An - Najah National University

Faculty of Graduated Studies

The Effect of Electromagnetic Radiation from Antennas on Children in Schools in Nablus Area

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Dedication

I would like to thank my mother and father for their love and endless support. Special thanks, to Hassan my life partner for his encouragement, to my sister and brothers, to all of my family, and friends with respect and love.

Acknowledgments

I'd like to thank my supervisor Prof. Issam Rashid Abdelraziq for his guidance, continued support and precious time. I will always be thankful for his wisdom and knowledge. Next, I'd like to thank my co-supervisor Dr. Mohammed Abu-Jafar for his encouragement and valuable suggestions for the work done in this thesis; it has been an honor to work with them. Special thanks to the schools and their teachers and children, for their help and cooperation to make this research possible.

الإقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان

The Effect of Electromagnetic Radiation from Antennas on Children in Schools in Nablus Area

أقر بأن ما اشتملت عليه هذه الرسالة، إنما هو نتاج جهدي الخاص، باستثناء ما تمت الاشارة اليه حيثما ورد، وأن هذه الرسالة ككل، أو أي جزء منها لم يقدم من قبل لنيل أي درجة علمية أو بحث علمي لدى أي مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's name: **اسم الطالب:**

Signature: **التوقيع:**

Date: **التاريخ:**

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List of Abbreviation

Symbol	Abbreviation
a	After
a.m	Before Midday
A/m	Ampere per Meter
ANOVA	Analysis of Variance
b	Before
B	Magnetic Flux Density
dB(A)	Decibel(s) by a Weighting Filter (A)
dB	Decibel(s)
DBP	Diastolic Blood Pressure
DNA	Deoxyribonucleic Acid
E	Internal Electric Field
ELF	Extremely Low Frequency
EMF	Electromagnetic Field
EMR	Electromagnetic Radiation
F	Frequency
Fig.	Figure(s)
FM	Frequency Modulation
G	Gauss
GSM	Global System for Mobile Communication
H	Magnetic Field Strength
HF	High Frequency
HPR	Heart Pulse Rate
HRV	Heart Rate Variability
Hz	Hertz
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IF	Intermediate Frequency
J	Current Density
LI	Light Intensity
Max	Maximum
Min	Minimum
mG	Milli Gauss
MP	Mobile Phone
nT	Nano Tesla
p.m	After Midday
P , p	Power Density
P-value	Probability
R	Pearson Correlation Coefficient
RF	Radio Frequency

rms	root mean square
SAR	Specific Absorption Rate
S	Schools
S1	Yaseed Primary School for Girls
S2	Yaseed Primary School for Boys
S3	Masqat Primary School for Boys
S.D.	Standard Deviation
SBP	Systolic Blood Pressure
SPL	Sound Pressure Level
SPO_2 %	Blood Oxygen Saturation
TV	Television
T	Tesla
V/m	Volt per Meter
W/kg	Watt per Kilogram
W/m^2	Watt per Meter Square
WHO	World Health Organization
σ	Electrical Conductivity
1/Ω.m	1 over Meter ohm
µ	Magnetic Permeability
Ω	Ohm
ρ	Mass Density
ɳ	Field Resistance

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Abstract

This study concerns about the effects of Electromagnetic radiation from antennas on arterial blood pressure (systolic (SBP), diastolic (DBP)), heart pulse rate (HPR), blood oxygen saturation (SPO_2%) of children in schools.
The sample consists of 273 children of both genders (91 female, 182 male), classified into two groups; 10-12 years and 13-16 years. The sample was taken from three different schools in Nablus area. The measured power flux density in schools was 1862μw/m^2, 353.166μw/m^2 and 18.278μw/m^2. Measurements of blood oxygen saturation, heart pulse rate, arterial blood pressure (systolic and diastolic) were taken for the selected sample before and after the exposure to electromagnetic radiation from antennas. Positive correlation (Pearson Correlation Coefficient) was found for all measured variables. The statistical results showed that Pearson correlation coefficient (R) between the dependent variables (SBP, DBP, HPR, SPO_2%) before and after the exposure to electromagnetic radiations from antennas is strong and the Probability (P) is < 0.05.
This study shows that there is a significant shift of the measured mean values of arterial blood pressure (systolic and diastolic), heart pulse rate, and blood oxygen saturation of the children due to exposure of electromagnetic radiation from antennas within the normal ranges.

Chapter One

Introduction

1.1 Background

An electromagnetic field is a generic term for fields of force generated by electrical charges or magnetic fields. Under certain circumstances EMF can be considered as radiation when they radiate energy from the source of the fields. Electromagnetic waves periodically change between positive and negative. The speed of the changes, or the number of changes per second, is called the frequency and is expressed in hertz (1 Hz = 1 full cycle of change per second) (EGHEEF, 2005).

The growing use of wireless communication in the last decade has introduced concerns about health risks from the so called man made electro smog. Various epidemiological and experimental studies have been carried out and the results have shown to have a close relation between biological effects and electromagnetic radiation (Cindy *et al.*, 2009).

Often when people think of EMF, they think of radiation that is associated with X-rays, radioactivity or nuclear energy. What people consider as ‘radiation’ is ionizing radiation that contains sufficient energy to cause ionization; that is, they can dislodge orbiting electrons from atoms or break bonds that hold molecules together, producing ions or charged particles (EGHEEF, 2005).

These are not the only types of radiation in the electromagnetic spectrum: there is a continuous spectrum of fields as shown in Fig1.1. All other types of radiation do not have enough energy to result in ionization and so are referred to as “non-ionizing radiation”. Radiation and fields can be divided into discrete bands having different interactions on living organisms: ultraviolet radiation, visible light, infra-red radiation, microwaves, radiofrequency fields and low frequency fields” (EGHEEF, 2005).

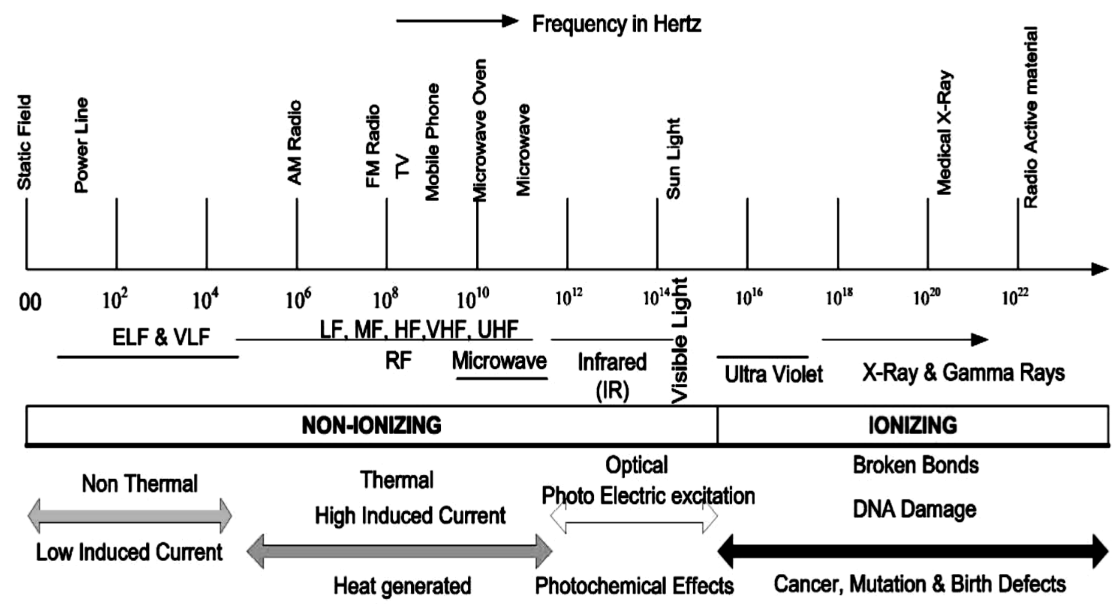

Fig. 1.1 Electromagnetic spectrum (Tayebeh *et al*, 2012)

The examples of non-ionizing EMR are divided into frequency (f) bands, namely: radio frequency (RF) (100 kHz < f ≤ 300 GHz), intermediate frequency (IF) (300 Hz < f ≤ 100 kHz), extremely low frequency (ELF) (0 < f ≤ 300 Hz), and static (0 Hz) as shown in Table 1.1 (SCENIHR, 2007).

Table 1.1 Typical sources of electromagnetic fields (Otto *et al.*, 2007)

Band name	Abbreviation	Frequency range (typical values)	Common occurrence/uses (examples)
Static electric field	-	0 Hz	Clouds and thunder, charged surfaces (e.g. TV sets) and spark discharges, Dc rail systems
Static magnetic field	-	0 Hz	Terrestrial magnetic field and permanent magnetism
Extremely low frequency	ELF	1-300 Hz	Railway power supply household power supply (50 Hz) household devices (electric blankets or water beds, night storage heaters)
Low frequency	LF	1 (300)-100 kHz	Visual display unit
High frequency	HF	100kHz-300 GHz	Radio, TV, other radio application, mobile phones, microwave oven, WLAN, Bluetooth, and anti-theft devices radar

1.2 Previous Studies

Nonionizing electromagnetic fields are among the fastest growing forms of environmental pollution (Levitt *et al.*, 2010), so many of studies show the relation between electromagnetic radiation and biological effects on human body.

Kumar has been shown in his research that an increasing risks for brain tumors in children and teenagers, they are five times more likely to get brain cancer, if they use mobile phones (Kumar, 2009).

Ahamed and his team showed that mobile phone (MP) has caused changes in heart rate variability (HRV) indices and the change varied with its position. The parameters used in this study for quantifying the effect on HRV are scaling exponent and sample entropy. The result indicates an increase in both the parameters when MP is kept close to the chest and a decrease when kept close to the head (Ahamed *et al.*, 2008).

Mahapatra studied the energy supplied to the semi permeable membrane surrounding the cell in human body, the increase in temperature due to energy absorbed, the change in the ratios of concentrations of Na^+, K^+ ions in and outside of the cell (Mahapatra, Kancharapara Study Centre).

Radiation from cell phone towers has been associated with greater increase in brain tumor. This is due to the damage in the blood brain barrier and the cells in the brain which are Biological Effects of Cell Tower Radiation on Human Body concerned with learning, memory and movement. This is what Hardell Lennart found in his research (Lennart *et al.*, 2009)

A pregnant woman and the fetus both are vulnerable because of the fact that these RF radiations continuously react with the developing embryo and increasing cells. In addition, Microwave radiation damages the placental barrier (Frey, 1998).

A study in Australia found that children live near TV and FM broadcast towers had more than twice the rate of leukemia as children living more than seven miles away from these towers (Hocking *et al.*, 1996). In another study, TV signal exposed workers were observed to have increased

Immunoglobulin G and A and decreased lymphocytes and T8 cells, resulting in a decrease in immune response (Moszczynski *et al.*, 1999).

Exposure to electromagnetic fields has shown to be in connection with Alzheimer's disease, motor neuron disease and Parkinson's disease (WHO, 2007).

Simko has shown in his study that Leakage of calcium ions into the cytosol acts as a metabolic stimulant, which accelerates growth and healing, but it also promotes the growth of tumors. Loss of calcium ions causes leaks in the membranes of lysosomes releasing DNAase that causes DNA damage. Another possibility of DNA damage is via increased free radical formation inside cells, which further causes cellular damage in the mitochondria (Simko, 2007).

A study done by Agarwal has shown Continuous exposure to EMR has been associated with reduction in sperm viability and mobility by around 25 percent in men (Agarwal *et al.*, 2006).

Hamada and his group found that when sperm exposure to cell phone electromagnetic waves affect their motility, morphology and even their count (Hamada *et al.*, 2011).

Hardell reported higher odds ratios in the 20–29 year-old group than other age ranges after more than 5 years of use of either analog or cordless phones. Recently in a London symposium Hardell reported that after even just 1 or more years of use there is a 5.2-fold elevated risk in children who begin use of mobile phones before the age of 20 years, whereas for all ages the odds ratio was 1.4 (Hardell *et al.*, 2006).

Some researchers have found that the risk of parotid gland tumors (a salivary gland in the cheek) is increased with heavy cell phone use (Sadetzki *et al.*, 2008).

Schoemaker and his group studied the association between mobile phone use and acoustic neuroma (Schoemaker *et al.*, 2005).

Another study showed that effect of acute 2nd (2G) and 3rd (3G) generation mobile phone exposure on human cognitive function (Leung *et al.*, 2011).

Hardell found that patient with glioblastoma survival is reduced where mobile phone use began at younger ages (Hardell *et al.*, 2012).

A study in Thailand found a threefold risk of leukemia from cell phone use and more than a fourfold risk for any lymphoid leukemia (Kaufman *et al.*, 2009). Cooke also reported that Acute increament in Lymphocytic Leukemia by 1.41-fold risk and Acute Myelogenous Lekeumia by 2.08-fold risk with >15 years since first use of mobile phones (Cooke *et al.*, 2010). Gultekin and Moeller found that used cellphones can produce hotspots in living brain tissue (Gultekin *et al.*, 2012).

Volkow reported that 50 min of use of a mobile phone produces significant change in glucose metabolism in the area of the brain that absorbs the most radiation (Volkow *et al.*, 2011). Levis founded that long-term mobile phone use doubling the risk of head tumors (Levis *et al.*, 2011).

A study done by Ciejka and Goraca has shown decrement of the heart rate that was observed after 14 days of exposure to EMF (Ciejka *et al.*, 2009).

Vangelova concluded that the systolic and diastolic blood pressure, total cholesterol and low-density lipoprotein cholesterol higher after exposure to EMF (Vangelova *et al.*, 2006). Szmigielski also found that workers exposed to radiofrequency EMF have lowering in blood pressure and heart rate (Szmigielski *et al.*, 1998).

Exposure to a radiofrequency EMF for 35 min causes increase in the resting blood pressure between 5-10 mm Hg. This work has been done by Braune (Braune *et al.*, 1998).

An Increase in heart rate variability during the use of mobile phone was found by Andrzejak and his group (Andrzejak *et al.*, 2008).

One study showed that exposure to magnetic fields as low as 16 milligauss increased risk for miscarriage by 180% (Odouli *et al.*, 2002).

Al-Faqeeh concluded that the effect of EMR from the transformers on children health resulted in increasing tympanic temperature, heart pulse rate, arterial blood pressure (systolic and diastolic) but the blood oxygen saturation was decreased (Al-Faqeeh, 2013).

1.3 The interaction between the electromagnetic fields and human body

Biochemical reactions in the human body generate currents. When people exposed to EMR, induced currents will be created in the human body. Once the internal and induce electric field strength exceeds a few volts per meter, tissues will be stimulated nerve fibers (Ahmadi *et al*, 2010). The forces exerted by electric fields on living cell can cause rotation, destruction, deformation of cells because of the conductivity of living tissues (Aliyu *et al*, 2012). Living matter couples to low-frequency electric fields, to low-frequency magnetic fields and to the absorption of energy from electromagnetic fields. In one hand, when interaction happened between human body and electric field, electric charges flow, the polarization of bound charge, and the reorientation of electric dipoles already present in tissue. Magnitudes of these different effects depend on electrical conductivity and permittivity (governing the magnitude of polarization effects) which are vary with the type of body tissue and depend on the frequency of the applied field. External electric fields on the body induce a surface charge on the body; this result in induced currents in the body, the distribution of which depends on exposure conditions, on the size and shape of the body, and on the body's position in the field. On the other hand, when low-frequency magnetic fields interact with the human body, induced electric fields and circulating electric currents are resulted. The magnitudes of the induced field and the current density are proportional to the electrical conductivity of the tissue, to the rate of change and magnitude of the magnetic flux density (Vladimir *et al*, 2012).

1.4 Study Objectives

In Palestine, There is a lack of information about electromagnetic radiation and its effects on human health. This study will help to get the effect of EMR power density on the children in schools near wireless telecommunication antennas (who school in areas less than 300 m), such as the effect on blood pressure, heart pulse rate and blood oxygen saturation.

In addition, measurements of electromagnetic radiation in different locations will be compared with the recommended EMF levels from International Commission on Non–Ionizing Radiation Protection and other organization.

Chapter Tow

Theory

Electromagnetic fields are quantified in terms of the electric field strength E, expressed as volts per meter ($V.m^{-1}$) and magnetic field strengths H, expressed as amperes per meter ($A.m^{-1}$) or as magnetic flux density B, expressed as tesla (T).

The two quantities are related by the expression:

$$B = \mu H \qquad 2.1$$

where μ is the constant of proportionality (the magnetic permeability); in vacuum and air, as well as in nonmagnetic (including biological) materials.

Exposure to time-varying EMF results in internal electric fields and in body currents and energy absorption tissues that depend on the coupling mechanisms and the frequency involved. The internal electric field E and current density J are related by Ohm's Law:

$$J = \sigma E \qquad 2.2$$

where σ is the electrical conductivity of the medium (ICNIRP, 2010).

Exposure to a mobile phone antenna is measured in terms of power density. This is a measure of the rate at which RF energy is reaching a person from that base station. The unit of power density is 'watt per square meter' (W/m^2). The actual exposure of an individual depends on the height of the transmitting antennas on the mast, the power output and gain of the antennas, the direction of the beam, and the distance of the individual from the antennas (EGHEEF, 2005).

This can be written as (ACA, 2000)

$$P = \frac{SG}{4\pi R^2} \qquad 2.3$$

where:

P = power density (W/m^2)

S = transmitted power (W)

G = linear power gain of antenna

R = distance to the center of radiation of antenna (m)

The power density can be written as

$$P = \frac{E^2}{\eta} \qquad 2.4$$

$$P = EH \qquad 2.5$$

$$P = \eta H^2 \qquad 2.6$$

Where P is the power density, E is the electric field intensity and η is the field resistance taken as 377Ω for free space (in air) (ICNIRP, 1998).

Antennas emit radiofrequency beams that are very narrow in the vertical direction, but quite broad in the horizontal direction. The RF power intensity at the ground directly below antenna is low (beam from antenna would be expected to reach ground between 50 and 300 meters).The field intensity increases slightly as one moves away from the antenna and then decreases at greater distance from the antenna (Hammash, 2004).

In general, the radiation exposure is predominantly determined by the following parameters (Haumann, 2002):

*Distance to the antenna site

* Line of sight to the antenna site

* Type of the antennas, e.g. omni directional or directional antennas

* Number, power, and orientation of the antennas

* Capacity of the antenna site (number of channels/frequencies)

* Vertical distance between location and antenna site

* Type of building construction/type of window glass

* Total reflection of the environment

The coverage area of a typical antenna is illustrated in Fig. 2.1 (Allam, 2011).

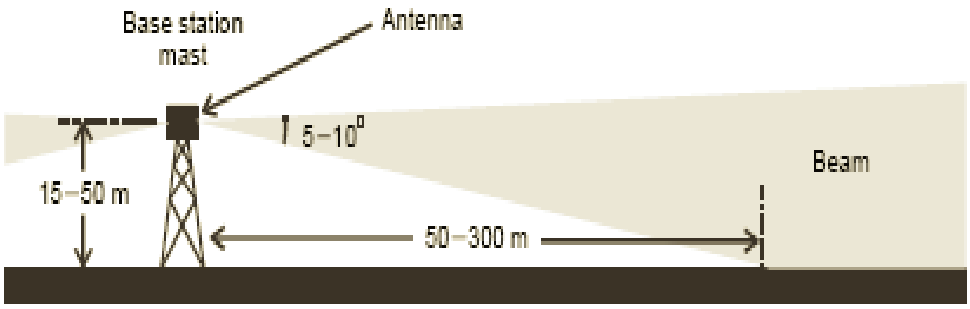

Fig. 2.1 Direction of coverage due to a base station antenna (Allam, 2011)

SAR stands for Specific Absorption Rate. It measures the level of absorption of EMR by the body. Specific absorption rates (SARs) are generally expressed in watts per kilogram (W/kg) of tissue. SAR number of the phone is 1.6 watts/kg or below since it must meet the Federal Communications Commission (FCC) standard (Logical Health LLC, 2008). SAR related to electric fields by:

Where σ is the conductivity of the tissue (1/Ω.m), ρ is the mass density of the tissue (kg/m^3), and E is the rms electric field strength (V/m).

Every tissue has different values of σ and ρ. For example, human brain have ρ = 1700 kg/m^3 and σ = 0.7 S/m (Gray, 2000)

Some researcher's depends on these values of σ and ρ, for human brain is given 1.1531 S/m for the conductivity and 1030 kg/m^3 as the mass density of the tested tissue (Chiang, 2008).

2.1 Health Parameters

Several health effects of Electromagnetic radiation exposure on humans were observed such as:

1. Blood Pressure

All of the organs in the human body need oxygen to survive. Blood carries oxygen and nutrients to the organs through a complex system of blood vessels that reach every single part of the human body. Each time the heart beats push blood through the body. As blood travels through the body, it places pressure on the walls of the blood vessels. Blood pressure keeps blood flowing smoothly throughout the body (Bella, 2011).

Blood pressure is measured using two numbers – the systolic (top number) over the diastolic pressure (bottom number). The systolic pressure is the pressure of blood in the vessels when the heart is beating. The diastolic pressure is the pressure between heart beats, when the heart is at rest and refilling. Blood pressure is given as one number over another – for example 110 over 75. A normal blood pressure is less than 120/70 millimeters of mercury (mm Hg), while it is normal for blood pressure to fluctuate throughout the day–rising during intense activity and falling when at rest (Johnson, 2006).

2. Heart Pulse Rate

Due to the rhythmic contraction (systole) and relaxation (diastole) of the heart´s left ventricle as it pumps blood throughout the body. Each systole and the following diastole are known as one cardiac cycle. Therefore, pulse rate is an expression of the heart rate, describing the number of times the cardiac cycle occurs each minute.

Pulse rate affected by several factors, including gender, age, exercise, medications, body temperature and emotions.

The average resting pulse rate in a healthy adult is about 70-80 bpm, but range is usually extended to 60-90 bpm. On one hand, normal pulse rate will vary depending on the level of physical activity. In a healthy adult, it can decrease to 40 bpm during sleep and up to 180 bpm during intense exercise. On another hand, women have (72-80 bpm) a slightly faster resting pulse rate than men (64-72 bpm). Also, there is inverse relationship between heart rate and age (King *et al.*, 2008).

3. Blood Oxygen Saturation

Every living organism requires oxygen for its survival. Health blood oxygen levels are essential for proper functioning of the body. Less amount of oxygen flowing through the blood or oxygen deprivation can lead to organ failure.

Blood oxygen saturation is defined as the ratio of oxhemoglobin to the total concentration of hemoglobin in blood. One hemoglobin molecule can carry a maximum of four molecules of oxygen. The 10000 hemoglobin molecules can carry a maximum of 40000 oxygen molecules; if they were carrying 36000 oxygen molecules, then the oxygen saturation level would be (36000/40000)*100 or 90% (Schutz, 1982)

The level can be measured with the help of a pulse oximeter attached to a finger. A 95-100% level is considered as normal or healthy while 80-94% oxygen is considered as low blood oxygen or hypoxemia. In children, 97% oxygen level (at least 97% of the blood stream should be oxygen saturated) is considered as normal. Very low level of oxygen (less than 80%) can lead to serious symptoms. Hyperoxia is a condition caused by very high level of oxygen in blood which causes cell death and serious damage, especially to the central nervous system, eye and lungs (Michael, 2007).

Chapter Three

Methodology

3.1 Study Sample

This study was conducted on a group of children (males and females) who were studying in various schools distributed in three locations in Nablus area (the permit paper is in appendix B).

The sample of this study are 273 children of both genders (91 female, 182 male), distributed in three different schools. The ages of the children were between 10-16 years. The students chosen that had no history of heart cardiovascular disease. In addition, the average exposure hours were 5 hours per day. Moreover, the children were asked not to smoke or to eat salty food before taking the measurements, because these factors affect the health parameters.

The study sample was calculated according to Cochran formula (Cochran, 1977):

$$n = \frac{z^2 pq}{\delta^2} \quad 3.1$$

Where,

n = a random sample size of children in each school.

z = value for selected alpha level of 0.025 in each tail = 1.96

(p)(q) = estimate of variance, q = 1 - p, p = 0.9, q = 0.1

δ = acceptable margin of error for proportion being estimated to be 0.055

n = 114.3

Applying the correction formula (Colin, 1994):

$$m = \frac{n}{1 + n/N} \qquad 3.2$$

Where,

m = corrected sample size that should be used.

n = sample size of selecting children in school.

N = population of the total children that founded in each school.

Using the previous formula, the number of children that should be examined (m) is:

(91) in Yaseed Primary School for Girls in Yaseed village.

(85) in Yaseed Primary School for Boys in Yaseed village.

(97) in Masqat Primary School for Boys in Asira AL-Shamaliyeh town.

Location of villages are shown in Fig. 3.1

Fig. 3.1 Location of Yaseed and Asira AL-Shamaliyeh (Google Earth, http://www.google.com/intl/en_uk/earth/explore/products/plugin.html)

For Yaseed Primary School for Girls there are no buildings or trees between antenna and the school and the level of the antenna is in the same level of the school high. The other two schools there are buildings and trees between antenna and the schools.

This study was conducted between February and May 2013. The measurements were done twice; the first was at 8:00 a.m, the second measurement was at 1:00 p.m.

The children were asked to be at rest for half an hour before they started their regular studying hours.

Light Intensity and Sound Pressure Level were taken every minute during measurement to normalize the light and noise effect and to make sure that the only parameter that plays the important role in children activity is EMR intensity.

The measured parameters were taken during a period of one month for each school and three times for each child on three successive days. The EMR intensity was measured in the school at different location (classrooms, paths, and courtyard) and averaged to get the value of EMR intensity during the children study. The values of EMR intensity in all schools ranged from 18.278μw/m^2 (-39.53 dB/m^2) to 1862μw/m^2 (-20.674 dB/m^2).

Children who live in areas less than 300 m from the base of antenna were not included in the sample to make sure that the effect of EMR intensity on the measured parameters is excluded.

The Table 3.1 below shows the selected of this sample in these schools

Table 3.1 The selected sample in three studied schools

S	School Name	Number of Children	Number of Children 10-12 years	Number of Children 13-16 years
S1	Yaseed Primary School for Girls	91	39	52
S2	Yaseed Primary School for Boys.	85	35	50
S3	Masqat Primary School for Boys	97	22	75

The distances between the base of antenna and the schools and height of antenna above the ground are given in Table 3.2 below.

Table 3.2 The distance between the base of antenna and schools and height of antenna

School	Distance between the schools and the base of antenna in meters (m)	Height of antenna above the ground in meters (m)
S1	150	6
S2	250	6
S3	300	15

3.2 Stages of Study:

Several stages were performed in this study as follows:

1. Selecting schools in Nablus area
2. Selecting children who are living far away from antenna (>300 m) and not having health problems.
3. Dividing children to two groups 10-12 years and 13-16 years
4. Measuring the sound pressure level.
5. Measuring the light intensity of the room.
6. Measuring the EMR intensity in different places in school (classrooms, paths, and courtyard).

7. Measuring the parameters as the following:
    1. Blood oxygen saturation
    2. Blood pressure
    3. Heart pulse rate
8. All measurements for each child were repeated; three times in the morning (8:00 – 8:30) a.m, and three times after midday (1 – 1:30) p.m in three different days (one time every day).

3.3 Experimental Apparatus:

Several instruments and tools were used in performing our study. These instruments are:

1- Spectran of radio frequency (RF) 6080, Fig. 3.2 is to measure the power flux density (P), in (w/m^2), or in (dBm), with accuracy ± 3dB, spectran offers two demodulation modes, Amplitude Modulation (AM), Frequency Modulation (FM), frequency range (0-7GHz max).

Fig. 3.2 Spectran of radio frequency (Instructions manual for spectran RF 6080,Aaronia AG, Germany, 2007)

2- Hioki 3423 lux hitester digital illumination meter, this instrument is used to measure the light intensity. It measures a broad range of luminosities from the low light provided by induction lighting up to a maximum intensity of 199,900 lux. In this study, the light was kept around 500 lux or less. The lux hitester digital meter is shown in Fig. 3.3

Fig. 3.3 Hioki 3423 lux hitester digital illumination (Instruction Manual for the Lux Hitester 3423, 2012)

3- Automatic Blood Pressure Monitor (micro life AG, Modno.BP 2BHO), Measuring range: (30-280 mmHg) with accuracy ± 2% mm-Hg, and ± 2% for reading heart pulse rate with operating temperature range of +10 °C to +40 °C that is used for measuring arterial blood pressure (systolic, diastolic and pulse rate), the automatic blood pressure monitor shown in Fig. 3.4

Fig. 3.4 Arterial Blood Pressure and Heart Pulse Rate Meter, model WS-300 (Instruction manual 1998 a)

4- Pulse Oximeter LM-800 Fig. 3.5 with accuracy ± 1%, is used to measure the blood oxygen saturation of each children (Instruction Manual for Pulse Oximeter LM-800, 2012).

Fig. 3.5 Pulse Oximeter LM-800 (Instruction Manual for Pulse Oximeter LM-800, 2012)

5- Sound Pressure Level Meter Fig. 3.6, is to measure the noise level in dB. (Quest Technologies U.S.A, Model 2900 type 2) with accuracy of ± 0.5 dB at 25 °C. This device gives the reading with a precision of 0.1dB (Instruction Manual for Models 2900 Integrating and Logging Sound Pressure Level Meter, 1998 b).

Fig. 3.6 Sound pressure level meter model 2900 type 2 (Instruction Manual for Models 2900 Integrating and Logging Sound Pressure Level Meter, 1998 b)

3.4 Statistical Analysis

The collected data were digitalized in a database developed with SPSS and Microsoft excel program. The measurements were analyzed statistically as the following:

Pearson correlation factor (R) and the probability (P) will be used to measure the strength correlation between variables before and after exposure to light.

The (R) values ranged from zero to one as follows (Brown *et al.*, 1998):

a. $0.00 \leq R \leq 0.39$, weak correlation
b. $0.40 \leq R \leq 0.59$, moderate correlation
c. $0.60 \leq R \leq 0.79$, strong correlation
d. $0.80 \leq R \leq 1.0$, very strong correlation.

The P-values ranged from zero to one as follows (William *et al.*, 2007):

a. $0.000 \leq P \leq 0.050$, strong significant relationship.

b. $0.050 \leq P \leq 1.000$, no significance.

Analysis of variance (ANOVA) test was used in this work to detect association between arterial blood pressure (diastolic and systolic), heart pulse rate and blood oxygen saturation with power density before and after exposure to EMR.

3.5 Reference Levels

There are many organizations which study the effect of exposure to electromagnetic radiation (EMR) on biological systems and human health, such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP), and the World Health Organization (WHO) and others, these organizations put regulation and exposure guidelines for EMR.

Table 3.3 shows ICNIRP reference levels for general public exposure to time varying electric and magnetic fields (ICNIRP, 1998).

Table 3.3 Reference levels for general public exposure to time varying electric and magnetic fields (ICNIRP, 1998)

Frequency range	E-field strength ($V\ m^{-1}$)	Magnetic strength H($A\ m^{-1}$)	Magnetic flux density B (μT)
1–10 MHz	$87/f^{½}$	0.73/f	0.92/f
10–400 MHz	28	0.073	0.092
400–2,000 MHz	$1.375\ f^{½}$	$0.0037\ f^{½}$	$0.0046\ f^{½}$
2–300 GHz	61	0.16	0.20

(Where f is the frequency in MHz)

SAR stands for Specific Absorption Rate. It measures the level of absorption of EMR by the body. Specific absorption rates (SARs) are generally expressed in watts per kilogram (W/kg) of tissue.

The reference values for SAR in Europe and USA are shown in Table 3.4 (Seabury, 2005)

Table 3.4 Standard values for SAR in Europe and USA (Seabury, 2005)

	Whole body SAR	Spatial peak SAR	Averaging time	Averaging mass
Europe	0.08 W/kg	2 W/kg	6 min	10 gm
USA	0.08 W/kg	1.6 W/kg	30 min	1 gm

For ICNIRP, the Public exposure and Occupational exposure guidelines for Mobile phone base station with frequency 900 MHz and 1.8 GHz are given in Table 3.5 (ICNIRP, 1998).

Table 3.5 ICNIRP public exposure and occupational exposure guidelines for mobile phone base station (ICNIRP, 1998)

Frequency	900 MHz	1.8 GHz
	Power density (W/m^2)	Power density (W/m^2)
Public exposure limits	4.5	9
Occupational exposure limits	22.5	45

In Germany, Building Biology Institute provided the following guidelines for power flux density exposure, where the exposure levels are given in Table 3.6 (Building Biology Institute, 2008).

Table 3.6 Reference levels for power flux density exposure (exposure levels in μW/m^2) (Building Biology Institute, 2008)

Power flux density (μW/m^2)	
< 0.1	no concern
(0.1 - 10)	slight concern
(10 - 1000)	severe concern
> 1000	extreme concern

Chapter Four

Results

This chapter includes the results which conducted on the sample of children in the schools in Nablus area.

4.1 Light Intensity (LI) and Sound Pressure Level (SPL) Measurements Results

The light intensity and sound pressure levels measured to make sure that the only parameter that plays the important role in children' activity is EMR intensity. Several studies show the relation between light intensity, sound pressure levels and health parameters (Abdelraziq *et al.*, 2000; Qamhieh, *et al.*,2000; Abdelraziq *et al.*, 2003; Abdelraziq *et al.*, 2003; Sadeq,2010; Al-Sheikh Ibrahim, 2012; Abo-Ras, 2012; Sadeq *et al.*, 2012; Al-Sheikh Mohammad, 2013; Ibrahim *et al.*, 2013; Al-Sheikh Mohammad *et al.*, 2013; Al-Faqeeh,2013; Abu-Sabha, 2014; Suliman, 2014; Darawshe, 2014; Abu Hadba, 2014).

The results of measurement of average light intensity and average sound pressure level for three different schools are shown in Table 4.1.

Table 4.1 Average light intensity and average sound pressure level for three different schools

School	sound pressure level in dB(A)	light intensity in lux
S1	46.1	444.8
S2	44.5	339.7
S3	43.1	315.0

From Table 4.1, it can be observed that average values of light intensity are less than 500 Lux and sound pressure level are less than 50 dB(A) that they are within the recommended range (OSHA, 2011), (the engineering toolbox, 2013).

4.2 EMR Intensity Measurements Results

The sample was composed of 273 children of both genders (91 female, 182 male). The age of the sample was between 10-16 years. The results of measurement of EM intensity for all schools are shown in Table 4.2.

Table 4.2 EMR intensity for schools

S	Distance between the schools and antenna in meters (m)	EMR intensity in dB/m^2(average)	EMR intensity in $\mu w/m^2$(average)
S1	150	-20.67	1862
S2	250	-26.03	353.2
S3	300	-39.53	18.28

The average values of the measured EMR intensity levels for antennas, of studied schools are shown in Fig. 4.1.

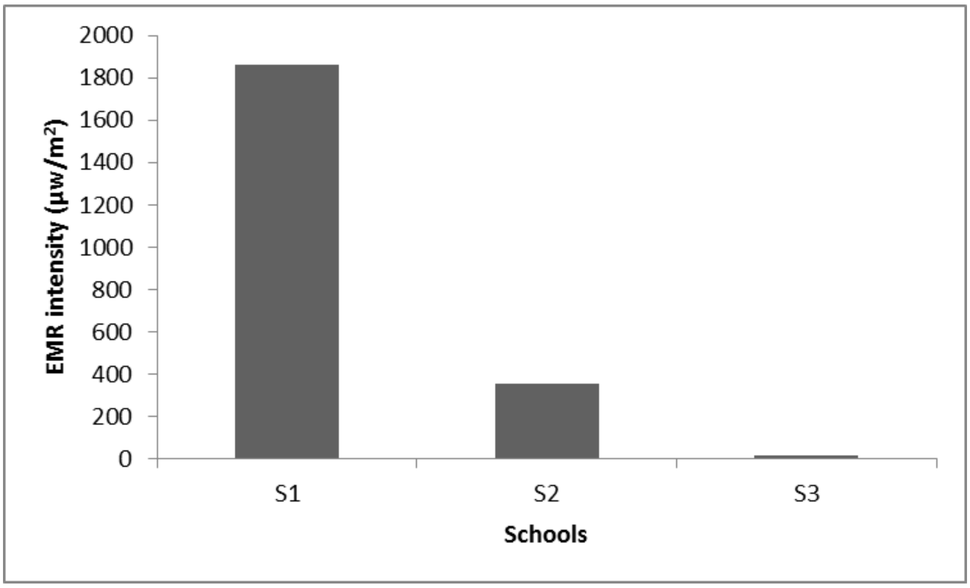

Fig. 4.1 Average values of the measured EMR intensity levels for antennas in studied schools

The electric and magnetic fields, magnetic flux density, were calculated using the following equations

$$B = \mu H \qquad 2.1$$

$$P = \frac{E^2}{\eta} \qquad 2.4$$

$$P = \eta H^2 \qquad 2.6$$

Specific absorption rate for human brain was calculated, using equation

$$SAR = \frac{\sigma|E^2|}{\rho} \qquad 2.7$$

There are two values for σ and ρ, according to these two values SARs were calculated (Gray, 2000; Chiang, 2008). The results are tabulated in table 4.3 for three different schools.

Table 4.3 Average values of electric and magnetic fields, magnetic flux density and SAR for human brain and reference levels of it

	$E\times10^{-2}$ (V/m)	$H\times10^{-4}$ (A/m)	$B\times10^{-11}$ (Tesla)	$SAR\times10^{-6}$ (W/Kg) $\rho = 1030\ kg/m^3$ $\sigma = 1.1531\ S/m$	$SAR\times10^{-6}$ (W/Kg) $\rho = 1700\ kg/m^3$ $\sigma = 0.7\ S/m$
Reference level	41.3×10^2	1.1×10^3	1.4×10^4	2×10^6 (USA) Or 1.6×10^6 (Europe)	2×10^6 (USA) Or 1.6×10^6 (Europe)
S1	83.8	22.0	276.3	786.0	289.0
S2	36.5	9.7	121.8	149.0	54.9
S3	8.4	2.2	27.6	7.9	2.9

4.3 Health Effects of EMR Intensity Measurements Results

The health parameters which depend on EMR intensity as blood oxygen saturation, pulse rate and arterial blood pressure (systolic and diastolic) are measured.

Minimum, maximum, mean, and standard deviation of mean values of systolic and diastolic pressure (SBP and DBP), heart pulse rate (HPR) and oxygen saturation (SPO_2%) before (b) and after (a) exposure to EMR intensity for all selected children in all schools for two groups 10-12 years and 13-16 years are presented in Tables 4.4 to 4.9.

Table 4.4 The normal values, Min, Max, mean, and S.D. values of studied variables for selected children in Yaseed Primary School for girls (S1) (10-12 years age group)

	Normal	Min	Max	Mean	S.D.
SBP (b)	100-139[a]	71.0	149.0	104.0	16.4
SBP (a)		60.0	121.0	101.0	14.9
DBP (b)	60-90[a]	43.0	92.0	64.4	11.0
DBP (a)		40.0	86.0	60.7	10.4
HPR (b)	60-100[b]	58.0	114.0	91.7	14.1
HPR (a)		43.0	121.0	86.5	15.8
SPO_2% (b)	95-100[c]	86.0	99.0	96.1	3.1
SPO_2% (a)		85.0	99.0	93.4	3.7

(a- Chobanian *et al.*, 2003; b- Fuster *et al.*, 2001; c- Grap M., 1998)

Table 4.5 The normal values, Min, Max, mean, and S.D. values of studied variables for selected children in Yaseed Primary School for girls (S1) (13-16 years age group)

	Normal	Min	Max	Mean	S.D.
SBP (b)	100-139[a]	84.0	142.0	115.0	11.8
SBP (a)		84.0	135.0	114.0	12.0
DBP (b)	60-90[a]	51.0	105.0	74.5	11.6
DBP (a)		49.0	94.0	67.8	8.8
HPR (b)	60-100[b]	67.0	112.0	88.3	12.2
HPR (a)		62.0	110.0	81.2	11.4
SPO_2% (b)	95-100[c]	91.0	99.0	97.0	2.0
SPO_2% (a)		82.0	99.0	93.6	4.1

Table 4.6 The normal values, Min, Max, mean, and S.D. values of studied variables for selected children in Yaseed Primary School for Boys. (S2) (10-12 years age group)

	Normal	Min	Max	Mean	S.D.
SBP (b)	100-139[a]	82.0	143.0	112.0	13.5
SBP (a)		88.0	132.0	110.0	10.8
DBP (b)	60-90[a]	42.0	91.0	64.3	10.8
DBP (a)		45.0	90.0	63.6	11.0
HPR (b)	60-100[b]	57.0	124.0	90.6	15.8
HPR (a)		55.0	117.0	81.3	15.0
SPO_2% (b)	95-100[c]	93.0	99.0	97.7	1.5
SPO_2% (a)		90.0	99.0	96.7	2.0

Table 4.7 The normal values, Min, Max, mean, and S.D. values of studied variables for selected children in Yaseed Primary School for Boys (S2) (13-16 years age group)

	Normal	Min	Max	Mean	S.D.
SBP (b)	100-139[a]	88.0	146.0	120.0	13.2
SBP (a)		85.0	141.0	114.0	12.3
DBP (b)	60-90[a]	46.0	93.0	65.2	9.3
DBP (a)		47.0	77.0	61.8	6.6
HPR (b)	60-100[b]	61.0	115.0	86.2	12.9
HPR (a)		55.0	102.0	76.4	12.2
SPO_2% (b)	95-100[c]	93.0	99.0	97.8	1.3
SPO_2% (a)		90.0	99.0	95.7	2.9

Table 4.8 The normal values, Min, Max, mean, and S.D. values of studied variables for selected children in Masqat Primary School for Boys (S3) (10-12 years age group)

	Normal	Min	Max	Mean	S.D.
SBP (b)	100-139[a]	91.0	138.0	110.0	13.0
SBP (a)		84.0	144.0	107.0	15.8
DBP (b)	60-90[a]	44.0	104.0	65.6	13.6
DBP (a)		41.0	101.0	61.7	13.3
HPR (b)	60-100[b]	57.0	104.0	82.3	12.7
HPR (a)		62.0	99.0	78.0	10.9
SPO_2% (b)	95-100[c]	90.0	99.0	96.9	2.3
SPO_2% (a)		87.0	99.0	93.9	3.4

Table 4.9 The normal values, Min, Max, mean, and S.D. values of studied variables for selected children in Masqat Primary School for Boys (S3) (13-16 years age group)

	Normal	Min	Max	Mean	S.D.
SBP (b)	100-139[a]	76.0	152.0	115.0	13.0
SBP (a)		11.0	168.0	114.0	19.3
DBP (b)	60-90[a]	41.0	99.0	63.9	10.0
DBP (a)		40.0	84.0	60.7	8.9
HPR (b)	60-100[b]	55.0	117.0	84.6	14.6
HPR (a)		56.0	112.0	80.2	13.0
SPO_2% (b)	95-100[c]	91.0	99.0	97.7	1.6
SPO_2% (a)		87.0	99.0	95.8	2.9

(a- Chobanian *et al.*, 2003; b- Fuster *et al.*, 2001; c- Grap M., 1998)

The net change of systolic and diastolic pressure (SBP and DBP), pulse heart rate (HPR) and oxygen saturation (SPO_2%), before and after exposure to EMR from antenna, for all children 10-12 years age and 10-13 years age, are measured and given in Tables 4.10 and 4.11

Table 4.10 Net change of systolic and diastolic pressure (SBP and DBP), heart pulse rate (HPR) and oxygen saturation (SPO_2%), before and after exposure to EMR from antenna, for all children 10-12 years age

Differences between averages	S1	S2	S3
SBP (mmHg)	3	2	3
DBP (mmHg)	3	1	4
HPR (beats/min)	6	10	4
SPO_2%	3	1	3

Table 4.11 Net change of systolic and diastolic pressure (SBP and DBP), pulse heart rate (HPR) and oxygen saturation (SPO_2%), before and after exposure to EMR from antenna, for all children 13-16 years age

Differences between Averages	S1	S2	S3
SBP (mmHg)	1	6	1
DBP (mmHg)	6	4	3
HPR (beats/min)	7	10	5
SPO_2%	3	2	2

4.3.1 Systolic and Diastolic Blood Pressure Results

Values of diastolic and systolic blood pressure of selected children were taken by using automatic digital electronic wrist blood pressure meter, three times for each child during (8:00 – 8:30) a.m and three times during (1:00 – 1:30) p.m.

The percentage differences (decreases) in systolic and diastolic blood pressure for both groups of children in each school are represented in Figs 4.2 – 4.3.

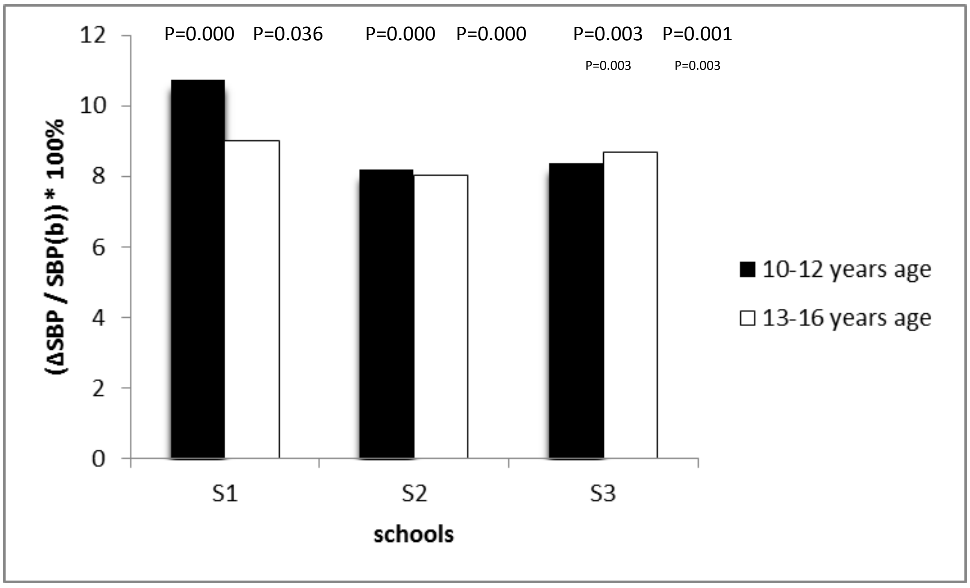

Fig. 4.2 Percentage differences in systolic blood pressure (SBP) for 10-12 years age group and for 13-16 years age group in each studied school and P values are given of each school

Fig 4.2 shows that for S1 and S2 percentage differences (decreases) of 10-12 years age group more than 13-16 years age group which is contrast with S3.

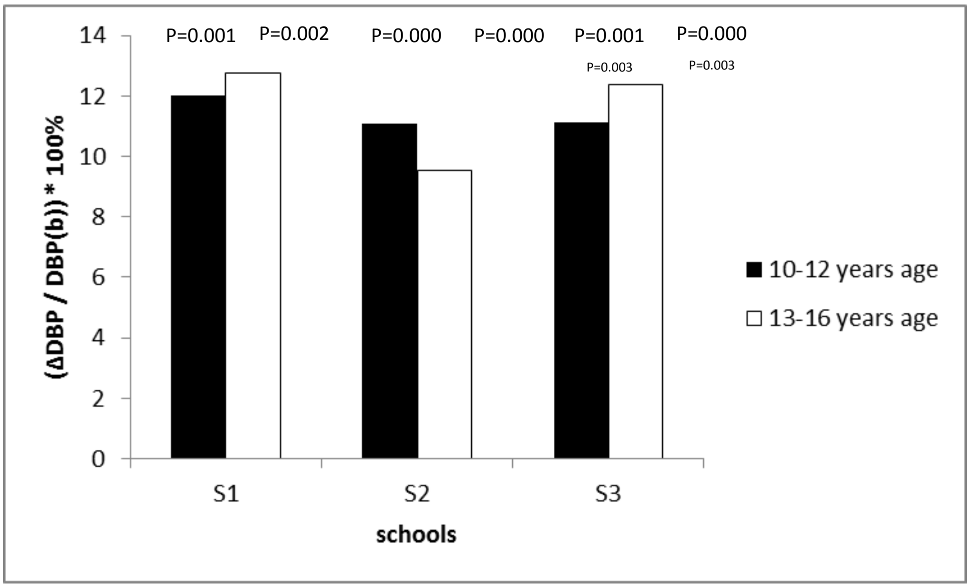

Fig. 4.3 Percentage differences in diastolic blood pressure (DBP) for 10-12 years age group and for 13-16 years age group in each studied school and P values are given of each school

Fig 4.3 shows that the percentage differences (decreases) in diastolic blood pressure (DBP) are larger for 13-16 years age group than for 10-12 years age group in S1 and S3, but for S2 percentage differences in DBP are larger for 10-12 years age group than for 13-16 years age group.

4.3.2 Heart Pulse Rate Results

The Automatic Digital Electronic Wrist Blood Pressure Meter was used three times for each child during (8:00 – 8:30) a.m and three times during (1:00 – 1:30) p.m. The average values of heart pulse rate for two groups children in each studied school before (b) and after (a) exposure to EMR from antenna are shown in Fig 4.4.

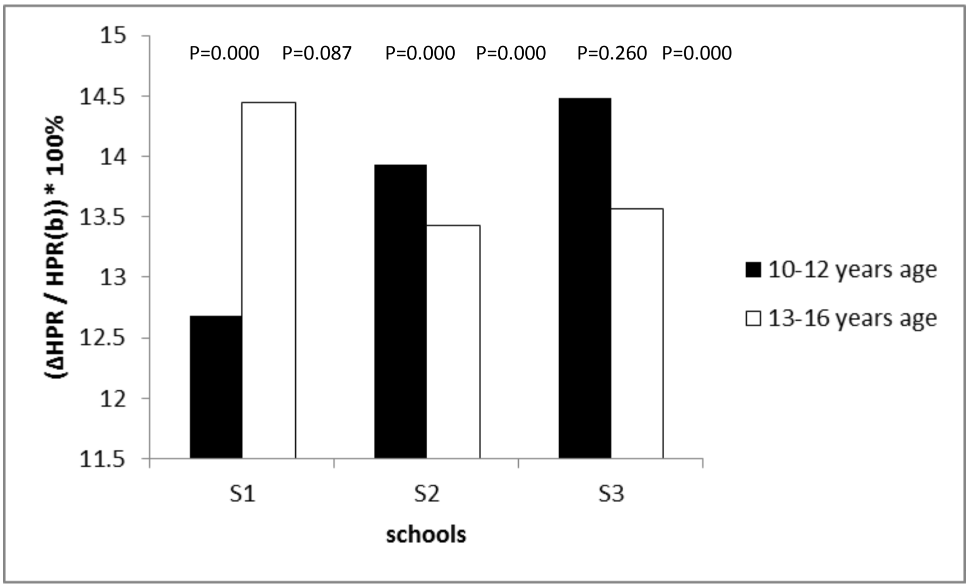

Fig. 4.4 Percentage difference in heart pulse rate (HPR) for 10-12 years age group and for 13-16 years age group in each studied school and P values are given of each school

Fig 4.4 shows that the percentage differences (decreases) in heart pulse rate (HPR) are larger for 10-12 years age group than for 13-16 years age group in S2 and S3, but for S1 percentage differences in HPR are less for 10-12 years age group than for 13-16 years age group.

4.3.3 Blood Oxygen Saturation (SPO_2%) Results

The Blood oxygen saturation (SPO_2%) of selected children was measured three times for each child by using Pulse oximeter LM-800, during (8:00 - 8:30) a.m and three times during (1:00 – 1:30) p.m.

The effects of the electromagnetic radiation on SPO_2% for studied children of schools are represented in Fig. 4.5.

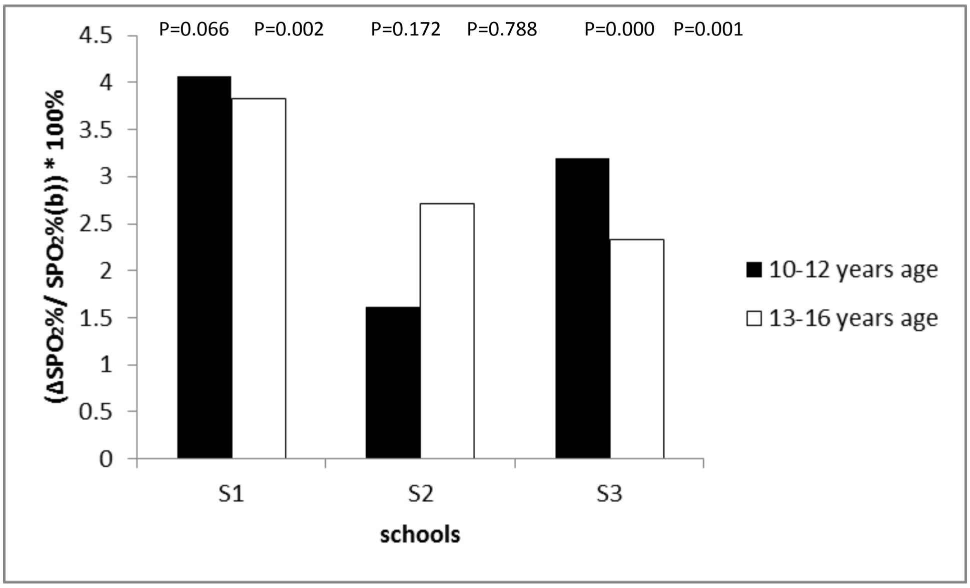

Fig. 4.5 Percentage difference in blood oxygen saturation (SPO_2%) for 10-12 years age group and for 13-16 years age group in each studied school and P values are given of each school

Fig 4.5 shows that blood oxygen saturation (SPO_2%) for S1 and S3 percentage differences (decreases) are larger for 10-12 years age group than 13-16 years age group which is contrast with S2.

4.4 Data Analysis of Result of EMR Intensity Dependent

Results of blood pressure (systolic and diastolic pressure), pulse rate, blood oxygen saturation, showed that there is shifting of these measurements after exposure to different intensities of EMR. It is found that there is a relation

(Pearson correlation coefficient) between blood pressure (systolic and diastolic pressure), heart pulse rate, and blood oxygen saturation before and after exposure to EMR. All of these relationships are presented in Tables 4.12 - 4.19

Table 4.12 Paired sample correlation of all studied variables before (b) and after (a) exposure to EMR for children in S1 (10-12 years)

Paired variables	Pearson Correlation coefficient (R)	Sig-P- value
SBP(b) & SBP(a)	0.564	0.000
DBP(b) & DBP(a)	0.510	0.001
HPR(b) & HPR(a)	0.610	0.000
SPO_2%(b) & SPO_2%(a)	0.297	0.066

Table 4.13 Paired sample correlation of all studied variables before (b) and after (a) exposure to EMR for children in S1 (13-16 years)

Paired variables	Pearson Correlation coefficient (R)	Sig-P- value
SBP(b) & SBP(a)	0.292	0.036
DBP(b) & DBP(a)	0.423	0.002
HPR(b) & HPR(a)	0.239	0.087
SPO_2%(b) & SPO_2%(a)	0.421	0.002

Table 4.14 Paired sample correlation of all studied variables before (b) and after (a) exposure to EMR for children in S2 (10-12 years)

Paired variables	Pearson Correlation coefficient (R)	Sig-P- value
SBP(b) & SBP(a)	0.645	0.000
DBP(b) & DBP(a)	0.588	0.000
HPR(b) & HPR(a)	0.655	0.000
SPO_2%(b) & SPO_2%(a)	0.236	0.172

Table 4.15 Paired sample correlation of all studied variables before (b) and after (a) exposure to EMR for children in S2 (13-16 years)

Paired variables	Pearson Correlation coefficient (R)	Sig-P- value
SBP(b) & SBP(a)	0.590	0.000
DBP(b) & DBP(a)	0.617	0.000
HPR(b) & HPR(a)	0.649	0.000
SPO_2%(b) & SPO_2%(a)	0.039	0.788

Table 4.16 Paired sample correlation of all studied variables before (b) and after (a) exposure to EMR for children in S3 (10-12 years)

Paired variables	Pearson Correlation coefficient (R)	Sig-P- value
SBP(b) & SBP(a)	0.609	0.003
DBP(b) & DBP(a)	0.638	0.001
HPR(b) & HPR(a)	0.251	0.260
SPO_2%(b) & SPO_2%(a)	0.768	0.000

Table 4.17 Paired sample correlation of all studied variables before (b) and after (a) exposure to EMR for children in S3 (13-16 years)

Paired variables	Pearson Correlation coefficient (R)	Sig-P- value
SBP(b) & SBP(a)	0.365	0.001
DBP(b) & DBP(a)	0.451	0.000
HPR(b) & HPR(a)	0.450	0.000
SPO_2%(b) & SPO_2%(a)	0.389	0.001

Table 4.18 Paired sample correlation of all studied variables before (b) and after (a) exposure to EMR for all children from 10-12 years old

Paired variables	Pearson Correlation coefficient (R)	Sig-P- value
SBP(b) & SBP(a)	0.619	0.000
DBP(b) & DBP(a)	0.570	0.000
HPR(b) & HPR(a)	0.587	0.000
SPO_2 %(b) & SPO_2%(a)	0.460	0.000

Table 4.19 Paired sample correlation of all studied variables before (b) and after (a) exposure to EMR for all children from 13-16 years old

Paired variables	Pearson Correlation coefficient (R)	Sig-P- value
SBP(b) & SBP(a)	0.391	0.000
DBP(b) & DBP(a)	0.547	0.000
HPR(b) & HPR(a)	0.446	0.000
SPO_2%(b) & SPO_2% (a)	0.368	0.000

Chapter Five

Discussion

The highest EMR intensity level was measured at Yaseed Primary School for Girls with 1862µw/m^2.The lowest value was at Masqat Primary School for Boys with 18.278µw/m^2.

This study was set on the effect of EMR pollution on blood pressure (systolic and diastolic pressure), pulse rate, blood oxygen saturation, in selected schools in Nablus area.

5.2 The Effect of EMR Pollution on health parameters

5.2.1 The Effect of EMR Pollution on Arterial Blood Pressure (Systolic and Diastolic)

Average values of systolic blood pressure are decreased after the child's exposed to EMR. For both groups of children, Yaseed boy school is the most affected school, where Pearson correlation coefficient is R = 0.645 for 10-12 years group and R = 0.590 for 13-16 years group. In this study, the systolic blood pressure decreased by 1-6 mm Hg. Pearson correlation coefficient for all children (10-12 years group) who have been exposed to electromagnetic radiation is R = 0.619, and R = 0.391 for 13-16 years group. Female children are more susceptible to electromagnetic radiation than male children R = 0.538.

There are noticeable decreased in diastolic blood pressure average values as shown in Figs. 4.4 – 4.5. All schools have large R values for 10-12 years group. R for Yaseed girl school 0.510, R for Yaseed boy school is 0.588 and R for Masqat school 0.638. For 13-16 years group, Yaseed boy school is the most affected school, where Pearson correlation coefficient is 0.617.

In this study, the diastolic blood pressure decreased by 1-6 mm Hg. Pearson correlation coefficient (R) for all children (10-12 years group) who have been exposed to electromagnetic radiation is 0.570 and 0.547 for 13-16 years group. Male children are more susceptible to electromagnetic radiation than female children where R is 0.546.

There are studies that showed that workers exposed to radiofrequency EMF have lowering in blood pressure (Szmigielski *et al.*, 1998).

5.2.2 The Effect of EMR Pollution on Heart Pulse Rate

Results of heart pulse rate for the selected children showed decrease of HPR values as shown in Figs 4.6 - 4.7. The most affected children are from Yaseed boy school where Pearson correlation coefficient is R = 0.655 for 10-12 years group and R = 0.649 for 13-16 years group. On one hand, 10-12 years children are more affected than 13-16 years children with R = 0.587.On the other hand, male are more affected than females R = 0.524. HPR values decreased about 4-10 beats/min after the children's exposure to EMR for at least 3 hours. A decrease of the heart rate was observed after 14 days of exposure to EMF (Ciejka *et al.*, 2009).

5.2.3 The Effect of EMR Pollution on Blood Oxygen Saturation SPO_2 %

Average values of blood oxygen saturation SPO_2 % are decreased after the children exposed to EMR from antenna as shown in Figs 4.8 and 4.9. The most affected children in 10-12 years group were from Masqat school where Pearson correlation coefficient is R = 0.768 and the most affected children in 13-16 years group were from Yaseed girl school where Pearson correlation coefficient is R = 0.421. Children for 10-12 years group are more affected than 13-16 years children with R = 0.460. Male children R = 0.379 are more affected than females R = 0.347. The difference between values of blood oxygen saturation before and after exposed to EMR is 1-3 %. The results of this study are in agreement with Abdel Aziz's study (Abdul Aziz, 2010). Abdel Aziz found a decrement of 12.2% in red blood cells (RBC) after exposing to frequency of 900 MHz for two weeks. Accordingly, the blood oxygen saturation was also decreased.

Children in Yaseed boy school are the most affected from the antennas electromagnetic radiation, the second school is Yaseed girl school, as was concluded from R values between the variables before and after exposure to EMR. The results indicate that Children for 10-12 years group are more affected than 13-16 years children because of the vital activity for young children. In this study, male children are more affected from EMR pollution than female children, except for systolic blood pressure where female children are more affected. This result is due to that the male's body contains electromagnetic waves more than a female's body (Kumar *et al*., 2008) and the monthly period (Eric *et al*., 2010) for females.

According to guidelines of Building Biology Institute, measurements of power flux density in Table 4.2 are in the range of 10-1000μW/m^2 and >1000μW/m^2, where the highest value is 1862μW/m^2 and lowest value is 18.28μW/m^2. In Iran, a group of researcher found that the average power flux density from the base station was 0.02mW/m^2 in urban area and 0.05mW/m^2 in the rural area (Tayebeh *et al*., 2012). According to table 4.3, the highest value of the magnetic flux density was in Yaseed Primary School for Girls S1 (B = 2.76×10^{-5} G). Comparing the results of SAR values in Table 4.2 with the standard values of SAR in Table 3.4, it is clear that the results of SAR values in this research were much below the standard levels, where the highest value of SAR is 786μW/kg. According to Table 4.3, the electric field, magnetic field strength and magnetic flux density are much below than the reference levels in Table 3.3. Where the highest value of E = 0.838V/m, H = 22×10^{-4}A/m, and B = 2.76 nT.

Values of E, H, B and SAR are too small and changes in SBP, DBP, HPR, SPO_2% parameters are in the normal ranges, so these decrements in measured values are properly not from electromagnetic radiation only, but may also from sound pressure level and light intensity as studied by Al-Sheikh Ibrahim, Al-Sheikh Mohammad, Abo-Ras, Abdelraziq, Sadeq and Ibrahim (Al-Sheikh Ibrahim, 2012; Al-Sheikh Mohammad, 2013; Abo-Ras, 2012; Abdelraziq *et al.*, 2003; Sadeq *et al.*, 2012; Ibrahim *et al.*, 2013; Al-Sheikh Mohammad *et al.*,2013). In addition, a study in China showed the same observation on the effect of noise on blood pressure. It is found that the workers with eight hour average noise exposure of 85 dB(A) had lower arterial elasticity and higher blood pressure than workers with workplace average noise exposure of 59 dB(A) (Chan, 2007). A study by Zahr looked at 55 preterm infants between 23 and 37 weeks, exposing them to common environmental noises such as alarms, phones and loud conversations, it was found that the average blood oxygen saturations were significantly lower during noisy periods (Zahr, 1995).

Peng showed that pulse rate increased and the blood oxygen saturation decreased as the intensity of light went up (Peng, 2001).

In the future, long term studies will need for the effect of exposure to EMR from antenna, to show if there’s any effect of it on health parameters and on different kind of cancer and other disease.

Chapter Six

Recommendations

The following are some recommendations which can be carried on to reduce the effect of EMR from antenna on children health:

1. Building schools in locations should be far away from antenna at least 300m.
2. Planting trees around the schools, to decrease the EMR pollution inside the schools.
3. Using a plaster cement form as pre-manufactured tiles in addition to polystyrene, or electrolytic manganese dioxidenand MnZn-ferrite to shield these schools effectively from outside electromagnetic interference.
4. Explaining the results of the EMR risks on children health to the teachers of the schools.
5. Measuring the intensity of the EMR from antenna and other sources periodically and make sure that it does not increase with time.
6. Measuring the different variables such as arterial blood pressure (systolic (SBP), diastolic (DBP)), heart pulse rate (HPR), blood oxygen saturation (SPO_2%) of children schools periodically to make sure that children health is normal.

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Appendix A

The measured date for all children in three different schools

Table A.1: SBP, DBP, HPR and SPO_2% before (b) and after (a) exposure to EMR for 10-12 years age group for Yaseed primary school for girl (S1)

Student No.	SBP (b)	SBP (a)	DBP (b)	DBP (a)	HPR (b)	HPR (a)	SPO_2% (b)	SPO_2% (a)
student 1	104	84	48	61	101	82	97	96
student 2	121	110	73	63	103	108	99	97
student 3	85	60	56	46	102	97	97	93
student 4	72	112	61	60	109	96	96	98
student 5	98	116	67	71	76	80	99	96
student 6	101	101	81	52	73	95	99	97
student 7	73	73	43	48	93	89	93	96
student 8	87	104	51	51	68	73	97	90
student 9	111	120	86	80	114	121	97	98
student 10	93	111	77	64	90	88	97	93
student 11	90	102	56	63	74	72	99	98
student 12	100	103	61	68	97	96	98	98
student 13	89	86	65	60	89	86	96	89
student 14	102	81	65	47	92	89	97	95
student 15	104	110	65	60	84	107	97	91
student 16	94	87	55	59	58	78	98	99
student 17	106	87	67	40	92	96	99	96
student 18	120	80	55	45	96	117	90	88
student 19	105	102	72	54	68	59	97	96
student 20	104	92	62	77	85	63	97	99
student 21	110	99	59	59	78	66	96	89
student 22	123	115	60	54	101	108	86	94
student 23	104	105	68	66	114	99	95	85
student 24	73	91	49	59	101	94	90	97
student 25	114	97	61	63	90	78	93	91
student 26	129	116	58	55	113	75	98	96
student 27	71	76	49	40	99	84	91	91
student 28	97	94	62	65	100	101	97	94
student 29	123	121	70	68	111	94	90	88
student 30	105	112	80	77	92	87	97	90
student 31	149	121	53	58	90	84	97	90
student 32	110	105	67	60	73	68	94	94
student 33	103	97	65	57	91	76	96	90
student 34	120	121	92	86	71	43	95	89
student 35	108	107	87	56	109	97	98	95
student 36	102	100	64	74	100	80	99	91
student 37	111	112	62	65	101	86	99	92
student 38	117	116	70	68	96	82	98	88
student 39	117	116	68	67	82	78	99	96

Table A.2: SBP, DBP, HPR and SPO_2% before (b) and after (a) exposure to EMR for 13-16 years age group for Yaseed primary school for girl (S1)

Student No.	SBP (b)	SBP (a)	DBP (b)	DBP (a)	HPR (b)	HPR (a)	SPO_2% (b)	SPO_2% (a)
student 1	113	116	68	72	78	74	99	99
student 2	103	103	70	62	68	80	99	98
student 3	116	88	73	64	96	93	98	91
student 4	122	113	78	69	109	93	99	85
student 5	115	84	70	62	92	102	99	98
student 6	114	111	85	71	100	86	98	98
student 7	130	108	85	64	102	76	93	90
student 8	120	122	81	77	109	71	97	91
student 9	104	121	75	74	100	85	92	92
student 10	104	100	56	60	82	79	91	92
student 11	87	101	65	62	68	64	95	93
student 12	122	114	82	92	105	95	92	86
student 13	115	130	99	79	94	82	96	97
student 14	103	123	80	70	83	98	97	90
student 15	108	111	55	67	69	86	97	96
student 16	108	98	69	62	72	77	95	90
student 17	110	106	81	60	88	110	96	95
student 18	138	104	59	69	71	91	98	98
student 19	118	122	73	64	85	79	99	97
student 20	100	93	57	70	96	96	98	90
student 21	128	135	89	69	100	99	98	98
student 22	116	114	69	64	81	82	97	97
student 23	100	124	70	70	92	65	99	92
student 24	119	117	68	71	102	76	99	89
student 25	127	121	52	65	102	66	98	99
student 26	97	131	68	61	99	71	98	92
student 27	116	121	70	72	90	78	94	85
student 28	116	135	87	63	96	84	94	91
student 29	128	113	92	76	87	85	99	90
student 30	108	126	67	68	85	73	95	90
student 31	130	128	105	60	90	88	96	94
student 32	113	128	74	71	112	103	99	98
student 33	111	110	70	55	87	83	99	99
student 34	84	91	51	49	74	77	98	90
student 35	119	117	71	68	67	84	94	82
student 36	111	107	65	60	87	96	99	98
student 37	129	122	94	63	68	86	98	92
student 38	110	118	80	75	85	89	96	98
student 39	109	107	71	54	78	71	98	99

student 40	135	123	79	76	75	64	98	92
student 41	114	107	83	77	97	79	98	96
student 42	110	113	70	60	80	76	97	99
student 43	142	103	64	64	108	86	98	95
student 44	110	113	73	64	79	65	99	94
student 45	134	134	99	94	95	62	97	94
student 46	122	120	78	74	85	73	97	94
student 47	115	117	74	68	95	65	96	94
student 48	117	126	81	82	98	80	97	93
student 49	113	104	71	51	71	64	96	97
student 50	133	123	73	82	88	82	98	93
student 51	123	111	83	67	89	82	97	95
student 52	114	103	71	61	80	71	99	93

Table A.3: SBP, DBP, HPR and SPO_2% before (b) and after (a) exposure to EMR for 10-12 years age group for Yaseed primary school for boy (S2)

Student No.	SBP (b)	SBP (a)	DBP (b)	DBP (a)	HPR (b)	HPR (a)	SPO_2% (b)	SPO_2% (a)
student 1	82	98	61	84	78	69	95	96
student 2	117	105	71	62	82	82	99	99
student 3	143	131	78	81	116	107	98	93
student 4	128	111	73	61	101	94	99	97
student 5	130	127	73	67	70	79	98	98
student 6	106	108	70	72	111	116	98	99
student 7	98	112	62	59	93	87	99	98
student 8	117	107	47	58	70	79	97	90
student 9	109	88	42	45	71	75	99	99
student 10	100	104	50	67	87	77	99	96
student 11	110	106	61	58	76	94	98	98
student 12	113	102	59	58	79	80	95	98
student 13	99	91	56	53	98	95	99	98
student 14	101	107	77	58	100	84	97	97
student 15	102	118	48	50	81	76	97	97
student 16	137	127	91	90	124	99	97	97
student 17	108	96	63	57	77	66	98	97
student 18	121	132	71	67	123	85	99	93
student 19	96	96	53	47	74	69	98	98
student 20	121	109	80	52	88	67	99	97
student 21	103	105	68	67	102	90	99	99
student 22	133	120	71	80	117	92	98	99
student 23	116	118	77	66	100	80	95	93
student 24	109	113	67	78	99	117	99	97
student 25	97	106	54	54	57	55	98	98

student 26	103	110	61	62	88	64	95	97
student 27	130	109	69	71	100	85	98	93
student 28	106	121	50	53	93	67	98	98
student 29	122	114	73	83	80	62	98	96
student 30	120	116	69	61	91	80	99	97
student 31	125	116	69	53	75	56	98	97
student 32	110	97	53	57	90	62	93	96
student 33	99	105	57	64	90	86	98	97
student 34	104	98	64	63	98	85	97	97
student 35	119	119	62	67	92	85	98	97

Table A.4: SBP, DBP, HPR and SPO_2% before (b) and after (a) exposure to EMR for 13-16 years age group for Yaseed primary school for boy (S2)

Student No.	SBP (b)	SBP (a)	DBP (b)	DBP (a)	HPR (b)	HPR (a)	SPO_2% (b)	SPO_2% (a)
student 1	124	97	72	60	78	87	99	98
student 2	112	102	78	68	107	86	99	99
student 3	99	107	63	48	73	63	99	98
student 4	110	109	52	62	78	69	99	97
student 5	136	121	66	64	97	81	99	99
student 6	127	109	62	54	66	85	97	99
student 7	117	99	55	51	74	74	97	97
student 8	121	118	63	63	74	66	97	97
student 9	117	109	71	65	97	89	98	97
student 10	118	119	62	63	88	85	99	98
student 11	120	112	78	66	100	94	97	97
student 12	112	107	52	48	69	62	98	99
student 13	119	116	70	69	98	100	97	97
student 14	111	115	72	64	89	82	98	97
student 15	106	141	46	56	74	83	99	99
student 16	119	108	62	58	89	82	98	96
student 17	88	85	62	54	113	102	98	97
student 18	124	109	66	62	88	63	99	90
student 19	127	131	93	73	98	95	97	96
student 20	129	112	64	62	82	74	95	98
student 21	119	127	51	62	76	76	98	90
student 22	120	115	61	68	111	97	97	93
student 23	138	140	73	77	89	70	98	91
student 24	96	90	54	57	87	90	98	96
student 25	142	102	60	60	85	72	99	96
student 26	121	105	67	58	85	77	98	90
student 27	94	100	52	58	81	61	98	90
student 28	134	133	71	70	115	84	98	93
student 29	132	126	54	58	94	91	98	94
student 30	110	123	73	74	74	63	98	97
student 31	128	128	71	68	86	71	95	97
student 32	102	106	57	60	87	59	96	95

student 33	101	108	59	47	93	75	99	93
student 34	136	130	81	69	90	71	98	90
student 35	126	115	69	66	70	66	99	97
student 36	134	125	73	63	80	69	98	98
student 37	129	128	79	62	89	68	98	95
student 38	128	129	63	59	76	65	98	99
student 39	103	96	62	58	93	89	95	98
student 40	109	107	62	62	79	71	98	94
student 41	122	112	59	57	85	69	99	99
student 42	114	102	61	63	72	64	98	92
student 43	129	113	59	60	61	63	99	99
student 44	110	109	62	61	65	55	93	92
student 45	132	134	86	71	114	84	95	98
student 46	124	105	71	54	88	93	97	97
student 47	132	110	65	68	87	72	99	92
student 48	146	135	62	68	74	60	99	96
student 49	142	117	64	56	99	65	97	92
student 50	110	105	70	64	95	90	99	97

Table A.5: SBP, DBP, HPR and SPO_2% before (b) and after (a) exposure to EMR for 10-12 years age group for Masqat Primary School for Boys (S3)

Student No.	SBP (b)	SBP (a)	DBP (b)	DBP (a)	HPR (b)	HPR (a)	SPO_2% (b)	SPO_2% (a)
student 1	98	103	62	49	97	78	99	98
student 2	129	90	69	52	102	88	98	98
student 3	127	141	80	78	104	64	99	98
student 4	113	113	53	56	76	77	99	95
student 5	123	120	73	79	76	90	97	95
student 6	138	125	74	72	89	81	96	91
student 7	121	144	91	101	94	73	96	93
student 8	100	107	56	71	57	68	97	92
student 9	123	128	104	61	64	80	98	99
student 10	96	105	63	60	70	68	95	91
student 11	115	97	69	74	83	84	90	87
student 12	101	104	67	64	74	92	97	90
student 13	104	95	61	62	84	94	92	88
student 14	102	99	58	54	71	80	97	92
student 15	105	99	61	53	70	63	97	91
student 16	125	104	72	62	80	84	95	95
student 17	112	99	68	59	80	62	99	99
student 18	100	98	58	51	83	64	98	94
student 19	108	106	51	48	86	84	99	95
student 20	95	84	44	41	90	75	98	95
student 21	103	97	54	58	77	66	97	96
student 22	91	90	55	53	104	99	99	94

Table A.6: SBP, DBP, HPR and SPO_2% before (b) and after (a) exposure to EMR for 13-16 years age group for Masqat Primary School for Boys (S3)

Student No.	SBP (b)	SBP (a)	DBP (b)	DBP (a)	HPR (b)	HPR (a)	SPO_2% (b)	SPO_2% (a)
student 1	113	111	59	62	88	71	99	95
student 2	114	101	67	55	111	87	99	90
student 3	121	104	59	48	71	75	96	99
student 4	112	105	74	58	96	83	93	92
student 5	128	72	59	40	69	79	98	99
student 6	125	111	68	67	90	77	91	90
student 7	135	135	68	60	82	60	93	93
student 8	120	100	69	61	95	82	97	91
student 9	121	122	58	49	84	94	99	94
student 10	108	110	76	54	89	77	96	98
student 11	101	98	58	59	80	81	99	96
student 12	119	127	53	55	97	87	98	90
student 13	95	103	41	53	73	74	98	98
student 14	97	111	64	67	76	76	93	94
student 15	108	118	79	80	78	85	97	87
student 16	122	118	71	74	69	80	99	93
student 17	83	80	52	48	67	70	99	90
student 18	122	119	73	69	85	93	99	96
student 19	118	115	68	73	77	80	97	96
student 20	107	87	63	48	62	65	97	94
student 21	94	102	62	65	85	103	99	97
student 22	104	102	67	62	88	96	99	98
student 23	109	127	45	64	88	90	98	98
student 24	113	121	60	62	59	69	99	95
student 25	113	103	58	44	98	75	99	97
student 26	109	111	69	62	88	87	97	91
student 27	127	121	67	59	74	57	98	97
student 28	111	125	99	55	58	88	99	99
student 29	137	140	80	75	109	62	99	97
student 30	113	125	56	62	117	105	97	98
student 31	118	118	60	52	57	58	99	98
student 32	116	135	72	58	108	59	98	98
student 33	117	122	62	63	93	84	98	91
student 34	109	111	68	66	73	73	98	98
student 35	99	102	44	41	100	95	97	95
student 36	121	115	69	61	88	75	98	97
student 37	128	108	70	60	86	76	98	99
student 38	106	88	52	43	105	96	98	98

student 39	76	136	43	67	106	72	97	97
student 40	109	108	57	54	84	81	98	99
student 41	107	105	68	62	108	100	96	97
student 42	111	109	58	57	74	83	99	99
student 43	126	128	79	66	88	80	99	97
student 44	108	123	62	61	100	89	98	93
student 45	96	104	59	53	89	75	99	98
student 46	133	130	70	59	68	61	98	94
student 47	133	128	58	50	61	62	97	99
student 48	121	109	62	58	106	100	99	99
student 49	140	126	72	62	82	74	97	93
student 50	135	135	67	49	95	87	99	99
student 51	124	115	63	58	88	74	99	99
student 52	130	168	81	76	90	73	95	92
student 53	119	122	68	61	97	90	96	92
student 54	134	124	74	69	92	76	98	95
student 55	110	111	53	64	70	66	97	94
student 56	103	97	54	57	103	98	98	99
student 57	112	114	63	59	86	81	98	99
student 58	119	136	61	59	106	87	99	95
student 59	121	126	62	56	73	57	98	98
student 60	120	110	54	61	81	63	98	97
student 61	101	84	49	45	101	92	97	95
student 62	96	101	57	64	91	90	97	99
student 63	124	123	61	62	64	79	97	92
student 64	115	120	66	64	55	56	99	98
student 65	152	114	76	65	90	93	98	96
student 66	132	131	74	73	94	94	99	98
student 67	124	130	71	69	88	79	99	99
student 68	102	118	56	68	56	90	97	97
student 69	111	111	73	68	76	68	96	92
student 70	112	112	57	58	81	100	97	96
student 71	115	130	64	67	77	71	99	96
student 72	131	123	72	73	82	97	98	96
student 73	119	130	71	84	69	83	99	99
student 74	111	120	43	64	73	61	97	97
student 75	116	124	72	78	85	112	98	97

Appendix B: consent form

An-Najah National University

Faculty of Graduate Studies

Dean's Office

جامعة النجـــاح الوطنية

كلية الدراسـات العليا

مكتب العميد

وزارة التربية والتعليم العالي
مديرية التربية والتعليم نابلس
04-02-2013
قسم الوارد

التاريخ : 2013/2/3م

حضرة السيد مدير التربية والتعليم نابلس المحترم

الموضوع : تسهيل مهمة الطالبة/ رهام عصام اسعيد ظاهر ، رقم تسجيل 11054901،

تخصص ماجستير فيزياء

تحية طيبة وبعد،

الطالبة/ رهام عصام اسعيد ظاهر، رقم تسجيل 11054901، تخصص ماجستير فيزياء، في كلية الدراسات العليا، وهي بصدد اعداد الاطروحة الخاصة بها والتي عنوانها:

(تأثير الأشعة الكهرومغناطيسية الناتجة عن ابراج محطات البث على أطفال المدارس في منطقة نابلس)

يرجى من حضرتكم تسهيل مهمتها في السماح لها تطبيق الدراسة واخذ القياسات من ضغط دم وعدد نبضات القلب وتركيز الاكسجين في الدم (دون اخذ عينات دم من الطلبة) على طلبة المرحلة الاساسية في المدارس الحكومي التابعة في محافظة نابلس لاستكمال مشروع البحث.

شاكرين لكم حسن تعاونكم.

مع وافر الاحترام ،،،

عميد كلية الدراسات العليا

د. محمد أبو جعفر

الطالبة / ، عنوان الأطروحة:

(The Effect of Electromagnetic Radiation from Antennas on Children's Schools in Nablus Area)

فلسطين، نابلس، ص.ب 7، 707 هاتف:/2345115، 2345114، 2345113 (09)(972)* فاكسميل:2342907(09)(972)

Nablus, P. O. Box (7) *Tel. 972 9 2345113, 2345114, 2345115 هاتف داخلي (5) 3200

* Facsimile 972 92342907 *www.najah.edu - email fgs@najah.edu

جامعة النجاح الوطنية
كلية الدراسات العليا

آثار الأشعة الكهرومغناطيسية الناتجة عن أبراج محطات البث على أطفال المدارس في منطقة نابلس

اعداد
رهام عصام اسعيد ظاهر

اشراف
أ.د عصام راشد عبد الرازق
د .محمد ابو جعفر

قدمت هذه الأطروحة استكمالا لمتطلبات الحصول على درجة الماجستير في الفيزياء بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس – فلسطين
2014

آثار الأشعة الكهرومغناطيسية الناتجة عن أبراج محطات البث على أطفال المدارس في منطقة نابلس

اعداد

رهام عصام اسعيد ظاهر

اشراف

أ.د عصام راشد عبد الرازق

د .محمد ابو جعفر

الملخص

ألقت هذه الدراسة الضوء على تأثير الإشعاع الكهرومغناطيسي من أبراج محطات البث على ضغط الدم الشرياني (ضغط الدم الانبساطي و الانقباضي) و معدل نبض القلب و نسبة الأكسجين في الدم على أطفال المدارس .

تتكون عينة الدراسة من 273 طالب من كلا الجنسين (91 طالبة، 182طالب)، مقسومين على مجموعتين، 10–12 سنة و 13–16 سنة . وقد أخذت العينة من المدارس المختلفة و القريبة على أبراج محطات البث في منطقة نابلس. و قد كانت قيمة كثافة تدفق الطاقة في المدرسة الأولى 1862 ميكرو واط/م^2 و 353.166 ميكرو واط/م^2 في المدرسة الثانية و 18.278 ميكرو واط/م^2 في المدرسة الثالثة. و قد اخذت قراءات ضغط الدم الشرياني (ضغط الدم الانبساطي و الانقباضي) و معدل نبض القلب و نسبة الأكسجين في الدم للعينة المختارة قبل و بعد التعرض للأشعة الكهرومغناطيسية من أبراج محطات البث. و قد وجد أن هناك علاقة بين المتغيرات المقاسة. و قد أظهرت النتائج الإحصائية أن معامل ارتباط بيرسون بين المتغيرات (ضغط الدم الانبساطي، ضغط الدم الانقباضي، معدل نبض القلب، نسبة الأكسجين في الدم) قبل و بعد التعرض للأشعة الكهرومغناطيسية من الأبراج مناسب و الاحتمالية < 0.05.

أظهرت هذه الدراسة أن هناك تغيير في قيم ضغط الدم الشرياني (ضغط الدم الانبساطي و الانقباضي) ومعدل نبض القلب و نسبة الأكسجين في الدم نتيجة لتعرضهم للأشعة الكهرومغناطيسية من الأبراج.