



Resident's Perception of the health impact in living proximity of telecommunication base station: A case study of Malaysia

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ABSTRACT

The location of telecommunication towers is of particular public concern due to the dread of potential health peril from the electromagnetic field (EMFs) emitted by these devices. This paper outlines the results of a case study to determine residents' perceptions towards living near telecommunication towers in Malaysia, and how they evaluate the health impacts of these structures. The results provide initial evidence that telecommunication towers have little influence on residents' perception on health symptoms and that it would not be a reason for them to move away. Furthermore, the results show that more than half of the respondents feel that it is safe to live near a telecommunication tower but it raises aesthetic concern. The outcome provides a potential source of information for related government agencies in assessing increasing health concern for residents living near telecommunication towers.

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Introduction

In the past decade, the use of mobile communication technologies for mobile phoning, texting, as well as now-mobile internet services has become a crucial part of human life. Based on statistical data (ITU, 2016a), global mobile penetration has increased approximately 126% in 2016 compared to the past 10 years, and mobile subscription is expected to further increase in the future. Technology advancement in Malaysia, especially in network performance (mobile broadband), devices (smart phone), and mobile services and applications (web streaming, video surfing), has led to increasing demand for personal internet use, which has rose from 21.38% in 2000 to 78.79% in 2016 (ITU, 2016b).

To supply mobile data traffic for internet users, the ubiquitous mobile communication network infrastructure has expanded in Malaysia. The telecommunication companies have to build more base stations at strategic locations to ensure a high quality mobile network service to end-users, and to stay ahead of the competition from other service providers. However, most of these locations are located in highly populated areas near residential areas, such as on the rooftops of shop lots and apartments, open spaces at playing fields, or parking lots of shopping complexes (Din, 2009). Malaysia has an estimated total of 16,000–18,000 telecommunication base stations (cellular and broadband) nationwide (Ngui, 2016).

The number of telecommunication base stations built in residential areas has increased public concern due to substantial controversy about the potential health effects of the radiofrequency electromagnetic fields (EMFs) emissions of base stations (D'Angelo, Costantini, Kamal, & Reale, 2015; Din, 2009; Isabona, Srivastava, & Robert, 2016; Ozovehe, Usman, & Hamdallah, 2015; Siegrist, Earle, Gutscher, & Keller, 2005). According to Cousin and Siegrist (2010) and Hallberg and Oberfeld (2006), the health effects of EMF are headaches, giddiness, nausea, skin rashes, feeling warm, depression, night sweats, memory loss, disturbances in menstruation, and insomnia.

Several bodies have been established internationally to deal with these health issues. These bodies provide guidelines and standards aiming to allay public fear on the effects of EMF. Malaysian telecommunication companies use the guidelines provided by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) (1998), Institute of Electrical and Electronics Engineers (IEEE) (1999), and the World Health Organization (WHO) (Din, 2009; Tukimin, Mahadi, Ali, & Thari, 2009). Based on radiation detection tests by the Malaysian Communications and Multimedia Commission (MCMC), the radiation effects of EMF from telecommunication base stations in Malaysia are still at a low level (Ngui, 2016), with simulation tests and empirical tests at base station sites showing radiation levels to be well below 1%. This indicates that radiation is less than 1%, compared to the ICNIRP-recommended level for mandatory standards for emission of EMFs from infrastructure.

Many prior studies indicated that people living in the vicinity of telecommunication base stations suffer from adverse health conditions (e.g. Augner & Hacker, 2009; Isabona et al., 2016; Roje, Poljak, & Sarolic, 2003; Shahbazi-Gahrouei, Karbalaee, Moradi, & Baradaran-Ghahfarokhi, 2014). All of these studies have been empirically tested in other countries, but not in Malaysia. There are very few studies which investigate the impact of telecommunication base stations on residents' health in Malaysia. The only existing study was conducted in Penang, Malaysia by Suleiman, Gee, and Krishnapillai (2014). Hence, this study aims to help fill the research void by including study sites in all the states in West Malaysia including Perlis, Kedah, Penang, Perak, Selangor, Kuala Lumpur, Negeri Sembilan, Melaka, Johor, Kelantan, Terengganu, and Pahang. The study determines residents' perceptions towards living near telecommunication base stations and the possible health effects of EMF.

Residents' perceptions towards living near telecommunication base station

A base station is a radio transmitter or receiver, comprising an antenna and based on a cellular system, used in a modern mobile telecommunications network. Each cell can be thought of as an electromagnetic wave that spreads out from the antenna to connect them to the telephone network, and handles carry-over to the next base station if a mobile user leaves the coverage range (Kundi & Hutter, 2009). Telecommunication base stations are low-power, multichannel two-way radios. The antennas are mounted on either transmission towers or roof-mounted structures, and produce radiofrequency (RF) radiation (Ng, 2003). The base station needs to be of a certain height to ensure wide coverage.

In the past, this cellular infrastructure had very large cells with each cell having 10 km radius, and were mainly located along highways to provide service for car-phones (Kundi & Hutter, 2009). In the last decade, a digital mobile phone system was widely used

and cell sizes got much smaller. More base stations were erected in residential areas, including more sensitive locations such as kindergartens, schools, and hospitals (Arning, Kowalewski, & Ziefle, 2014). Because the mobile devices and the base stations are two-way radios, they produce RF radiation to communicate, and thus expose humans to this radiation. These transmissions are low-power transmissions due to the short transmission range, and therefore RF radiation exposure levels are considered to be very low (Ng, 2003).

Despite the low level of RF exposure, long-time exposure can lead to chronic suicide; especially for those living near base stations or cell sites. According to Arning et al. (2014), residents' perception of mobile telecommunication technology is that of dread and fear of the potential health hazards from EMF emitted by these mobile phones and base stations. The locations of telecommunication base stations often evoke arguments from nearby residents because of the health risk, which then indirectly affects the property price or value (see studies of Bond, 2007; Bond & Wang, 2005; Brandt & Maennig, 2012; Filippova & Rehm, 2011).

Health effects in the vicinity of telecommunication base stations

The health effects of EMF have been widely studied in the last decade (Kundi & Hutter, 2009; Santini, Santini, Danze, Le Ruz, & Seigne, 2002, 2003), but the findings are heterogeneous and inconsistent. Klaps et al. (2016) outlined the problems for investigating the effects of base stations. The first problem is the proper definition of the independent variable, or a general set of measurement indicators to examine exposure to base station signals. The second problem is to study the outcome assessment due to people suffering from idiopathic environmental intolerance attributed to EMF in experimental trails, while lab experiments may cause inaccurate results in studying the subjective well-being and physiological indicators of the subjects (Hutter, Moshhammer, Wallner, & Kundi, 2006; Neubauer et al., 2007). The third problem concerns population selection. Even though base stations are ubiquitous, the actual exposure intensity is very low and hardly detectable, making it hard to measure an accurate human exposure level. Therefore, a random selection of study sites or respondents carries the risk of imprecise findings that may include only a few persons – or virtually no one – who have been exposed to EMF (Klaps et al., 2016).

Many studies have been conducted to examine the health effects of EMF in real life. In France, Santini et al. (Santini et al., 2002, 2003) researched the symptoms experienced by residents who live near base stations in correlation with their sex and distance from the base station. The results showed that residents living within a 300m distance from base stations feel tiredness; those within 200m experience headaches, sleep disturbances, and discomfort; while those within 100m experience irritability, depression, loss of memory, dizziness, a decrease in libido, and other symptoms. More women than men reported headache, nausea, loss of appetite, sleep disturbance, depression, discomfort and visual disturbances.

Navarro, Segura, Portolés, and de Mateo (2003) conducted a health survey in Murcia, Spain, including 101 residents living in the vicinity of base stations, in their analysis. The survey examined microwave sickness and RF syndrome. The microwave power density was measured at each respondent's house, where the strength of an electric field in the frequency range 1 MHz to 3 GHz was assessed in bedrooms. This

study found severe health symptoms like headaches, sleep disturbances, concentration difficulties, and discomfort.

A cross-sectional study examined the relationship between exposure from base station and health symptoms (Mohler et al., 2010). This study randomly selected residents in urban and rural areas who had been living near 10 base stations for more than one year. A total of 36 households at each location were investigated. Several cognitive tests were run, and well-being and sleep quality were evaluated. The RF-EMF measurement was collected in the bedrooms of 336 households. The findings found that health symptoms were generally more frequent at higher exposure levels, and statistically increased the prevalence of headache, vegetative symptoms, and difficulty in concentration. Sleep quality was found to be insignificantly affected by the base stations.

Abdel-Rassoul et al. (2007) identified the possible neuro-behavioural deficits among residents living near a base station in Menoufiya Governorate, Egypt. A total of 85 respondents were involved, comprising 37 residents living underneath base station antennas, and another 48 respondents working in an agricultural directorate building approximately 10m opposite the base station. Headache, memory changes, tremors, dizziness, depression, and sleep disturbances were found to affect the respondents significantly more frequently than controls. However, according to Kundi and Hutter (2009) critique, this study may be criticised for including employees who work near the base stations because other factors such as stressful working environment, indoor pollutants and other attributes of the workplace which may cause health symptoms were not assessed.

Several studies applying personal dosimetry disclosed different results in Germany. For example, Heinrich, Ossig, Schlittmeier, and Hellbrück (2007) used a double-blind experiment (i.e. neither experimenters nor the respondents knew whether the antenna was on or off) to investigate the effects of a base station's EMF on the well-being of employees working in close proximity. The results showed that none of the observed symptoms could be related to a statistically significant difference between having the antenna on or off. Kuhnlein, Heumann, Thomas, Heinrich, and Radon (2009), Thomas et al. (2008), and Thomas, Heinrich, Von Kries, and Radon (2010) also found that none of the symptoms of adults, children nor adolescents were significantly correlated to exposure. However, Heinrich, Thomas, Heumann, von Kries, and Radon (2010)'s study found different results. They found that a few symptoms were significantly associated with exposure – for example, headache experienced by adolescents at noon time after exposure in the highest quartile during morning time, and irritation experienced at bedtime after exposure in the highest quartile during afternoon hours. On the other hand, children reportedly experienced concentration problems.

Mohler et al. (2010) and Mohler, Frei, Fröhlich, Braun-Fahrlander, and Rösli (2012) conducted a series of investigations, combining a cross-sectional study (with 1,375 participants) and longitudinal study (955 respondents) in the area of Basel, Switzerland. The studies found homogeneous results and observed no associations between RF-EMF exposure and sleep disturbances or excessive daytime sleepiness. This corresponded with Hutter et al. (2006)'s study. Numerous meta-reviews have been done by researchers to better understand the effects of base station exposure in the health and well-being context (e.g. Klaps et al., 2016; Kundi & Hutter, 2009; Rösli, Frei, Mohler, & Hug, 2010; Rösli & Hug, 2011).

In more recent studies, Baliatsas et al. (2016) explored a possible change in the prevalence of non-specific symptoms, registered by general practitioners, among residents living in the proximity of a base station before and after an increase in installed base station antennas. A total of 1,069 adult participants from different regions in the Netherlands were analysed. The study compared two time periods (before and after) and revealed that after increasing the total number of base stations, a higher prevalence of most non-specific symptoms was observed. Also, a statistically significant prevalence of ear symptoms and musculoskeletal symptoms was found for the two different periods. Wiedemann, Freudenstein, Böhmert, Wiart, and Croft (2017) conducted an online survey with 2454 respondents in six European countries to identify the potential risks from base stations and access points comprising Wi-Fi routers and cell phones. This study found that respondents were convinced that even a very low EMF exposure can have chronic negative health effects. They regarded EMF exposure as a moral issue, which elicits antagonistic feelings.

On the other hand, in the case of Penang, Malaysia, Suleiman et al. (2014) used 14 symptoms to compare the possible health effects on residents exposed (170 respondents) and not exposed (31 respondents) to EMF from telecommunication towers. Residents who live within the radius of 0–150m from the base station were considered as EMF exposed, while more than 150m were considered as not exposed. The findings revealed that symptoms like headache, giddiness, insomnia, loss of memory, diarrhoea, mental slowness, reduced reaction times and mood swings were observed to significantly affect both exposed and non-exposed residents, but that the existing base station caused more adverse health effects in exposed residents compared to those who were not exposed.

Methodology

A methodology is a model that entails the theoretical framework that served as a guideline about how research is done in the context of a particular paradigm (Sarantakos, 2012). Positivism is used to describe an approach to the study of society that depends particularly on scientific evidence, such as statistics, which can reveal the true nature of how society works (Clark, 1998). The positivist paradigm was selected for this research for the purpose of understanding the health impacts of EMF to residents living near telecommunication base station. The positivist paradigm was used to guide the research design, data collection and data analysis, which are discussed in the following sections.

Research design, data collection and data analysis

Due to selecting positivism as the philosophical assumption for this research, quantitative methods involving a survey questionnaire was employed. This approach was selected because this research bases its knowledge claims on pragmatic grounds; with respect to perceptions on health hazards from living in the vicinity of a base station. The data collection started with the development of a survey instrument, aimed to establish a set of health symptoms that affect residents living near base stations in West Malaysia. The questionnaire was designed as a self-administered survey. Next, the survey instrument was pilot-tested and then refined. The selection of respondents

took place according to purposely random sampling in 12 Malaysian states in four regions during 2016. The questionnaire included sets of questions on certain themes, respondents' profile, the characteristics of residence, and evaluative questions to gauge residents' perception on the impacts of base stations. The primary data from the questionnaire survey were analysed using a descriptive analysis by the SPSS software.

Respondents' background profile

The summary statistics of the sample are presented in [Table 1](#). The majority of respondents were male, aged more than 43 years, married, with high school education level and general employees in Malaysia.

In total, 606 respondents were collected and analysed, comprising 202 house owners, 286 renters and 118 inheritors. The study site was four main regions in West Malaysia: 467 respondents from the Northern region, 43 respondents from the Central region, 30 respondents from the Southern region and 66 respondents from the East coast. A total of 460 respondents live in residential areas, and 116 respondents work in proximity of a telecommunication base station. Most of the respondents have lived in residences near a telecommunication base station for more than 10 years (37.6%). The data collection was restricted to residents who live not more than 400m away from a telecommunication tower, with 116 respondents living within 100m, 140 respondents living within 101–200m, 136 respondents living within 201–300m and 211 respondents living within 301–400m. The characteristics of residence are presented in [Table 2](#).

Table 1. Respondent profiles.

Sociodemographic		
Profile	Frequency	Percent (%)
<i>Gender</i>		
Male	342	53.77
Gender	294	46.23
<i>Age</i>		
19–24 years	155	24.37
25–30 years	146	22.96
31–36 years	48	7.55
37–42 years	114	17.92
More than 43 years	173	27.20
<i>Marital status</i>		
Single	239	37.58
Married	380	59.75
Widow	17	2.67
<i>Education level</i>		
Secondary school	63	9.91
High school	246	38.68
Diploma/Degree	231	36.32
Master/PhD	21	4.87
No formal Education	65	10.22
<i>Occupational sector</i>		
Management	91	14.31
Engineering	45	7.08
Medical	22	3.46
Education	73	11.48
Employees	405	63.68

Table 2. Characteristics of residence.

Characteristics	Frequency	Percent (%)
<i>Region</i>		
Northern region (Pulau Pinang/Perak/Perlis/Kedah)	467	77.06
Central region (Selangor/Kuala Lumpur/N Sembilan)	43	7.00
Southern region (Johor/Melaka)	30	4.95
East coast (Kelantan/Terengganu/Pahang)	66	10.89
<i>Type of building</i>		
Single unit houses	128	21.12
Terrace	279	46.04
Semi-detached	83	13.70
Offices	116	19.14
<i>Ownership status</i>		
Own	202	33.33
Renting	286	47.19
Inherit	118	19.47
<i>Length of stay</i>		
Less than 1 year	56	9.24
2–5 years	176	29.04
6–9 years	146	24.09
More than 10 years	228	37.62
<i>Distance</i>		
Less than 100m	116	19.24
101–200m	140	23.22
201–300m	136	22.55
301–400m	211	34.99

Results

Perception of base station

Details regarding the residents' perception towards the effects of base stations are shown in Table 3. In total, 53.63% of respondents were aware of the effects of RF, while 46.37% had no awareness and were not sure about RF effects. Around 37% of respondents thought that base stations cause adverse health issues. Majority of respondents aware there was a base station nearby when they move into their premises (67.33%). Most of the respondents agreed that base station causes aesthetic concern (70.13%). More than half of the respondents feel comfortable and safe living or working nearby a base station. About 80% of respondents would not move away even if there is base station nearby. A few respondents agreed that the EMF is affecting their health. Headache is the main symptom of health problems experienced by the residents (37.8%), followed by fatigue (32.7%), vision problems (9.9%) and loss of appetite (7.1%).

Discussion and conclusion

The present study examined residents' perceptions on the health impacts of telecommunication base stations in Malaysia, as well as their awareness of the effect of EMF. The results revealed that the majority of respondents living in residential areas disagreed that base stations negatively affect their health, although they were aware of the radiation effects from base stations. This may be because people perceive the health risks from EMF to be chronic rather than acute illnesses. In addition, the MCMC has distributed information to Malaysian citizens and encouraged public awareness of EMF and the safety of base stations (Din, 2009; Ng, 2003; Tukimin et al., 2009). The existence

Table 3. Residents' perception towards impacts of base station.

Perception	Frequency	Percent (%)
<i>Aware about the radiation effect</i>		
Yes	325	53.63
No	173	28.55
No sure	108	17.82
<i>Base station gives adverse health effect</i>		
Yes	226	37.29
No	229	37.79
No sure	151	24.92
<i>Base station was built when you move into the premises</i>		
Yes	408	67.33
No	113	18.65
No sure	85	14.03
<i>Base station causes aesthetic concern</i>		
Yes	425	70.13
No	181	29.87
<i>Feel comfortable living/working near to base station</i>		
Yes	378	62.38
No	99	16.34
No sure	129	21.29
<i>Safe to live</i>		
Yes	323	53.30
No	106	17.49
No sure	177	29.71
<i>Is base station a factor to move out</i>		
Yes	63	10.40
No	488	80.53
No sure	55	9.08
<i>Health problem caused by the EMF from base station</i>		
Yes	41	6.77
No	366	60.40
No sure	199	32.84
<i>Symptoms experience since living near to base station</i>		
Headache	229	37.79
Fatigue	198	32.67
Nausea and vomiting	20	3.30
Sight problem	60	9.90
Skin problems	40	6.60
Loss of appetite	43	7.10
Nose bleed	16	2.64

of a base station in a specific area would not cause residents to move away from the area but it raises the aesthetic concern. Majority of respondents were aware that there was a base station proximity when they move into their premises, indicating that the base station is not a main obstacle for choosing a place to live. Like the study of Santini et al. (2002, 2003), this study too found significant evidence of symptoms like headache, nausea, loss of appetite and visual disturbances.

The authorities should not neglect this issue, even if there are only a few respondents who face health problems because of their proximity to base stations. To reduce the intensity of RF, telecommunication companies should consider sharing base stations to mount their transceivers rather than increase the number of towers. Local authorities should regulate base station construction to strictly follow the guidelines provided by the Institute of Electrical and Electronics Engineers (IEEE) (1999) and the International Commission on Non-Ionizing Radiation Protection (ICNIRP) (1998). It is also recommended that the MCMC conduct random audits to ensure that the wireless communication environment conforms to the EMF safety level.

Furthermore, the MCMC should openly disclose details on the localities of each telecommunication base station, including the names of the telecommunication companies operating them, on an official website. This will not only encourage transparency but can also avoid the build and operation of illegal base stations. Other than that, public opinion should be considered before construction of base stations rather than face protest after the base station has been built.

This research is limited to a descriptive analysis of the primary data. For future study on this topic, the running of regression analysis is suggested to evaluate the relationship between house distance and health impacts on residents living in the vicinity of a base station. In addition, this research suggests for the future study on the impact of the base station towards the property value.

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References

- Abdel-Rassoul, G., El-Fateh, O. A., Salem, M. A., Michael, A., Farahat, F., El-Batanouny, M., & Salem, E. (2007). Neurobehavioral effects among inhabitants around mobile phone base stations. *NeuroToxicology*, 28(2), 434–440.
- Arning, K., Kowalewski, S., & Ziefle, M. (2014). Health concerns versus mobile data needs: Conjoint measurement of preferences for mobile communication network scenarios. *Human and Ecological Risk Assessment*, 20(5), 1359–1384.
- Augner, C., & Hacker, G. (2009). Are people living next to mobile phone base stations more strained? Relationship of health concerns, self-estimated distance to base station, and psychological parameters. *Indian Journal of Occupational and Environmental Medicine*, 13(3), 141.
- Baliatsas, C., van Kamp, I., Bolte, J., Kelfkens, G., van Dijk, C., Spreeuwenberg, P., Yzermans, J. (2016). Clinically defined non-specific symptoms in the vicinity of mobile phone base stations: A retrospective before-after study. *Science of the Total Environment*, 565, 714–720.
- Bond, S. (2007). Cell phone tower proximity impacts on house prices: A New Zealand case study. *Pacific Rim Property Research Journal*, 13(1), 63–91.
- Bond, S., & Wang, K. (2005). The impact of cell phone towers on house prices in residential neighborhoods. *Appraisal Journal*, 73(3), 256–277.
- Brandt, S., & Maennig, W. (2012). Perceived externalities of cell phone base stations: The case of property prices in Hamburg, Germany. *Environment and Planning A*, 44(2), 396–410.
- Clark, A. M. (1998). The qualitative-quantitative debate: Moving from positivism and confrontation to post-positivism and reconciliation. *Journal of Advanced Nursing*, 27(6), 1242–1249.

- Cousin, M., & Siegrist, M. (2010). Risk perception of mobile communication: A mental models approach. *Journal of Risk Research*, 13(5), 599–620.
- D'Angelo, C., Costantini, E., Kamal, M. A., & Reale, M. (2015). Experimental model for ELF-EMF exposure: Concern for human health. *Saudi Journal of Biological Sciences*, 22(1), 75–84.
- Din, N. M. (2009). Radio frequency radiation study. Retrieved March 30, 2018, from rfemf.mcmc.gov.my/skmmgovmy/.../Radio-Frequency-Radiation-Study_Uniten.pdf
- Filippova, O., & Rehm, M. (2011). The impact of proximity to cell phone towers on residential property values. *International Journal of Housing Markets and Analysis*, 4(3), 244–267.
- Hallberg, Ö., & Oberfeld, G. (2006). Letter to the editor: Will we all become electrosensitive? *Electromagnetic Biology and Medicine*, 25(3), 189–191.
- Heinrich, S., Ossig, A., Schlittmeier, S., & Hellbrück, J. (2007). Elektromagnetische felder einer UMTS-mobilfunkbasisstation und mögliche auswirkungen auf die befindlichkeit - Eine experimentelle felduntersuchung. *Umweltmedizin in Forschung Und Praxis*, 12(3), 171–180.
- Heinrich, S., Thomas, S., Heumann, C., von Kries, R., & Radon, K. (2010). Association between exposure to radiofrequency electromagnetic fields assessed by dosimetry and acute symptoms in children and adolescents: A population based cross-sectional study. *Environmental Health*, 9(1), 75.
- Hutter, H. P., Moshhammer, H., Wallner, P., & Kundi, M. (2006). Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. *Occupational and Environmental Medicine*, 63(5), 307–313.
- Institute of Electrical and Electronics Engineers (IEEE). (1999). *IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, Pub. L. No. IEEE Std C95.1*. IEEE.
- International Commission on Non-Ionizing Radiation Protection (ICNIRP). (1998). ICNIRP guidelines for limiting exposure to time-varying guidelines for limiting exposure to time-varying. *Health Physics*, 74(4), 494–522.
- Isabona, J., Srivastava, V. M., & Robert, O. O. (2016). Spatial variation of the electromagnetic radiations due to exposure to telecommunication base station transmitters in a pilot region. *International Journal of Applied Engineering Research*, 11(22), 10994–11001.
- ITU. (2016a). ICT facts and figures: Mobile-cellular subscriptions. Retrieved March 30, 2018, from <https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx>
- ITU. (2016b). ICT facts and figures: Percentage of individuals using the internet. Retrieved March 30, 2018, from <https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx>
- Klaps, A., Ponocny, I., Winker, R., Kundi, M., Auersperg, F., & Barth, A. (2016). Mobile phone base stations and well-being - A meta-analysis. *Science of the Total Environment*, 544, 24–30.
- Kuhnlein, A., Heumann, C., Thomas, S., Heinrich, S., & Radon, K. (2009). Personal exposure to mobile communication networks and well-being in children—A statistical analysis based on a functional approach. *Bioelectromagnetics*, 30(4), 261–269.
- Kundi, M., & Hutter, H. P. (2009). Mobile phone base stations—Effects on wellbeing and health. *Pathophysiology*, 16(2–3), 123–135.
- Mohler, E., Frei, P., Braun-Fahrlander, C., Fröhlich, J., Neubauer, G., & Rössli, M. (2010). Effects of everyday radiofrequency electromagnetic-field exposure on sleep quality: A cross-sectional study. *Radiation Research*, 174(3), 347–356.
- Mohler, E., Frei, P., Fröhlich, J., Braun-Fahrlander, C., & Rössli, M. (2012). Exposure to radio-frequency electromagnetic fields and sleep quality: A prospective cohort study. *PLoS ONE*, 7(5). doi:10.1371/journal.pone.0037455
- Navarro, E. A., Segura, J., Portolés, M., & de Mateo, C. G. (2003). The microwave syndrome: A preliminary study in Spain. *Electromagnetic Biology and Medicine*, 22(2–3), 161–169.
- Neubauer, G., Feychting, M., Hamnerius, Y., Kheifets, L., Kuster, N., Ruiz, I., ... Rössli, M. (2007). Feasibility of future epidemiological studies on possible health effects of mobile phone base stations. *Bioelectromagnetics*, 28(3), 224–230.
- Ng, K. H. (2003). *Radiation, mobile phones, base stations and your health*. Kuala Lumpur: Gains Print Sdn. Bhd.
- Ngui, A. (2016). EMF radiation levels at telecommunication base stations still low: MCMC. *The Sun Daily*. Retrieved April 21, from <http://www.thesundaily.my/news/1773239>

- Ozovehe, A., Usman, A. U., & Hamdallah, A. (2015). Electromagnetic radiation exposure from cellular base station: A concern for public health. *Nigerian Journal of Technology*, 34(2), 355–358. Retrieved from <http://10.0.16.218/njt.v34i2.20%5Cnhttp://bibliotecavirtual.unad.edu.co:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=aci&AN=115962187&lang=es&site=ehost-live>
- Roje, V., Poljak, D., & Sarolic, A. (2003). Safety aspects of the GSM base station radiation concerning human health. In *IEEE International Symposium on Electromagnetic Compatibility*, 2, 720–723.
- Rööslä, M., Frei, P., Mohler, E., & Hug, K. (2010). Systematic review on the health effects of exposure to radiofrequency electromagnetic fields from mobile phone base stations. *Bulletin of the World Health Organization*, 88(12), 887–896.
- Rööslä, M., & Hug, K. (2011). Wireless communication fields and non-specific symptoms of ill health: A literature review. *Wiener Medizinische Wochenschrift*, 161(9–10), 240–250.
- Santini, R., Santini, P., Danze, J. M., Le Ruz, P., & Seigne, M. (2002). Enquête sur la santé de riverains de stations relais de téléphonie mobile: I/Incidences de la distance et du sexe. *Pathologie Biologie*, 50(6), 369–373.
- Santini, R., Santini, P., Danze, J. M., Le Ruz, P., & Seigne, M. (2003). Enquête sur la santé de riverains de stations relais de téléphonie mobile: II/Incidences de l'âge des sujets, de la durée de leur exposition et de leur position par rapport aux antennes et autres sources électromagnétiques. *Pathologie Biologie*, 51(7), 412–415.
- Sarantakos, S. (2012). *Social Research* (4th ed.). England: Palgrave Macmillan.
- Shahbazi-Gahrouei, D., Karbalaee, M., Moradi, H. A., & Baradaran-Ghahfarokhi, M. (2014). Health effects of living near mobile phone base transceiver station (BTS) antennae: A report from Isfahan, Iran. *Electromagnetic Biology and Medicine*, 33(3), 206–210.
- Siegrist, M., Earle, T. C., Gutscher, H., & Keller, C. (2005). Perception of mobile phone and base station risks. *Risk Analysis*, 25(5), 1253–1264.
- Suleiman, A., Gee, T. T., & Krishnapillai, A. D. (2014). Electromagnetic radiation health effects in exposed and non-exposed residents in Penang. *Journal of Geoscience and Environment Protection*, 2, 77–83. April.
- Thomas, S., Heinrich, S., Von Kries, R., & Radon, K. (2010). Exposure to radio-frequency electromagnetic fields and behavioural problems in Bavarian children and adolescents. *European Journal of Epidemiology*, 25(2), 135–141.
- Thomas, S., Kühnlein, A., Heinrich, S., Praml, G., Nowak, D., Von Kries, R., & Radon, K. (2008). Personal exposure to mobile phone frequencies and well-being in adults: A cross-sectional study based on dosimetry. *Bioelectromagnetics*, 29(6), 463–470.
- Tukimin, R., Mahadi, W. N. L. W., Ali, M. Y. M., & Thari, M. N. M. (2009). Public awareness on electromagnetic field in Malaysia. In *International Engineering Convention* (pp. 486–492). Damascus, Syria: FEIC.
- Wiedemann, P. M., Freudenstein, F., Böhmert, C., Wiart, J., & Croft, R. J. (2017). RF EMF risk perception revisited: Is the focus on concern sufficient for risk perception studies? *International Journal of Environmental Research and Public Health*, 14, 6.