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ASSOCIATION BETWEEN MOBILE PHONES USE WITH MALIGNANT BRAIN TUMOR (GLIOMA): SYSTEMATIC REVIEW AND META-ANALYSIS

Yadolah Fakhri[1], Farahnaz Ghahremanfard[8], Moayed Avazpour[2], Mahboobeh Moradi[3], Nazak Amanidaz[4], Yahya Zandsalimi[5], Bigard Moradi[6], Leila Rasouli Amirhajeloo[7], Hassan Keramati[8*]

[1]Food and Cosmetic Health Research Center, Hormozgan University of Medical Sciences, Bandar Abbas, Iran.
[2]Department of Environmental Health Engineering, School of Public Health,
Ilam University of Medical Sciences, Ilam, Iran.
[3]Studends Research Office, Department of Environmental Health Engineering, School of Public Health,
Shahid Beheshti University of Medical Sciences, Tehran, Iran.
[4]Environmental Health Research Center, Golstan University of Medical Sciences, Golstan, Iran.
[5]Environmental Health Research Center, Kurdistan University of Medical Sciences, Sanandaj, Iran.
[6]Department of Health Public, Kermanshah University of Medical Sciences, Kermanshah, Iran.
[7]Department of Environmental Health Engineering, School of Public Health,
Qom University of Medical Sciences, Qom, Iran.
[8]Cancer Research Center, Semnan University of Medical Sciences, Semnan, Iran.
Email: Hkarmatee@gmail.com

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Abstract

Nowadays, due to the extensive use of mobile phones and their portability, exposure to the electromagnetic non-ionizing waves is inevitable. Several research has studies the association between the malignant brain tumor of Glioma and the use of mobile phone, the results of which were contradictory. Therefore, the present study intended to conduct a systematic meta-analysis review on the association between the use of mobile phone and the risk of malignant brain tumor. Using the quality assessment scale of Newcastle-Ottawa Scale (NOS), it was realized that 7 out of 9 case-control studies and 2 out of 3 Cohort studies ranked high. In overall, 12 studies (9 case-control and 3 Cohort) were reviewed in the present meta-analysis. The heterogeneity of case-control and cohort studies was respectively 81% (P<0.001) and 47% (P=0.048) and in overall it was 79% (P<0.001). The mean odds ratio of case-control and cohort studies was estimated about REM=1.03 (P=0.762), FEM=0.91 (P=0.597) respectively and it was REM=1 (P=0.996) in overall. The results of the current study did not confirm the assumption that the increased risk of Glioma malignant brain tumor is associated with the use of mobile phones.

Keywords: Mobile Phone; Malignant Tumor; Brain; Glioma; Systematic Review; Meta-Analysis.

1. Introduction

Waves are divided into two ionizing and non-ionizing categories [1]. One of the non-ionizing waves is electromagnetic waves. Nowadays, exposure to electromagnetic waves emitted by mobile phones (low-energy electromagnetic waves in the range of 800 to 2000 MHz) is inevitable [2.3]. This exposure has caused many concerns in the field of health. Mobile phones have been used since 1983 and, Nowadays, a majority of people are using mobile throughout the world [4]. For instance, about 129.86 out of the 140-million Japanese population, 91% of Americans and 94% of British people used mobile phone in 2011 [5-7].

Furthermore, mobile phone ownership had increased from 12% in 1999 to 76% in 2009. According to Hardell et al. (2011) in Sweden and IARC Interphone, both the IARC[1] and WHO classified the emitted waves of mobile phones into the class 2B (Possible Carcinogenic Class) [9 ,8]. Many research has reported that exposure to the electromagnetic waves of mobile phones causes headaches, poor concentration and memory, fatigue, drowsiness and nervousness in human ,10] [11, interface with the performance of cardiac batteries (at a distance of less than 5 cm) in people with heart disease[12], and adverse effects on reproductive system like male infertility [13]. One of the damaging effects of exposure to electromagnetic waves on health is brain damages especially malignant brain tumor [14]. Studies have shown that brain tumor is more prevalent in the side of the head that is more ipsi lateral with mobile phone compared to the other parts of the brain [15,16].

On the contrary, several research has revealed that the emitted waves by mobile phones increase the temperature of brain tissues and its surrounding tissues to a slight extent [17]. Furthermore, there are inconclusive evidences about potential mechanisms of carcinogenesis of these waves [9]. Many investigations have been conducted into the effects of electromagnetic waves of mobile phones on the risks of brain tumor. The findings of these studies were contradictory.

For instance, Frumkin et al. and Cardis et al. found that exposure to electromagnetic waves of mobile phone do not cause any damage to DNA cells [15,18] and do not increase the risk of brain tumor [19]. Conversely, according to several studies, exposure to electromagnetic waves of mobile phones can increase the risk of brain tumor significantly [20-24]. Consequently, the current study aimed at conducting a systematic meta-analysis review of the related literature and studies on the association between the use of mobile phone and the risk of malignant brain tumor (Glioma; 60% of all central nervous system tumors).

2. Materials and Methods

The purpose of the present study was a systematic meta-analysis review of the association between electromagnetic field of mobile phone and the risk of malignant brain tumor.

To this end, several databases including SID, Irandoc, Scopus, Pubmed and ISI Web of Science were used to collect related studies and data throughout Iran and the world.

1.2. Criteria and quality assessment of studies

First, a list of titles and abstracts of all the studies available in the aforesaid databases was compiled by three researchers (Ya, F., Ha, K. & Bi, M.) to avoid bias on the part of the researchers. The titles and abstracts of the studies conducted from 2000 to 2016 were examined independently.

The search took two weeks from 23 March 2016 to 09 April 2016 and the related studies were included in the present research independent of each other and based on blinding the initial assessment. The similar studies were excluded. The main inclusion criterion of different article into the present study was their reference to electromagnetic field of mobile phones and the risk of malignant brain tumor.

The studies which were not a part of seminal research and were associated with clinical decision-makings and investigations irrelevant to brain tumor all were excluded from the present study. Second, the abstract of the selected studies was reviewed by the researcher using the standard STROBE[1] checklist.

STROBE consists of 43 various sections which evaluates diverse methodological aspects of a study including sampling methods, measurement of variable, data statistical analysis and research objectives [25]. The minimum and maximum attainable score was considered 40 and 45 respectively in this checklist. In finale, the top articles which attained the minimum score (40) of STROBE checklist entered the study and their data were collected for a meta-analysis. Furthermore, Funnel Plot and Egger's test were used in order to determine Publication Bias.

2.2. Data Collection

The present study meta-analyzed 12 articles (9 case-control and 3 cohort), conducted from 2005 to 2014, all of which adhered to a quite similar methodology. The important information required for data analysis including the subject, title, methodology, type of research, period of investigation, score of each study in NOS[1] system, RO[2] of malignant brain tumor, sex of participants, sample size and confidence level were collected.

3.2. Quality of studies

The case-control and cohort studies were scored according to the quality assessment criteria of NOS including Exposure, Comparability and Selection. The score range in NOS system is 0 to 9. The current study divided the score of articles into low score (<7) and high score (≥7).

4.2. Data statistical analysis and synthesis

Data meta-analysis was performed by Comprehensive Meta-Analysis V. 2.2.064. To estimate the heterogeneity of studies, I^2 Higgins was used. Accordingly, Random Effect Model and Fixed Effect Model were used for the meta-analysis of the studies whose I^2 was greater and smaller than 50% respectively. The subgroups included the score of quality assessment i.e. qualitative score (low & high) and the type of study. Moreover, the significance level was $P<0.05$ in the present study.

3. Results

1.3. Identifying related studies

In overall, 376 articles were found searching Scopus, Ovid, Irandoc, PubMed, Embase and ISI Web of Science databases. About 207 articles were excluded at the stage of Eligibility due to irrelevant title, abstract and other reasons. About 157 out of the rest 169 articles were also excluded due to their reported correlation, hazard risk, mean missing key data for meta-analysis, letters, comments and correspondences. Ultimately, 12 articles (9 case-control & 3 cohort studies) were selected for the meta-analysis in the present study (Figure 1). Despite the investigation into the use of mobile phone, the studies of Hardell et al[26 ,23], Warren et al. [27] and Muscat [28]were also excluded from the present meta-analysis study due to the undistinguished malignant and benign brain tumors in their studies.

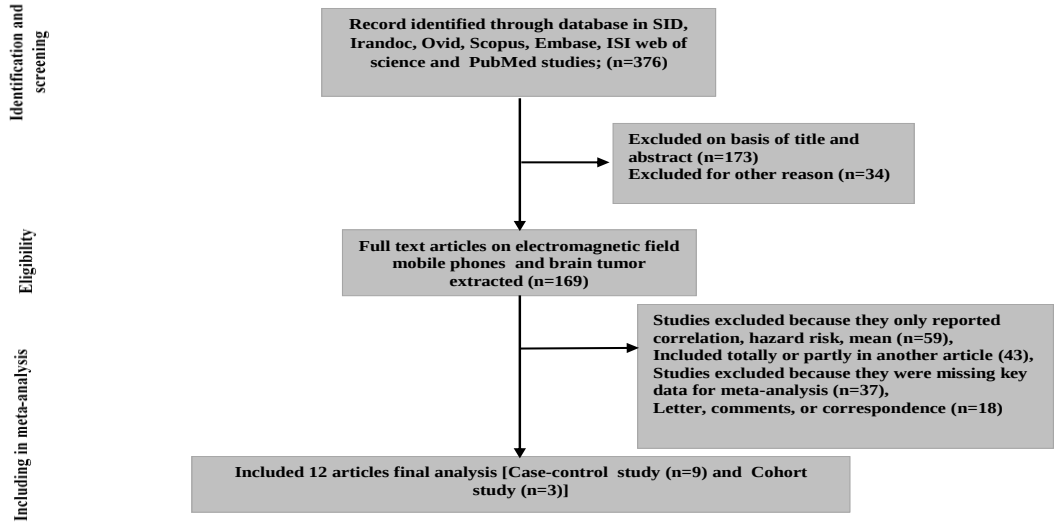

Figure1. Flow diagram for identification of relevant case-control and cohort studies.

2.3. Characteristics of studies

Table 1 presents the overall characteristics of the studies including the year of publication, country, type of study, type of tumor, period of investigation, field of study and the results. The years of investigation ranged from 1990 to 2009 and they were published from 2005 to 2014.

An overall 27,694 individuals (119,84 patients & 15,710 control) participated in 18 articles. The mean age of the participants was 49.8 years. Out the overall participants, about 26.6% used digital phones, 29.6% used analog phones, 37.6% used cordless phones, and 18.6% used mobile phones. However, mobile phones were overall used by all the participants.

Table 1. Overall characteristics of the 16 case-control articles and 2 cohort articles included in the final analysis.

Based on the quality assessment criteria of NOS, 7 out of 9 case-control studies (Table 2) and all the 3 cohort studies (Table 3) scored >7.

Study	Year of Publication	Country	Study Design	Study Period	Study Length (years)	Type of Tumor	Type of Phone and Exposure	Outcome	Ref
Benson et al	2013	United Kingdom	Cohort	1999 - 2005	7	Glioma, meningioma or non-CNS cancers	Mobile phones; Non-subscribers and subscribers	Mobile phone use was not associated with increased incidence of glioma, meningioma or non-CNS cancers	[29]
Hardell et al	2010	Sweden	Case-Control	1997–2003	7	Malignant brain tumors (glioma)	Mobile phone , Cellular or cordless phone; use *and* not use	Confirmed our previous results of an association between mobile phone use and malignant brain tumors	[30]
Hardell et al	2013	Sweden	Case-Control	2007-2009	3	Malignant brain tumors (glioma)	Mobile phone , Cellular or cordless phone; use ,not use	Provide support for the hypothesis that RF-EMFs play a role both in the initiation and promotion stages of carcinogenesis	[31]

Lahkola et al	2005	5 North European countries: Denmark, Finland, Norway, Sweden, and United Kingdom; followed a protocol of the interphone Study	Case-Control	2000-2004	4	Malignant brain tumors (glioma)	Mobile phone (analog and digital); regular use *and* never or no regular use	Although our results overall do not indicate an increased risk of glioma in relation to mobile phone use, the possible risk in the most heavily exposed part of the brain with long-term use needs to be explored further before firm conclusions can be drawn	[32]
Aydin et al	2011	Denmark, Sweden, Norway, and Switzerland	Case-Control	2004-2008	4	Malignant brain tumors (glioma)	Mobile phone , Cellular or cordless phone; use ,not use	Regular users of mobile phones were not statistically significantly	[33]
Coureau et a	2014	France	Case-Control	2004-2006	2	Malignant and benign brain tumors	Mobile phone , analog and digital and cordless phones; ever regular use *and* never use	Data support previous findings concerning a possible association between heavy mobile phone use and brain tumors	[34]
Linet et al	2006	United States	Case-Control	1998-2000	2	Non-Hodgkin's lymphomas	Mobile phone , Cellular phone; lifetime ever use *and* never use	Among regular users compared to those who had never used hand-held cellular telephones, risks of NHL were not significantly associated with minutes per week, duration, cumulative lifetime or year of first use,	[35]

								although NHL was non-significantly higher in men who used cellular telephones for more than 8 years	
Mild et al	2007	Sweden	Case-Control	1997-2003	7	Malignant and benign brain tumors	Mobile phone (analog and digital); regular use *and* never or no regular use	Malignant brain tumors, increased with latency period, especially for astrocytoma grade III–IV	[36]
Cardis et al	2011	Australian, Canadian, French, New Zealand	Case-Control	2000-2004	4	Malignant and benign brain tumors	Mobile phone , Cellular or cordless phone (analog and digital); use *and* no use	Increased risk of glioma in long-term mobile phone users with high RF exposure and of similar, but apparently much smaller, increases in meningioma rise	[20]
Hardell et al	2014	Sweden	Case-Control	1997–2003 and 2007–2009	9	Malignant brain tumors	Mobile phone (analog and digital); regular use *and* never or no regular use	The OR increased statistically significant both per 100 h of cumulative use, and per year of latency for mobile and cordless phone use.	[37]
Frei et al	2011	Denmark	Cohort	1990-2007	17	Malignant and benign brain tumors	Mobile phone (analog and digital); regular use *and* never or no regular use ,Cellular phone;	There were no increased risks of tumors of the central nervous system, providing little evidence for a causal association	[38]

							Non-subscribers and subscribers		
Schuz et al	2006	Denmark	Cohort	1982 - 1995 to 2002	13	Malignant and benign brain tumors	Mobile phone (analog and digital); regular use *and* never or no regular use , Cellular phone; ever regular use *and* never use	There were no evidence for an association between tumor risk and cellular telephone use among either short-term or long-term users	[39]

Table-2. Methodological quality of studies included in the final analysis based on the Newcastle-Ottawa scale for assessing the quality of case-control studies.

	Year	Selection (Score)				Comparability (Score)	Exposure (Score)			
Study		Adequate definition of patient cases	Representativeness of patient cases	Selection of controls	Definition of controls	Control for important factor or additional factor	Ascertainment of Exposure (blinding)	Same Method of Ascertainment for Participants	Non response Rate[1]	Total Score[1]
Hardell et al	2013	1	1	1	0	2	1	1	1	8
Hardell et al	2014	1	1	1	0	2	1	1	1	8
Hardell et al	2010	1	1	1	0	2	0	1	0	6
Hardell et al	2009	1	1	1	1	2	1	0	1	8
Lahkola et al	2007	1	1	1	0	2	1	1	0	7
Mild et al	2007	1	1	1	0	2	0	1	0	6
Coureau et al	2014	1	1	1	1	1	1	1	0	7

Cardis et al	2011	1	1	1	1	2	1	1	0	8
Benson et al	2013	1	1	1	0	2	1	0	1	7

Table-3. Methodological quality of studies included in the final analysis based on the Newcastle-Ottawa scale for assessing the quality of cohort.

	Year	Selection (Score)				Comparability (Score)	Exposure (Score)			
Study		Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Comparability of cohorts on the basis of the design or analysis	Assessment of outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow up of cohorts	Total Score
Frei et al	2011	1	1	1	1	1	1	1	1	8
Schuz et al	2006	1	1	1	1	0	1	1	1	7
Benson et al	2013	1	1	1	0	2	1	0	1	7

Before excluding the studies with a higher CI[1] than other studies , the heterogeneity of case-control and cohort studies was respectively 87% (<0.001) and 67% (P=0.048) and it was 85% (P<0.001) in overall (Figure 2). After excluding the studies of Hardell (2010), Frei et al. and Mild et al., the heterogeneity of case-control and cohort studies was estimated respectively 81% (P<0.001), 47% (P=0.048) and it was 79% (P<0.001) in overall. Therefore, Random Effect Model and Fixed Effect Model were used for case-control and cohort studies respectively, and the Random Effect model was used for all studies in overall in order to calculate the mean odds ratio.

3.3. Use of Mobile Phone and Risk of Brain Tumor

The confidence interval obtained from Egger's test before and after the exclusion of the aforesaid studies was respectively 95% CI (0.8 to 3.8) (Figure 4A) and 95% CI (-0.15 to 3.61) (Figure 4B). Thus, the erratum[1] reached to an acceptable level after excluding the studies. Before excluding the aforementioned three studies with a low weight percentage, the REM[2] was 1.22 (P=0.117), 1.05 (P=0.809) respectively for case-control and cohort studies and 1.18 (P=0.138) in overall (Figure 2). After excluding the studies with low weight percentage, the mean odds ratio (OR) of case-control and cohort studies was estimated about REM=1.03 (P=0.762), FEM=0.91 (P=0.597) respectively and it was REM=1 (P=0.996) in overall

(Figure 3) indicating that the use of mobile phone is not associated with any increase or decrease in the risk of brain tumor.

4. Discussion

The results of the present meta-analysis showed that according to the high quality studies, there is not any significant association between the use of mobile phone and the risk of malignant brain tumor. In overall, using mobile phones cannot increase the risk of brain tumor (P-value>0.05).

Although several studies addressing vivo animal models and vitro cancer cell lines indicated that exposure to low frequencies of electromagnetic waves emitted by mobile phones causes biological changes in cytoplasm membrane, nucleus of cell and gene and eventually makes the brain cells become cancerous [43-40], the results of the present meta-analytical study revealed that there is not any significant association between the use of mobile phone and the risk of malignant brain tumor. These differences in the findings may contribute to the presence of confounders such as age [44], nutrition [45], other radiations [46] and errors in studies. Like the present study, Regina et al., who studied 480 rats exposed to microwaves with a frequency of 835.62 MHz, did not observe any significant increase in the risk of malignant brain tumor of Glioma. Nevertheless, it should be noted that the power statistics of the current study was low due to the low number of control (n=160) [47].

Before excluding the studies of Hardell et al. (2010), Mild et al. and Frei et al. with low weight percentage (wt%), the results indicated that the risk of malignant brain tumor increases in an insignificant manner (Table 2). Whereas, after excluding the aforesaid studies, the Publication Biasreached to an acceptable level and the risk of malignant brain tumor decreased (Figure 3).

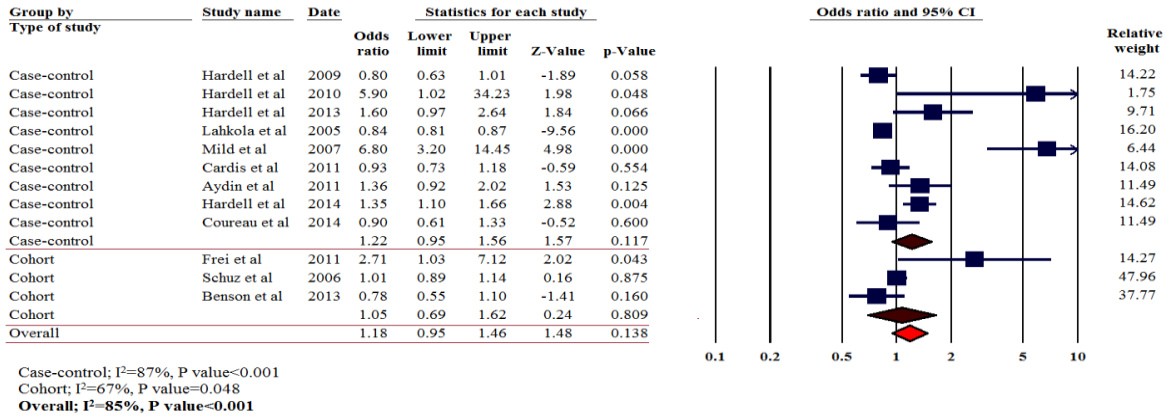

Figure 2. Forest plot of meta-analysis on EMF of mobile phones with malignant brain tumors before exclude low score studies.

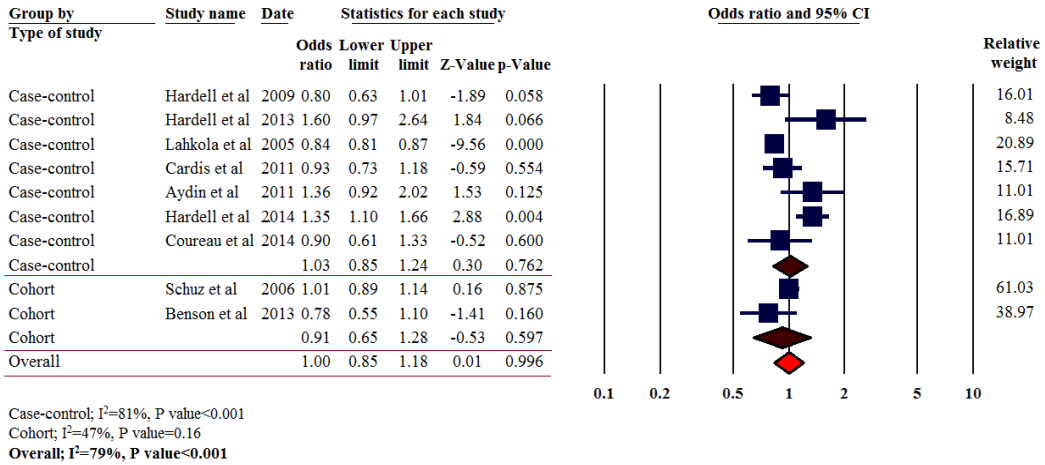

Figure 3. Forest plot of meta-analysis on EMF of mobile phones with malignant brain tumors after exclude low score studies .

Since the CI exceed 0 in Egger's test, there is not any significant erratum in overall [Egger's Test; Intercept = 1.72 CI (-0.15 to 3.61)]. As displayed in Figure 4, the reverse funnel plot indicated the absence of overall publication error (erratum) amongst the studies.

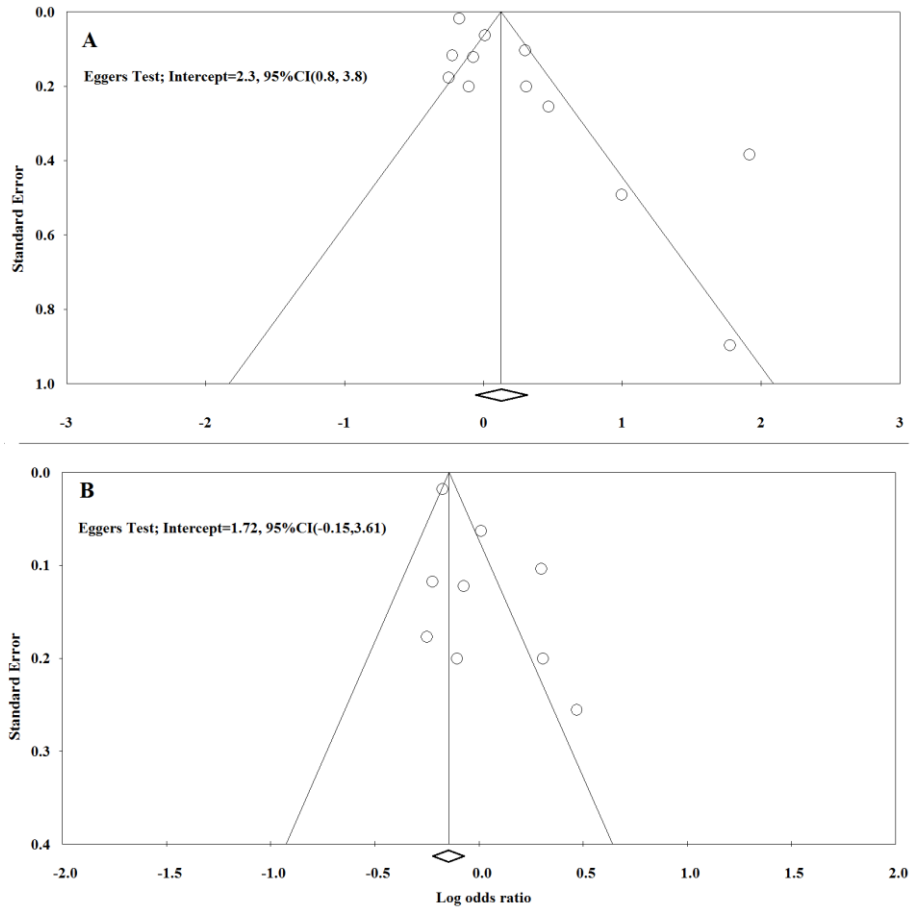

Figure: Funnel plot of the studies included in the meta analysis (A; before exclude high CI studies, B; after exclude high CI studies).

Exposure to ionizing waves causes brain tumor [48]. Due to the high energy level of these radiations, the breakage and rearrangement of DNA appears predominantly. Therefore, the diagnosis of latency period will be simpler and more precise than the exposure to non-ionizing radiations such as the waves emitted by mobile phones[49] .

Considering the fact that non-ionizing radiations, like radiations emitted by mobile phones, are not potent enough to directly damage DNA, they are considered the second risk factor after ionizing radiation in terms of carcinogenetic risk. The latency period of brain tumor due to the exposure to mobile phone's radiations (non-ionizing) is less than ionizing radiations (<5 years)[50] . Since the causes of brain tumor have not yet been identified completely, one cannot define the latency period conclusively; hence, the range of 1 to 10 years is considered as the minimum latency period[53-51].

Like the other four meta-analyses, the overall results of the present study showed that the use of mobile phone cannot significantly increase the risk of brain tumor[57-54]. Unlike the present study, Myung et al. found that according to the studies with high score, there is a significant positive association between the use of mobile phone and the risk of malignant brain tumor[57]. The current study did not consider the blinding experiments whereas Myung et al. used blinding experiments. On the other hand, Myung et al. studied different types of phones including analog, digital and cordless phones as well. Like Hardell et al. which used blinding experiments, the results of the present study showed that according to almost 5 reviewed studies, there is not any significant difference between the case (patient) and control groups in terms of exposure to electromagnetic waves emitted by mobile phones[59 ,58 ,31 ,30 ,24]. On the contrary, other studies which did not use blinding experiments, except for Song et al., indicated a significant increase in the risk of brain tumor due to the use of mobile phones[60].

The limitations of the current study included language (except for English and Persian), undistinguishing blinding from un-blinding experiments, and not considering the effect of passage of time on the incidence of malignant brain tumor. It is recommended to determine the effects of confounders such as age, sex, type of study, period of study, electrical and magnetic fields on the heterogeneity of studies in the prospective meta-analyses.

5. Conclusions

The results of the this systematic meta-analysis showed that there is not ant significant association between exposure to electromagnetic waves of mobile phones and the risk of brain tumor. Despite the disassociation between the use of mobile phone and the risk of malignant brain tumor, more and newer investigations are required to draw upon more precise

conclusion in this regard due to the few number of studies reviewed in the current meta-analysis. To conclude, the results of the this study did not confirm the assumption that the increased risk of brain tumor is associated with the use of mobile phones.

7. References

1. Morgan, W.F. and M.B. Sowa, Non-targeted effects induced by ionizing radiation: Mechanisms and potential impact on radiation induced health effects. Cancer letters, 2015. 356(1): p. 17-21.
2. Joseph, W., et al., Comparison of personal radio frequency electromagnetic field exposure in different urban areas across Europe. Environmental research, 2010. 110(7): p. 658-663.
3. Guidotti, T.L., P.O.E. From, and M.F. Martinez, Archives of Environmental & Occupational Health. Archives of Environmental & Occupational Health, 2007. 62(3).
4. Bortkiewicz, A., et al., Changes in tympanic temperature during the exposure to electromagnetic fields emitted by mobile phone. International journal of occupational medicine and environmental health, 2012. 25(2): p. 145-150.
5. Nakatani-Enomoto, S., et al., Effects of electromagnetic fields emitted from W-CDMA-like mobile phones on sleep in humans. Bioelectromagnetics, 2013. 34(8): p. 589-598.
6. Gajšek, P., et al., Electromagnetic field exposure assessment in Europe radiofrequency fields (10 MHz–6 GHz). Journal of Exposure Science and Environmental Epidemiology, 2015. 25(1): p. 37-44.
7. Saltos, A., et al., Cell-Phone Related Injuries in the United States from 2000–2012. Journal of Safety Studies, 2015. 1(1): p. 1-14.
8. WHO, IARC classifies radiofrequency electromagnetic fields as possibly carcinogenic to humans. 2011, press release n° 208.
9. Baan, R., et al., Carcinogenicity of radiofrequency electromagnetic fields. The lancet oncology, 2011. 12(7): p. 624-626.
10. Sandström, M., et al., Mobile phone use and subjective symptoms. Comparison of symptoms experienced by users of analogue and digital mobile phones. Occupational Medicine, 2001. 51(1): p. 25-35.
11. Arnetz, B., et al., The effects of 884 MHz GSM wireless communication signals on self-reported symptoms and sleep—An experimental provocation study. Piers Online, 2007. 3(7): p. 1148-1150.

12. Masao, T. and S. watanabe, biological and health effects of exposure to electromagnetic field from mobile communications systems. iatss research, 2001. 25(2): p. 40-50.
13. Kesari, K.K., S. Kumar, and J. Behari, Mobile phone usage and male infertility in Wistar rats. 2010.
14. Morgan, L.L., et al., Mobile phone radiation causes brain tumors and should be classified as a probable human carcinogen (2A)(Review). International journal of oncology, 2015. 46(5): p. 1865-1871.
15. Cardis, E., et al., Distribution of RF energy emitted by mobile phones in anatomical structures of the brain. Physics in medicine and biology, 2008. 53(11): p. 2771.
16. Langer, C.E. and E. Cardis, Brain Tumors and Mobile Phone Use: The Case–Control Approach. Epidemiology of Electromagnetic Fields, 2014: p. 215.
17. Wainwright, P., Thermal effects of radiation from cellular telephones. Physics in medicine and biology, 2000. 45(8): p. 2363.
18. Frumkin, H., et al., Cellular phones and risk of brain tumors. CA: a cancer journal for clinicians, 2001. 51(2): p. 137-141.
19. Shrestha, M., et al., Pituitary tumor risk in relation to mobile phone use: A case-control study. Acta Oncologica, 2015. 54(8): p. 1159-1165.
20. Cardis, E., et al., Risk of brain tumours in relation to estimated RF dose from mobile phones: results from five Interphone countries. Occupational and environmental medicine, 2011. 68(9): p. 631-640.
21. Liu, C., et al., Mobile phone radiation induces mode-dependent DNA damage in a mouse spermatocyte-derived cell line: a protective role of melatonin. International journal of radiation biology, 2013. 89(11): p. 993-1001.
22. Khalil, A., M. Gagaa, and A. Alshamali, 8-Oxo-7, 8-dihydro-2′-deoxyguanosine as a biomarker of DNA damage by mobile phone radiation. Human & experimental toxicology, 2012. 31(7): p. 734-740.
23. Hardell, L., et al., Use of cellular telephones and the risk for brain tumours: A case-control study. International journal of oncology, 1999. 15(1): p. 113-119.
24. Hardell, L., et al., Cellular and cordless telephones and the risk for brain tumours. European Journal of Cancer Prevention, 2002. 11(4): p. 377-386.

25. Von Elm, E., et al., The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Preventive medicine, 2007. 45(4): p. 247-251.
26. Hardell, L., et al., Long-term use of cellular phones and brain tumours: increased risk associated with use for⩾ 10 years. Occupational and Environmental Medicine, 2007. 64(9): p. 626-632.
27. Warren, H.G., et al., Cellular telephone use and risk of intratemporal facial nerve tumor. The Laryngoscope, 2003. 113(4): p. 663-667.
28. Muscat, J.E., et al., Handheld cellular telephone use and risk of brain cancer. Jama, 2000. 284(23): p. 3001-3007.
29. Benson, V.S., et al., Mobile phone use and risk of brain neoplasms and other cancers: prospective study. International journal of epidemiology, 2013: p. dyt072.
30. Hardell, L., M. Carlberg, and K. Hansson Mild, Mobile phone use and the risk for malignant brain tumors: a case-control study on deceased cases and controls. Neuroepidemiology, 2010. 35(2): p. 109-114.
31. Hardell, L., et al., Case-control study of the association between malignant brain tumours diagnosed between 2007 and 2009 and mobile and cordless phone use. International Journal of Oncology, 2013. 43(6): p. 1833-1845.
32. Lahkola, A., T. Salminen, and A. Auvinen, Selection bias due to differential participation in a case–control study of mobile phone use and brain tumors. Annals of epidemiology, 2005. 15(5): p. 321-325.
33. Aydin, D., et al., Mobile phone use and brain tumors in children and adolescents: a multicenter case–control study. Journal of the National Cancer Institute, 2011.
34. Coureau, G., et al., Mobile phone use and brain tumours in the CERENAT case-control study. Occupational and environmental medicine, 2014. 71(7): p. 514-522.
35. Linet, M.S., et al., Cellular telephones and non-Hodgkin lymphoma. International journal of cancer, 2006. 119(10): p. 2382-2388.
36. Mild, K.H., L. Hardell, and M. Carlberg, Pooled analysis of two Swedish case-control studies on the use of mobile and cordless telephones and the risk of brain tumours diagnosed during 1997-2003. International Journal of Occupational Safety and Ergonomics, 2007. 13.
37. Hardell, L. and M. Carlberg, Mobile phone and cordless phone use and the risk for glioma – Analysis of pooled case-control studies in Sweden, 1997–2003 and 2007–2009. Pathophysiology, 2015. 22(1): p. 1-13.

38. Frei, P., et al., Use of mobile phones and risk of brain tumours: update of Danish cohort study. Bmj, 2011. 343: p. d6387.
39. Schüz, J., et al., Cellular telephone use and cancer risk: update of a nationwide Danish cohort. Journal of the National Cancer Institute, 2006. 98(23): p. 1707-1713.
40. Marinelli, F., et al., Exposure to 900 MHz electromagnetic field induces an unbalance between pro-apoptotic and pro-survival signals in T-lymphoblastoid leukemia CCRF-CEM cells. Journal of cellular physiology, 2004. 198(2): p. 324-332.
41. Jin, M., et al., Biological and technical variables in myc expression in HL60 cells exposed to 60 Hz electromagnetic fields. Bioelectrochemistry and Bioenergetics, 1997. 44(1): p. 111-120.
42. Lee, S.-K., et al., Extremely low frequency magnetic fields induce spermatogenic germ cell apoptosis: possible mechanism. BioMed research international, 2014. 2014.
43. Ross, C.L., et al., The effect of low-frequency electromagnetic field on human bone marrow stem/progenitor cell differentiation. Stem cell research, 2015. 15(1): p. 96-108.
44. Hemminki, K., P. Kyyrönen, and P. Vaittinen, Parental age as a risk factor of childhood leukemia and brain cancer in offspring. Epidemiology, 1999. 10(3): p. 271-275.
45. Flavahan, W.A., et al., Brain tumor initiating cells adapt to restricted nutrition through preferential glucose uptake. Nature neuroscience, 2013. 16(10): p. 1373-1382.
46. Sadetzki, S., et al., Long-term follow-up for brain tumor development after childhood exposure to ionizing radiation for tinea capitis. Radiation research, 2005. 163(4): p. 424-432.
47. La Regina, M., et al., The effect of chronic exposure to 835.62 MHz FDMA or 847.74 MHz CDMA radiofrequency radiation on the incidence of spontaneous tumors in rats. Radiation research, 2003. 160(2): p. 143-151.
48. Krille, L., et al., Risk of cancer incidence before the age of 15 years after exposure to ionising radiation from computed tomography: results from a German cohort study. Radiation and environmental biophysics, 2015. 54(1): p. 1-12.
49. Little, M.P., et al., Risks associated with low doses and low dose rates of ionizing radiation: why linearity may be (almost) the best we can do 1. Radiology, 2009. 251(1): p. 6-12.

50. Radiation, U.N.S.C.o.t.E.o.A., Annex A: Epidemiological studies of radiation and cancer. 2006, UNSCEAR.
51. Little, M., et al., Mobile phone use and glioma risk: comparison of epidemiological study results with incidence trends in the United States. Bmj, 2012. 344: p. e1147.
52. Group, I.S., Brain tumour risk in relation to mobile telephone use: results of the INTERPHONE international case–control study. International journal of epidemiology, 2010: p. dyq079.
53. Hardell, L., M. CARLbERG, and K. Hansson Mild, Pooled analysis of case-control studies on malignant brain tumours and the use of mobile and cordless phones including living and deceased subjects. International Journal of Oncology, 2011. 38(5): p. 1465-1474.
54. Lahkola, A., K. Tokola, and A. Auvinen, Meta-analysis of mobile phone use and intracranial tumors. Scandinavian journal of work, environment & health, 2006: p. 171-177.
55. Kan, P., et al., Cellular phone use and brain tumor: a meta-analysis. Journal of neuro-oncology, 2008. 86(1): p. 71-78.
56. Hardell, L., et al., Meta-analysis of long-term mobile phone use and the association with brain tumours. International journal of oncology, 2008. 32(5): p. 1097-1103.
57. Myung, S.-K., et al., Mobile phone use and risk of tumors: a meta-analysis. Journal of Clinical Oncology, 2009. 27(33): p. 5565-5572.
58. Hardell, L., et al., Cellular and cordless telephone use and the association with brain tumors in different age groups. Archives of Environmental Health: An International Journal, 2004. 59(3): p. 132-137.
59. Hardell, L., M. Carlberg, and K.H. Mild, Case–control study of the association between the use of cellular and cordless telephones and malignant brain tumors diagnosed during 2000–2003. Environmental Research, 2006. 100(2): p. 232-241.
60. Stang, A., et al., The possible role of radiofrequency radiation in the development of uveal melanoma. Epidemiology, 2001. 12(1): p. 7-12.

Corresponding Author:
Hassan Keramati*,
Email: *Hkarmatee@gmail.com*