m}^2$, nighttime 1-100 $\mu\text{W}/\text{m}^2$, and for sensitive persons 0.1-10 $\mu\text{W}/\text{m}^2$.

Keywords: Radiofrequency radiation, school environment, health

Introduction

Radiofrequency (RF) radiation was in 2011 classified as a possible human carcinogen by the International Agency for Research on Cancer (IARC) at the WHO (1,2). Since then, RF radiation in the environment has increased considerably mainly due to the implementation of the fifth generation, 5G, for wireless communication (3-7). Health consequences of RF radiation on the developing child are of special concern (8-11). In Sweden the roll-out of the fifth generation, 5G, for wireless communication started in 2019/2020. Thereby older systems such as 2G and 3G are phased out, whereas 4G is still in operation, usually together with 5G. An appeal from scientists and physicians has required a moratorium of the expansion of 5G until potential health risks have been studied (www.5gappeal.eu). Others have required better protection against health effects in terms of lower limits for allowed exposure levels (www.emfcall.org, www.emfscientist.org). In spite of these requests, installation of 5G continues, causing increasing RF radiation exposure to humans and the environment, without any studies showing that it is safe in terms of health effects (4,12).

The growing child is particularly vulnerable to RF radiation (8,9). The exposure is of special concern in schools where children spend many hours each day. Therefore, a significant portion of children's exposure to RF radiation may be the school due to exposure sources inside the school such as Wi-Fi routers, wireless connected computers, and mobile phones (13). In addition, there are outside sources such as 4G and 5G base stations or masts. This study aimed to investigate the exposure to RF-radiation from nearby base stations for 4G and 5G in the areas close to a number of schools in Sweden.

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*Corresponding author:

Lennart Hardell, The Environment and Cancer Research Foundation, Örebro, Sweden.

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Materials and Methods

In total 10 schools in the city of Örebro in Sweden were selected at random for measurements of the RF radiation in the close environment. It was made during daytime on October 22-24, 2024, that is Tuesday to Thursday, during the time the students were at school. All four sides of the schools were measured during at least 6 minutes while walking on the schoolyard, if possible, otherwise on the nearest street. The meter was held with a stretched arm at the height of the shoulder during measurements. The measurements were made with the Narda broadband field meter NBM-550, with the probe EF-1891, measuring frequencies between 3 MHz-18 GHz and measurement range 0.6 V/m (955 $\mu\text{W}/\text{m}^2$) to 65 V/m (11,206,897 $\mu\text{W}/\text{m}^2$). This meter shows results in root mean square (RMS) for both minimum, maximum and average RF radiation level. The frequencies used for 5G in

city environments in Sweden are in general around 3.5 GHz while frequencies used for 4G are primarily around 2.6 GHz (<https://www.induo.com/b/lte-band-mobilt-bredband/>).

Results

The results of the RF radiation measurements are displayed in Table 1, in total at 40 spots. The lowest measured level was < 955 $\mu\text{W}/\text{m}^2$, which is the minimum detection level for the Narda meter. The maximum level varied from 10,716 to 68,452 $\mu\text{W}/\text{m}^2$, see Table 2. Both the average and maximum levels varied for all schools depending on the spot. Large difference was seen for Tullängens high school with the maximum level varying from 5,968 to 68,452 $\mu\text{W}/\text{m}^2$. Also, most of the other schools showed large variation of the maximum level of RF radiation, e.g., Rudbeck High School, Olaus Petri High School, and Svealund School, see Table 1.

Table 1: Minimum, average and maximum measured radiofrequency radiation in $\mu\text{W}/\text{m}^2$ (RMS) in the surroundings of 10 schools, Örebro, Sweden, using Narda NBM-550 broadband field meter.

Tullängens High School		East	North	South	West
October 22, 2024	Min	<955	< 955	<955	<955
	Average	1,020	2,924	8,883	1,053
	Max	5,968	21,094	68,452	10,610
Navet					
October 22, 2024	Min	<955	<955	<955	< 955
	Average	446	955	832	892
	Max	4,692	10,716	4,414	8,216
Rudbeck High School					
October 22, 2024	Min	< 955	<955	< 955	1,827
	Average	2,924	11,039	1,916	9,880
	Max	34,760	49,962	10,823	27,673
Karolinska High School					
October 22, 2024	Min	< 955	< 955	< 955	< 955
	Average	923	802	1,020	987
	Max	5,125	7,486	12,606	4,013
Drakenberg School					
October 22, 2024	Min	<955	<955	<955	< 955
	Average	2,294	2,149	1,227	3,820
	Max	13,309	22,308	7,486	23,873
Engelbrekt School					
October 23, 2024	Min	< 955	< 955	< 955	< 955
	Average	2,547	1,375	1,916	1,573
	Max	22,154	13,073	12,955	15,663
Olaus Petri					
October 23, 2024	Min	< 955	< 955	< 955	< 955
	Average	611	717	3,447	1,784
	Max	4,589	8,123	36,510	20,353
Svealund School					

October 23, 2024	Min	< 955	< 955	< 955	< 955
	Average	1,121	987	5,500	5,810
	Max	13,548	6,622	34,186	38,101
Änglanda School					
October 23, 2024	Min	< 955	< 955	<955	< 955
	Average	1,453	637	1,916	490
	Max	17,113	3,447	10,294	6,373
Almby School					
October 24, 2024	Min	< 955	< 955	< 955	< 955
	Average	832	717	923	1,227
	Max	4,414	5,889	9,177	17,656

Table 2: Maximum measured radiofrequency radiation in $\mu\text{W}/\text{m}^2$ (RMS) in the surroundings of 10 schools in Örebro, Sweden in October 22-24, 2024. All measurements were made with Narda NBM-550 broadband meter.

School	Maximum	Direction
Tullängens High School	68,452	South
Rudbeck High School	49,962	North
Olaus Petri High School	44,589	East
Svealund School	38,101	West
Drakenberg School	23,873	West
Almby School	17,656	West
Änglanda School	17,113	East
Engelbrekt School	15,663	West
Karolinska High School	12,606	South
Navet School	10,716	North

Discussion

The environmental exposure to RF radiation is increasing, in large part due to the deployment of 5G. Evidence indicates that children and adolescents are more vulnerable than adults to RF radiation exposure (14,15). This is due to the fact that their cells are rapidly dividing and the organ systems are immature. RF radiation exposure may have adverse neurobehavioral effects and also negative impact on cognition (16,17). We have previously published seven case studies (18-24) and one summary of these case studies on health effects on people from exposure to 4G/5G base stations (7). Our case studies, that also included children aged 4-8 years, showed clear negative health effects also among the children. Most prevalent were negative impact on sleep, fatigue and headache, see Table 1 in (7). The RF radiation levels inside the buildings were measured with a meter, Safe and Sound Pro II, measuring peak maximum levels, showing that exposures were in the range of 135,983 to $> 3,180,000 \mu\text{W}/\text{m}^2$. In one additional case study not included in (7), an eight year old boy, was reported to suffer headaches when in school where a

max peak level of $267,000 \mu\text{W}/\text{m}^2$ was measured outside the school at the schoolyard (25).

In this present study, the maximum levels were lower than those measured in the previous case studies (7). Levels ranged from 10,716 to $68,452 \mu\text{W}/\text{m}^2$ in close surroundings of the 10 measured schools, see Table 2. However the results using Safe and Sound Pro II showing peak values, as in our previous studies, are not comparable with the present findings based on measurements with the Narda broad band meter. The latter results are based on Root Mean Square (RMS) calculations, i.e. the square root of the average of the squares of a set of numbers. Thus these results show lower values than the peak measurements using Safe and Sound Pro II. This is shown in one of our previous case studies where both meters were used, see Table 2 in (22). The Narda meter RMS results were considerably lower than Safe and Sound maximum peak exposure values. As one example, at two different spots, the Safe and Sound meter showed max peak levels of $749,000 \mu\text{W}/\text{m}^2$ (sleeping room, desk, daughter) and $504,000 \mu\text{W}/\text{m}^2$ (sleeping room, pillow, daughter). The Narda RMS maximum levels at the same spots were $137,889 \mu\text{W}/\text{m}^2$ and $88,616 \mu\text{W}/\text{m}^2$, respectively (22). Both measurements were made at the same time.

Numerous studies have shown neurological effects at exposure levels below the ICNIRP limits (26). Those limits have been adopted by most countries although they only protect against thermal acute effects observed at very high intensities within an hour in animal laboratory experiments (27). Oxidative damage of DNA has been reported to be caused by the production of reactive oxygen species (ROS) (10,28). This may cause long-term health effects such as increased risk of cancer (29). In 2016 a group of scientists published recommendations for more protective RF exposure limits than those by ICNIRP. The EUROPAEM EMF guidelines, based on scientific results showing negative health impacts from long term exposure, recommend maximum daytime RF radiation exposure to be $10\text{-}1,000 \mu\text{W}/\text{m}^2$, while nighttime exposure should not exceed $1\text{-}100 \mu\text{W}/\text{m}^2$. For sensitive

persons, the maximum levels should not exceed 0.1-10 $\mu\text{W}/\text{m}^2$ (30).

Conclusion

Our results of RF radiation measurements indicate that the exposure to RF-radiation from nearby 4G and 5G base stations in the surroundings of 10 schools in Sweden is high. These levels may cause increased risks of both short term and long term negative effects on children's health.

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Availability of data and materials

The information generated and analyzed during the current study is available from the corresponding author on reasonable request.

Author's contributions

LH and MN contributed to the conception, design and writing of the manuscript. Both authors read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable

Patient consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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