

**Cell Phones, Electromagnetic Radiation, and Cancer:
A Study of Author Affiliation, Funding, Bias, and Results**

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Abstract

Mobile phone use has dramatically increased in the United States and around the world because of increasing access to this technology. The first study revealing a correlation between wireless technology, electromagnetic radiation (EMR), and health problems was published in 1975, and since then, researchers, scientists, and other professionals have issued many reports that prove either a correlation between cell phones and cancer exists or does not exist. Previous meta-analyses have determined that the evidence is controversial, the current data is not persuasive, and the field is too current.

The purpose of this paper is to study the correlation between cell phones, EMR, and cancer. This paper reviews the previous medical literature on the correlation between cell phones, EMR, and cancer. Specifically, this paper analyzes author affiliation, grant and funding information, and correlation results to see if a bias currently exists among these studies. This paper is different from previous studies because the information is current, the variables are grouped and measured differently, and both affiliation and funding information is provided.

After a qualitative and quantitative review of the current research, there appears to be a relationship between the place of funding or author affiliation of a study and whether or not the author(s) find a correlation between cell phones and cancer. This relationship means that there is a significant possibility that bias exists in the results of these studies. Researchers, policymakers, politicians, health care workers, governments, and citizens must all be aware of the funding of studies and the bias of results.

Key Words: cell phones, electromagnetic radiation, cancer, health, public policy

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Purpose

The purpose of this paper is to study the correlation between cell phones, EMR, and cancer. This paper reviews the previous medical literature on the correlation between cell phones, EMR, and cancer. Furthermore, this paper analyzes author affiliation, grant and funding status, and results to see if a bias currently exists among studies.

Introduction and Background

Background

In 1865, James Clerk Maxwell proposed and published the theory of electromagnetic radiation (Columbia Encyclopedia, 2008). Electromagnetic radiation is “energy radiated in the form of a wave as a result of the motion of electric charges” (2008). If the motion of a magnetic field changes or accelerates, the magnetic field can provide an electric field (2008). The produced electromagnetic wave is both a transverse and a polarized wave (2008). More importantly, “electromagnetic radiation does not require a material medium and can travel through a vacuum” (2008).

Mobile phones produce EMR. Mobile phone use has greatly expanded both domestically and internationally in recent years. According to the U.S. Census Bureau’s latest Statistical Abstract Report in 2004, cell phone use in the United States has increased by 300 percent since 1995. In 1995, only 34 million Americans had a cell phone subscription (2004). However, in 2004, the number of Americans that had a cell phone subscription approached 159 million (2004). According to Portio Research, a business of “Worldwide Cellular Markets Subscriber Data” that forecasts industry growth, “50% of the world's population will be using a cell phone by the end of 2009” (2006). The report predicts that Africa will have the highest rate of growth and will add “265 million new mobile subscribers over the next 6 years” (2006). The cell phone industry is substantial and continues to grow.

Debate regarding EMR and health started in the 1930s, when scientist began to postulate that high-frequency electromagnetic fields (EMFs) may cause health problems (Kundi, 2009, p. 316). Previously, the only health problem associated with EMFs was “tissue heating” (p. 316). Kundi writes, “Because of the enormous increase in mobile phone use starting in the mid-1990s and reaching almost 100% prevalence in many countries worldwide by now, concerns have been raised that even small risks for developing chronic diseases such as cancer from mobile phone use may have substantial impact on public health” (p. 316). Kundi continues, “In fact, never before in history has any device of comparative prevalent use been associated with such high exposure to high-frequency electromagnetic fields (EMFs)” (p. 316).

The first recorded study of a correlation between wireless technology, EMR, and health problems was published in 1975 in the journal *Annals of the New York Academy of Sciences* by Allan Frey. Since that study, scientists, doctors, and other professionals have issued dozens of reports and peer-reviewed journal articles that prove either a correlation between cell phones and cancer exists or does not prove that correlation exists. These reports are paid for privately, through a university or hospital, or by grants. These grants are paid for by individuals, hospitals, universities, NGOs, governments, and mobile phone companies. One must be cognizant of the source of funding when reviewing the results of such studies.

As of today, there is increasing concern in the fields of medicine, public health, policy, and law about this issue. The results of cell phone and cancer correlation studies will almost certainly shape the cell phone industry and the public health industry; therefore, researchers must explore the correlation between cell phones, EMR, and cancer. Researchers must also review author affiliation, grant and funding status, and results to see if a bias in these studies exists and influences the results. If a bias does exist, governments and other organizations must be willing to regulate and oversee the groups funding and performing these biased studies.

Previous Meta-analyses

There have been a few meta-analyses to determine the strength of the correlation between cell phones and cancer. To date, evidence has not shown a definitive correlation between cell phones and cancer. Meta-analyses have concluded that the information is controversial, the data is not persuasive, and the field is too new. Feychting et al. performed a large meta-analysis on EMF and health and concluded:

“There are no persuasive data suggesting a health risk, but this research field is still immature with regard to the quantity and quality of available data. This technology is constantly changing and there is a need for continued research on this issue” (2005, p. 165).

Another meta-analysis studied EMF exposure and ill-health. Roosli states that there is “little evidence that short-term exposure to a mobile phone or base station” cause ill-health or other symptoms (2008, p. 277). Finally, a meta-analysis from 1994 reviewed the health effects of EMF on childhood leukemia, lymphoma, and nervous system tumors. According to Washburn et al., there was “no statistically significant relation between combined relative risk estimates and 15 indicators of epidemiologic quality” (p. 299). Meta-analyses show that the current data is controversial, and researchers must continue to review the correlation as the field advances.

INTERPHONE Study

The largest study to date on the correlation between cell phones and cancer is the INTERPHONE study. According to Cardis et al., “the very rapid worldwide increase in mobile phone use in the last decade has generated considerable interest in the possible health effects of exposure to radio frequency (RF) fields” (2007). Hence, the INTERPHONE study was established. The INTERPHONE study is a “multinational case-control study” that was developed “to investigate whether mobile phone use increases the risk of cancer and, more specifically, whether the RF fields emitted by mobile phones are carcinogenic” (2007). The INTERPHONE study concentrated on “tumours arising in the tissues most exposed to RF fields from mobile phones: glioma, meningioma, acoustic neurinoma and parotid gland tumours” (2007). The patients’ cell phone use was recorded in each case (2007). The study collected information from 13 countries: Australia, Canada, Denmark, Finland, France, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden, and the United Kingdom (2007). The study included 7,658 controls and results demonstrated 2,765 cases of glioma, 2,425 cases of meningioma, 1,121 cases of acoustic neurinoma, 109 cases of malignant parotid gland tumour (2007). As of today, some studies have not been completed and are still being investigated.

Source of Funding Study

In January 2007, Huss et. al. published a comprehensive study concerning the source of funding in studies comparing health effects and mobile phone use. The authors found that out of “59 studies, 12 (20%) were funded exclusively by the telecommunications industry, 11 (19%) were funded by public agencies or charities, 14 (24%) had mixed funding (including industry), and in 22 (37%) the source of funding was not reported” (2007). The authors cited that the telecommunications industry documented the highest outcome number; however, the telecommunications industry “were least likely to report statistically significant results: The odds ratio was 0.11 (95% confidence interval, 0.02–0.78), compared with studies funded by public agencies or charities” (2007). The authors conclude, “The interpretation of results from studies of health effects of radiofrequency radiation should take sponsorship into account” (2007).

Methodology

Types of Cancer

The types of cancers this paper reviews for correlation and funding information include the following: acoustic neuroma, testicular cancer, glioma, and meningioma. According to the U.S. National Library of Medicine and the National Institutes of Health (NIH) medical dictionary, cancer is “a malignant tumor of potentially unlimited growth that expands locally by invasion and systemically by metastasis” (2010). Acoustic neuroma is “a nonmalignant usually slow-growing tumor involving the Schwann cells of a vestibular nerve that may cause deafness, tinnitus, and disturbance of the sense of balance and may be life threatening if not treated” (2010). Testicular cancer is cancer of the testicles. Glioma is “a tumor arising from glial cells” (2010). Finally, meningioma is “a slow-growing encapsulated tumor arising from the meninges and often causing damage by pressing upon the brain and adjacent parts” (2010).

Data Collection

A triangulation approach was used to review and present the materials. This approach included both quantitative and qualitative analysis. The author searched the Academic Search Complete online database from the University Libraries at the George Mason University School of Public Policy on two separate dates: March 3, 2010 and March 10, 2010. A combination of the search terms were used to find materials, including “cancer,” “cancers,” “electromagnetic field,” “electromagnetic fields,” “EMF,” “EMFs,” “electromagnetic radiation,” “EMR,” “cell phone,” “cell phones,” “cell,” “cellular,” “mobile phone,” “mobile phones,” and “mobile.” The database provided a total of 93 results. Only relevant materials from peer-reviewed journal articles, memos in peer-reviewed journals, or magazines were selected. Newspaper articles and summary articles from peer-reviewed journals in magazines were not selected. Of those 93 results, only 23 were used.

Next, the author used the snowball approach to find other articles (Rossi et al., 2004, p. 87). For example, if a previous article discussed a past journal article or website, that article or website would be pulled and reviewed. The author also reviewed other databases including ScienceDirect, Oxford Journals, JSTOR, and PubMed. After an exhaustive review of material, 50 total relevant information sources remained.

Once each abstract and article was reviewed for relevancy, the total articles from these databases were added to a comprehensive spreadsheet (Appendix A). Appendix A includes the following categories: title, year, type, author, author affiliation, result (yes, no, or inconclusive), funding type, and notes. The title, year, and author sections refer to the title, year, and author(s) of the article. The type section includes peer-reviewed journal articles, memos in peer-reviewed journal articles, magazine articles, and websites. Author affiliation includes either the source of funding information, or if that was unavailable, the university, hospital, NGO, government, or business where the author(s) worked. The results section summarizes if the author(s) found a correlation between cell phones and cancer. The funding type is the place from where funding or author affiliation came and includes government, hospital, university, NGO, magazine, pharma, business, mobile company, private, consulting firm, and international organization. Notes include any additional information not found elsewhere in the spreadsheet.

Statistical Analysis

Information from these correlation studies were collected and analyzed. Three variables were created in the statistical analysis program, STATA: affiliation, correlation, and year. The variable 'affiliation' is a nominal variable. This variable measures by whom the study was funded or with whom the author was affiliated. This variable has the following attributes: 0 = 'Government'; 1 = 'Mobile Company'; 2 = 'University/Hospital/NGO'; and 3 = 'Other.' The variable 'correlation' is an ordinal variable. This variable measures if the study finds a correlation between cell phone use and cancer. This variable has the following attributes: -1 = 'No'; 0 = 'Inconclusive' and 1 = 'Yes.' The variable 'year' is an interval-ratio variable. This variable measures the year the study was published. This variable falls between 2000 and 2010. This study is different from previous studies because the information is current, the variables are grouped and measured differently, and both affiliation and funding information is provided.

Results

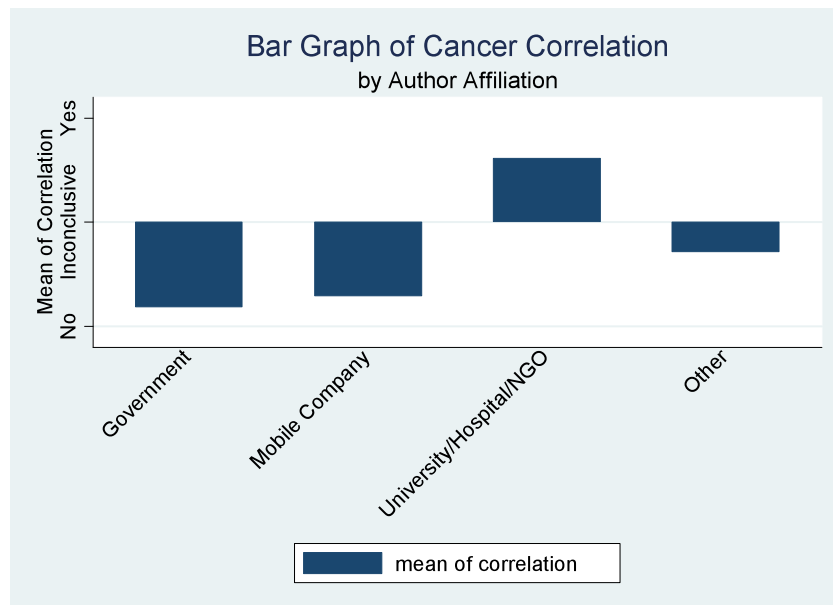
First, the 'tab' command was run to obtain information about each variable. The STATA analysis can be found in Appendix B. Out of 50 total articles, 11 were affiliated with or funded by the government, seven with the mobile companies, 18 with a university, hospital, or NGO, and 14 with other sources. Out of those 50 articles, 14 found a correlation between cell phones and cancer, 21 found no correlation, and 15 were inconclusive.

Then, a 'cross-tab' of the data was performed. The STATA analysis can be found in Appendix C. The government funded or was affiliated with 11 studies. Out of the 11 studies, the government found nine studies with no correlation and two with an inconclusive correlation. The mobile phone companies funded or were affiliated with seven studies. Out of the seven studies, the mobile phone companies found six studies with no correlation and one study with a correlation. Universities, hospitals, and NGOs funded or were affiliated with 18 studies. Out of the 18 studies, this group found 12 studies with a correlation, one study with no correlation, and five studies with an inconclusive correlation. Finally, the category 'other,' which includes magazines and businesses, funded or were affiliated with 14 studies. Out of the 14 studies, this group found one study with a correlation, five with no correlation, and eight with an inconclusive correlation. Some interesting findings in this cross-tab include: the government found no correlation in 81.82% of the studies; mobile phone companies found no correlation in 85.71% of

the studies; and, universities, hospitals, and NGOs did find a correlation in 66.67% of the studies. There appears to be a significant discrepancy between the author affiliation and the final correlation result between cell phones and cancer.

Next, a bar graph was created comparing the mean score of correlation by author affiliation (Figure 1).

Figure 1. Bar Graph of Cancer Correlation by Author Affiliation



This graph shows that studies funded by or affiliated with either the government or mobile companies are more closely aligned to not finding a correlation between cancer and cell phones. The graph also shows that studies funded by or affiliated with a university, hospital, or NGO are more closely aligned to finding a correlation between cancer and cell phones. Finally, the graph shows that studies funded by or affiliated with the 'other' category, such as magazines or businesses, are more closely aligned to finding an inconclusive correlation between cancer and cell phones.

Since the variables are categorical, the Chi-square test is the most appropriate. The Chi-square test "is a quantitative measure used to determine whether a relationship exists between two categorical variables" (Berman, 2007, p. 146). This paper attempts to identify a statistically significant finding between the variables 'affiliation' and 'correlation' and between 'year' and 'correlation.' The STATA analysis can be found in Appendix D. The first relationship tested is between 'affiliation' and 'correlation.' The null hypothesis is that no relationship exists between these two variables. The alternative hypothesis is that a relationship exists between these two variables. After running the Chi-square test, the p-value was < 0.0005 . This is a statistically significant finding at the alpha level of 0.05. The null hypothesis is rejected. There is a statistically significant relationship between the author affiliation and whether or not there is a

correlation between cell phones and cancer. This means that the funding or author affiliation for a specific study has a relationship with whether or not the author(s) find a correlation between cell phones and cancer.

The second relationship tested is between 'year' and 'correlation.' The null hypothesis is that no relationship exists between these two variables. The alternative hypothesis is that a relationship exists between these two variables. After running the Chi-square test, the p-value was 0.248. This is not a statistically significant finding at the alpha level of 0.05, so the null hypothesis can not be rejected. There is not a statistically significant relationship between the year the article was published and whether or not there is a correlation between cell phones and cancer. This means that the year the study was published has no relationship with whether or not the author(s) find a correlation between cell phones and cancer.

The final test that was performed was the ANOVA. Again, these variables are categorical, so the ANOVA is a suitable test. The ANOVA test "is used for testing means of a continuous variable across more than two groups" (Berman, 2007. p. 267). Since the correlation variable is ordinal, the ANOVA will treat it as pseudo interval-ratio variable. The final relationship tested is between 'correlation' and 'year.' The STATA analysis can be found in Appendix E. The null hypothesis is that the population means are the same between these two variables. The alternative hypothesis is that population means are not the same between these two variables. After running the ANOVA test, the global F-test was 2.42 and the p-value was 0.0266. This is a statistically significant finding at the alpha level of 0.05. Again, the null hypothesis can be rejected. The population means do not appear to be the same between the year the article was published and whether or not there is a correlation between cell phones and cancer. However, the lack of observations per category may make this ANOVA finding unreliable.

Discussion

Mobile Phone Companies

The mobile phone companies funded or were affiliated with seven total studies, six of which were not correlated to finding that cell phones cause cancer. In fact, researchers did not find a correlation in 85.71% of the studies mobile phone companies funded. Mobile phone companies monitor the results of cell phones and cancer studies carefully. To date, no large mobile phone company has acknowledged any correlation between mobile phones and cancer. Two of the largest mobile phone providers, Verizon Wireless and AT&T Wireless, both conclude that there is no current scientific evidence relating electromagnetic radiation from cell phones and negative health effects (AT&T, 2010; Verizon, 2010). Mobile phone companies continue to fund these studies, and in the current INTERPHONE study, two groups provide a significant amount of funding: GSM Association and Mobile Manufacturers Forum.

GSM Association

The GSM Association (GSMA) is a large organization that "represents the interests of the worldwide mobile communications industry" (GSMA, 2010). The GSMA is in 219 countries and works with approximately 800 mobile phone operators internationally (2010). The GSMA also works with "more than 200 companies in the broader mobile ecosystem, including handset

makers, software companies, equipment providers, Internet companies, and media and entertainment organizations” (GSMA, 2010). The GSMA’s business model is to innovate the industry and add clients (2010). The GSMA’s ultimate goal is to create “the growth of the mobile communications industry” (2010).

Mobile Manufacturers Forum

The Mobile Manufacturers Forum (MMF) is an “international association of telecommunications equipment manufacturers with an interest in mobile or wireless communications” (MMF, 2010). The MMF was created in 1998 (2010). The mission of MMF is “to facilitate joint funding of key research projects and cooperation on standards, regulatory issues and communications concerning the safety of wireless technology, accessibility and environmental issues” (2010). The MMF funds research, as it continues to do in the INTERPHONE study, and tries to affect regulatory and communications policy (2010).

Government

Governments funded or were affiliated with 11 studies. Out of the 11 studies government funded, researchers found nine studies with no correlation and two with an inconclusive correlation. The government found no correlation in 81.82% of the studies for which they provided funding. The United States government agencies most responsible for monitoring a relationship between cell phones and cancer are the Federal Communications Commission (FCC), Food and Drug Administration (FDA), Centers for Disease Control and Prevention (CDC), and the National Cancer Institute (NCI). None of these government organizations found a significant association between cell phones and cancer.

FCC

The Federal Communications Commission (FCC) is an independent government agency that “was established by the Communications Act of 1934 and is charged with regulating interstate and international communications by radio, television, wire, satellite and cable” (2010). The FCC is also one government organization responsible for regulating the safety of cell phones (2010). The FCC concludes on the results of cancer and cell phone research that “results to date have been inconclusive” (2010). They continue, “While some experimental data have suggested a possible link between exposure and tumor formation in animals exposed under certain specific conditions, the results have not been independently replicated,” and “other studies have failed to find evidence for a link to cancer or any related condition” (2010).

FCC Spectrum Auction Program

Beginning in 1994, the Federal Communications Commission (FCC) introduced a program to regulate and sell business licenses of the electromagnetic spectrum (FCC About Auctions, 2006). These FCC licenses provide individuals and businesses with the right to develop television, radio, and wireless technology that the American public will use (2006). Cellular phone radiation occurs in both the radio and microwaves frequency (Ketcham, 2010). The FCC regulates and sells licenses of this electromagnetic spectrum for the many types of wireless

technologies available today, and the government receives revenue from these auctions. The goal of the program is to increase business competition, increase wireless technology use, and decrease the cost of this technology.

FDA

The Food and Drug Administration (FDA) is a United States government agency “responsible for protecting the public health by assuring the safety, efficacy, and security of human and veterinary drugs, biological products, medical devices, our nation’s food supply, cosmetics, and products that emit radiation” (FDA, 2010). The FDA regulates the cell phone industry as a partner with the FCC (2010). With regards to the correlation between cell phones and cancer, the FDA only has authority to act “if cell phones are shown to emit radiofrequency energy (RF) at a level that is hazardous to the user” (2010). If this occurred, the FDA “could require cell phone manufacturers to notify users of the health hazard and to repair, replace or recall the phones so that the hazard no longer exists” (2010).

CDC

The Centers for Disease Control and Prevention (CDC) is a U.S. government agency and part of the Department of Health and Human Services (DHHS) (CDC, 2005). The CDC works with other government agencies to “create the expertise, information, and tools that people and communities need to protect their health – through health promotion, prevention of disease, injury and disability, and preparedness for new health threats” (2005). With regards to cell phones and cancer, the CDC determines that “although some studies have raised concerns, the scientific research, when taken together, does not indicate a significant association between cell phone use and health effects” (2005).

NCI

The National Cancer Institute (NCI) is a United States government agency (NCI, 2010). The NCI, established by the National Cancer Act of 1937, is responsible for “conducting and fostering cancer research; reviewing and approving grant-in-aid applications to support promising research projects on the causes, prevention, diagnosis, and treatment of cancer; collecting, analyzing, and disseminating the results of cancer research” (2010). NCI concludes, “Results from the majority of these studies have found no association between hand-held cellular telephone use and the risk of brain cancer; however, some, but not all, long-term studies have suggested slightly increased risks for certain types of brain tumors” (2010). NCI continues, “Further evaluation of long-term exposures (more than 10 years) is needed” (2010).

Other Organizations

Other organizations also weigh in on the debate between cancer and cell phone use. These other organizations fund or are affiliated with 14 studies. This group found one study with a correlation, five with no correlation, and eight with an inconclusive correlation. These other organizations fund studies, report findings, and even develop investigative branches regarding

this issue. These organizations include intergovernmental organizations, like the World Health Organization (WHO), and non-profit organizations, like the American Cancer Society (ACS).

WHO

The World Health Organization (WHO) is the “directing and coordinating authority for health within the United Nations system” (WHO, 2010). The WHO currently has 193 member states (2010). The WHO “is responsible for providing leadership on global health matters, shaping the health research agenda, setting norms and standards, articulating evidence-based policy options, providing technical support to countries and monitoring and assessing health trends” (2010). In 1996, the WHO created the International EMF Project in order to “assess the scientific evidence of possible health effects of EMF in the frequency range from 0 to 300 GHz” (WHO EMF, 2010). Any member state or agency within a state is able to participate in this program, and the states fund the program themselves (2010). According to the WHO International EMF Project,

“Electromagnetic fields of all frequencies represent one of the most common and fastest growing environmental influences, about which anxiety and speculation are spreading. All populations are now exposed to varying degrees of EMF, and the levels will continue to increase as technology advances” (2010).

Currently, the WHO oversees the INTERPHONE study. The WHO concludes that current science does not present a need for special precautions (WHO EMF & Public Health, 2000).

ACS

The American Cancer Society (ACS) is a “nationwide, community-based voluntary health organization” (ACS, 2010). ACS is one of the largest cancer organizations in the world, and ACS specializes in “cancer information services, community programs and services, research, and advocacy and public policy” (2010). ACS writes that most cell phone and cancer studies “have not found a link between cell phone use and the development of tumors” (2010). ACS continues, “However, these studies have had some important limitations” (2010). These limitations to previous studies include an insufficient length to the studies, a lack of focus on outcomes related to children, and rough measurements of cell phone use (2010). ACS suggests that further research is needed to address these limitations (2010).

Hospitals and Universities

Hospitals and universities are affiliated with or have funded 18 studies, of which 12 found a correlation. Universities, hospitals, and NGOs found a correlation in 66.67% of the studies they funded or with which they were associated. This is the largest group to find a significant correlation between cell phones and cancer. Hospitals and universities encompass the last main group of organizations that report on the relationship between cell phones and cancer. There are many hospitals and universities that report on this matter, and studies have been growing each year as more information is accumulated. For example, the University of Pittsburgh Medical Center recently distributed a study and memo reporting on the correlation between cancer and cell phones. In 2009, the Jennie Zoline Foundation to the University of Pittsburgh Medical

Center and the Osaka Medical Research Foundation for Incurable Diseases, with a grant from the Heinz Endowments to the Center for Environmental Oncology-University of Pittsburgh Cancer Institute, published a study entitled *Cell Phone Use and Acoustic Neuroma: The Need for Standardized Questionnaires and Access to Industry Data*. This journal article concluded that the correlation between cell phones and cancer is inconclusive; however, the article did lead to a hospital-wide memo warning about the “growing body of literature linking long-term cell phone use to possible adverse health effects including cancer” (UPCI Memo, 2009). Hospitals and universities continue to publish research and will continue to be an important source of information on this growing topic.

Public Policy Implications

The growing research regarding cancer and cell phones, and the implications of these studies, has a considerable effect on public policy. As of today, all prior meta-analyses have concluded that the evidence is questionable and the data is too contemporary and not convincing enough to provide a definitive answer. The two main arenas in which this debate will play out in the future are law and policy.

Law

The first lawsuit against the cell phone industry occurred in 1993 in Florida (Tsoukanelis, 2008). Mr. David Reynard filed a lawsuit against the cell phone industry because he believed the cell phone was the reason that his wife died of a brain tumor (2008). The judge decided there was a lack of evidence and dismissed the case (2008). However, this was the first time that many people began to think about this issue (2008). In 2002, another lawsuit against the cell phone industry occurred in Maryland (Parascandola, 2002). A neurologist from Baltimore, Maryland sued the cell phone industry for \$800 million (2002). After six years of cell phone use, he developed a tumor (2002). The judge again decided there was a lack of evidence and dismissed the case (2002). This case is currently in the appeals process (Consumer Affairs, 2005). The legal ramifications of this issue will continue as evidence of a correlation surfaces.

Policy

Science and politics come together in order to produce correct policy (Kraemer & Gostin, 2009). The cell phone and cancer debate has begun in recent years in the policy realm, and as more evidence proves or disproves a correlation, the policy debate will continue to change in the future. The first policy issue in the United States is currently occurring in Maine. Maine state representative, Andrea Boland, favors a current bill requiring cell phone manufacturers to place warning labels on all cell phone sold in Maine. This warning would read, “This device emits electromagnetic radiation, exposure to which may cause brain cancer. Users, especially children and pregnant women, should keep this device away from the head and body” (Walsh, 2010). There are also a growing number of consumer organizations focused on the debate to change current policy. The Environmental Health Trust is an organization that “educates individuals, health professionals and communities about controllable environmental health risks and policy changes needed to reduce those risks” (EHT, 2010). The site is run by Dr. Devra Lee Davis, and cell phone policy is a main focus of this project (2010). Internationally, this is a policy issue in

Germany as well (Ketcham, 2010). Germany has officially warned its citizens not to use wireless technology like WI-FI or home internet wireless hubs as they may cause cancer (2010).

The second policy debate is in regards to the groups that fund these studies. The INTERPHONE study is the first to provide significant oversight by the WHO. However, if a bias continues to be found in these studies, policymakers must determine how best to regulate and oversee these studies to avoid damaging bias. The legal and policy implications share a similarity with the curve of policy and law debate between the tobacco companies and cancer in the 1960's that presently continues (Fritschler & Rudder, 2007). Policy is a combination of science, values, and politics (Kraemer & Gostin, 2009, p. 666). This scientific issue will continue as researchers publish more evidence, politicians and government bodies begin to take action, and as more organizations get involved.

Conclusion/Policy Recommendations

There appears to be a relationship between author affiliation and correlation. There is a statistically significant relationship between the author affiliation and whether or not there is a correlation between cell phones and cancer. The place of funding or author affiliation of a study has a relationship with whether or not the author(s) find a correlation between cell phones and cancer.

This relationship means that there is a significant possibility that bias exists in the results of these studies. Researchers, policymakers, politicians, health care workers, governments, and citizens must all be aware of the funding of studies and the bias of results. An organization that represents the interests of the mobile phone companies may not be as willing to provide information or to continue funding studies with information against it. A government that relies on taxes and revenue shares from satellite auctions may not be willing to disclose specific information negative to its cause. Even a university or hospital may be willing to report positive findings solely in order to be published. All parties involved in these studies must be aware of these findings, and if evidence persists, policymakers must be willing and ready to take action to protect public health.

Future Research Questions

1. How do the results change with a larger sample size when more articles are published or more organizations conclude a definite correlation in the future?
2. How will this information change if all funding information from authors is disclosed, readily available, and converted to numbers that make the creation of regression analysis easier?
3. How will different statistical methods affect the data, specifically with regards to more time, a larger sample of articles, and more interval-ratio variables?
4. How would adding locations of these studies affect the data?
5. How do the results change if the categories are separated further?

Appendix A – Data

Title	Year	Type	Author	Author Affiliation	Result (Yes, No, or Inconclusive)	Funding Type	Notes
Cell-phone safety	2009	Magazine Article	Walsh, B.	Time Magazine	Inconclusive	Magazine	
No change in brain tumor incidence during a time when cell phone usage increased	2009	Memo in Peer-Reviewed Journal	National Cancer Institute	National Cancer Institute	No	Government	
Time trends in brain tumor incidence Rates in Denmark, Finland, Norway, and Sweden, 1974–2003	2009	Memo in Peer-Reviewed Journal	Dektou, J., Johansen, C., Auvinen, A., Feychting, M., Kjaerboe, L., & S	Danish Strategic Research Council	No	Government (Denmark)	*Funded by
The reality of mobile phones and cancer	2009	Magazine Article	Repacholi, M.	New Scientist	No	Magazine	
Keeping you up to date on recent developments in oncology	2009	Magazine Article	Medical Device Daily	Medical Device Daily	No	Business	
Qualitative effect on mRNAs of injury-associated proteins by cell phone like radiation in rat facial nerves	2009	Peer-Reviewed Journal Article	Ji-Geng, Y., Agrest, M., Lin-Ling, Z., Yuhui, Y., & Matloub, H.	Department of Plastic and Reconstructive Surgery, Medical College of Wisconsin, Milwaukee, Wisconsin, USA.	Yes	College	
Upregulation of Specific mRNA Levels in Rat Brain After Cell Phone Exposure	2008	Peer-Reviewed Journal Article	Ji-Geng, Y., Agrest, M., Lin-Ling, Z., Yuhui, Y., & Matloub, H.	Department of Plastic and Reconstructive Surgery, Medical College of Wisconsin, Milwaukee, Wisconsin, USA	Yes	College	
Is cell-phone safety assured? Or merely ignored?	2009	Magazine Article	Khairif, O.	Business Week	Inconclusive	Magazine	
Keep cell phones and PDAs away from EMG sensors and the human body to prevent electromagnetic interference artifacts and cancer	2009	Peer-Reviewed Journal Article	J-Mei, L., & Peper, E.	National Chung Cheng University, Taiwan, San Francisco state University, San Francisco, CA	Yes	University	
Cell phones and brain tumors: A review including the long-term epidemiologic data	2009	Peer-Reviewed Journal Article	Khazana, V., Teo, C., Kundt, M., Hardell, L., & Carberg, M.	Australian National University, Australia, Department of Neurosurgery, The Canberra Hospital, Garran ACT 2605, Australia, The Prince of Wales Private Hospital, Randwick NSW 2031, Australia, Institute of Environmental Health, Medical University of Vienna, Vienna A-1095, Austria, Department of Oncology, University Hospital, Orebro SE-701 85, Sweden	Yes	University, Hospital	*No funding requested

Title	Year	Type	Author	Author Affiliation	Result (Yes, No, or Inconclusive)	Funding Type	Notes
Cell phone use and acoustic neuroma: The need for standardized questionnaires and access to industry data	2009	Peer-Reviewed Journal Article	Han, Y., Kano, H., Davis, D., Niranjan, A., & Lunsford, L.	Jennie Zolner Foundation to the University of Pittsburgh Medical Center and a grant from the Heinz Endowments to the Center for Environmental Oncology-University of Pittsburgh Cancer Institute, Osaka Medical Research Foundation for Incurable Diseases	Inconclusive	University, NGO, Hospital	*Funded by
Cell phone radiation: Evidence from ELF and RF studies supporting more inclusive risk identification and assessment	2009	Peer-Reviewed Journal Article	Blackman, C.	Raleigh, NC 27607, USA	Inconclusive	Unknown	
Increased blood-brain barrier permeability in mammalian brain 7 days after exposure to the radiation from a GSM-900 mobile phone	2009	Peer-Reviewed Journal Article	Nirby, H., Bruu, A., Eberhardt, J., Malmgren, L., Persson, B., & Salfors	Hans and Mint Raising Charitable Foundation	Yes	NGO	*Funded by
The wireless dilemma: An inconvenient truth about a convenient technology	2009	Magazine Article	Schinn, S.		Yes	Magazine	*Selling Magazine Product
Cell phones and cancer: Still in no man's land	2009	Peer-Reviewed Journal Article	Kohli, D., Sachdev, A., & Vats, H.	Government Medical College and Hospital, Department of Internal Medicine, Sector 32, Chandigarh-160 030, India, University of Wisconsin, Madison, Wisconsin - USA	Inconclusive	Government, University	*No funding requested
To call or not to call?	2008	Magazine Article	Tsoukanidis, E.		Inconclusive	Magazine	
Biased confidence in risk assessment studies	2008	Peer-Reviewed Journal Article	Siegrist, M., Cousin, M., & Frei, M.	ETH Zurich, Institute for Environmental Decisions (IED), Consumer Behavior, Zurich, Switzerland	Inconclusive	Business	
Lifestyle and testicular dysfunction: A brief update	2008	Peer-Reviewed Journal Article	Agarwal, A., Desai, N., Ruffolo, R., & Carpi, A.	Center for Reproductive Medicine, Glickman Urological and Kidney Institute and Obst/Gyne and Women's Health Institute, Cleveland Clinic, Cleveland, OH, USA; Department of Human Morphology and Applied Biology, University of Pisa, Italy; Department of Reproduction and Ageing, University of Pisa, Italy	Yes	University	
Effect of cell phone usage on semen analysis in men attending infertility clinic: an observational study	2008	Peer-Reviewed Journal Article	Agarwal, A., Deepinder, F., Sharma, R., Ranga, G. & Li, J.	Reproductive Research Center, Glickman Urological Institute and Department of Obstetrics-Gynecology, Cleveland Clinic Foundation, Cleveland, Ohio; Karbhakya Medical Research and Diagnostic Center, Mumbai, India; Department of Quantitative Health, Cleveland Clinic Foundation, Cleveland, Ohio	Yes	Hospital	
Cell phones and cancer: More research needed	2008	Magazine Article	Klarif, O.	Business Week	Inconclusive	Magazine	

Title	Year	Type	Author	Author Affiliation	Results (Yes, No, or Inconclusive)	Funding Type	Notes
Why cell-phone health concerns persist	2008	Magazine Article	Yarov, J.	Business Week	Inconclusive	Magazine	
Does the use of cell phones cause brain tumors?	2008	Peer-Reviewed Journal Article	O'Keefe, S.	Clinical Research Nurse, Taussig Cancer Center, Cleveland, OH	Inconclusive	Hospital	
Effects of low-level radio-frequency (30Hz to 300GHz) energy on human cardiovascular, reproductive, immune, and other systems: A review of the recent literature	2008	Peer-Reviewed Journal Article	Janchen, J.	Air Force Research Laboratory, Directed Energy Bioeffects Division, Radio Frequency Radiation Branch, 8362 Hawks Road, San Antonio, TX 78235-5147, USA	No	Government	
Cell phones not linked to cancer	2005	Peer-Reviewed Journal Article	Pharmaceutical Representative		No	Pharma	*Refers to 'no link' study
Are cell phones safe?	2003	Magazine Article	Consumer Reports	Consumer Union	Inconclusive	Private	
Brain cancer with induction periods of less than 10 years in young military radar workers	2002	Peer-Reviewed Journal Article	Richter, E., Berman, T., & Levy, O.	Unit of Occupational and Environmental Medicine Hebrew University-Hadassah Jerusalem, Israel, Tamar Berman, Unit of Occupational and Environmental Medicine Hebrew University-Hadassah Jerusalem, Israel and Or Levy, Unit of Occupational and Environmental Medicine Hebrew University-Hadassah Jerusalem, Israel	Yes	University	
Recent studies show cell phone use is not associated with increased cancer risk	2001	Peer-Reviewed Journal Article	Nelson, N.	National Cancer Institute	No	Government	
Good news for mobile phone users?	2000	Peer-Reviewed Journal Article	Chauke, M.	Lancet	No	Unknown	
Do cell phones cause brain cancer?	2000	Magazine Article	Nordberg, T.	Food and Drug Administration's Food Safety Initiative program	No	Government	
Effects of radiofrequency electromagnetic waves (RF-EMW) from cellular phones on human ejaculated sperm: an in vitro pilot study	2009	Peer-Reviewed Journal Article	Agarwal, A., Dessai, N., Makker, K., Varghese, A., Mouradi, R., Sabanand	Center for Reproductive Medicine, Glitchman Urological and Kidney Institute, Obstetrics and Gynecology and Women's Health Institute, Cleveland Clinic, Cleveland, Ohio	Yes	Hospital	

Title	Year	Type	Author	Author Affiliation	Result (Yes, No, or Inconclusive)	Funding Type	Notes
Epidemiological evidence for an association between use of wireless phones and tumor diseases	2009	Peer-Reviewed Journal Article	Hardell, L., Carlberg, M., Mild, K. H.	Cancer-och Allergifonden, Cancerhjälpen, Örebro University Hospital Cancer Fund	Yes	University; Hospital	*Funded by
Public health implications of wireless technologies	2009	Peer-Reviewed Journal Article	Sage, C., Carpenter, D. O.	Sage Associates, 1396 Danielson Road, Santa Barbara, CA 93108, USA; Institute for Health and the Environment, University at Albany, Rensselaer, NY, USA	Yes	Consulting Firm; University	
Cell phones more dangerous than cigarettes!	2008	Peer-Reviewed Journal Article	Paril, R.	Center for Pain Treatment and Rehabilitation, Lake Forest Hospital	Yes	Hospital	*Editorial
Epidemiology of health effects of radiofrequency exposure	2004	Peer-Reviewed Journal Article	Alderson, A., Green, L., Kafetsis, D., & Sverdrlov, A.	The National Institute of Environmental Health Sciences (NIEHS)	Inconclusive	Government	
Cellular telephone use and risk of acoustic neuroma	2004	Peer-Reviewed Journal Article	Christensen, H. C., J. Schuz, Kosteljanetz, M., Poulsen, H. S., Thomsen,	European Commission Fifth Framework Program; Union Internationale Contre le Cancer; Danish Cancer Society	No	Government (EU); NGO; Non-profit	*Funded by
Cellular telephones and risk for brain tumors: A population-based, incident case-control study	2005	Peer-Reviewed Journal Article	Christensen, H. C., Schuz, J., Kosteljanetz, M., Poulsen, H. S., Boice Jr.	European Commission Fifth Framework Program; Union Internationale Contre le Cancer; International Epidemiology Institute; Danish Cancer Society; Mobile-Manufacturers' Forum; GSM Association	No	Government (EU); NGO; Private; Non-profit; Mobile Company; Mobile Company	*Funded by
Epidemiological studies of radio frequency exposures and human cancer	2003	Peer-Reviewed Journal Article	Elwood, J. M.	National Cancer Control Initiative, Rathdovnae St. Carlton, Melbourne, Australia	No	Government (Australia)	
Radio frequency safety	2006	Website	Federal Communication Commission (FCC)	Federal Communication Commission (FCC)	No	Government (US)	
Mobile phone use and risk of glioma in adults: Case-control study	2006	Peer-Reviewed Journal Article	Hepworth, S. J., Schoemaker, M. J., Muir, K. R., Sverdrlov, A. J., Ton	Mobile Telecommunications, Health and Research (MTHR); Mobile Manufacturers Forum; GSM Association; Union Internationale Contre le Cancer (UICC); Health and Safety Executive; the Department of Health; the UK network operators (02, Orange, T-Mobile, Vodafone, 3);	No	NGO; Mobile Company; Mobile Company; NGO; Government; Government; Mobile Company (4)	*Funded by
COMAR technical information statement: Safety issues associated with base stations used for personal wireless communications	2000	Website	IEEE Committee on Man and Radiation	IEEE Committee on Man and Radiation	Inconclusive	NGO	

Title	Year	Type	Author	Author Affiliation	Results (Yes, No, or Inconclusive)	Funding Type	Notes
The top ten unfounded health scares of 2004: Cell phones cause brain tumors	2004	Website	Kava, R., Simola, A., Weiser, R., & Mills, L.	American Council on Science and Health	No	NGO	
Mobile phone use and the risk of acoustic neuroma	2004	Peer-Reviewed Journal Article	Lonn, S., Ahlbom, A., Hall, P., & Feychting, M.	European Commission Fifth Framework Program; Swedish Research Council; Union Internationale Contre le Cancer; Mobile Manufacturers' Forum; GSM Association	Yes	Government (EU); Government (Sweden); NGO; Mobile Company; Mobile Company	*Funded by
Long-term mobile phone use and brain tumor risk	2005	Peer-Reviewed Journal Article	Lonn, S., Ahlbom, A., Hall, P., & Feychting, M., & the Swedish Interph	European Commission Fifth Framework Program; Swedish Research Council; Union Internationale Contre le Cancer; Mobile Manufacturers' Forum; GSM Association	No	Government (EU); Government (Sweden); NGO; Mobile Company; Mobile Company	*Funded by
Mobile phones, mobile phone base stations and cancer: a review	2005	Peer-Reviewed Journal Article	Moulder, J., Foster, K., Erdreich, L., & McNamee, J.	Radiation Oncology, Medical College of Wisconsin, Milwaukee, WI, USA; Bioengineering, University of Pennsylvania, Philadelphia, PA, USA; Expoent, 420 Lexington Avenue, New York, NY, USA; Consumer and Clinical Radiation Protection Bureau, Product Safety Program, Health Canada, Ottawa, Ont, Canada	Inconclusive	Hospital; University; NGO; NGO	
Cellular telephone use and cancer risk	2009	Website	National Cancer Institute	National Cancer Institute	No	Government (US)	
Cellular phones, cordless phones, and the risks of glioma and meningioma	2006	Peer-Reviewed Journal Article	Sohn, J., Bolder, E., Berg G., Schlahofer, B., Hettinger, I., Schlahofer, K.	European Commission Fifth Framework Program; German Mobile Phone Research Program; Union Internationale Contre le Cancer; Mobile Manufacturers' Forum; GSM Association	No	Government (EU); Government (Germany); NGO; Mobile Company; Mobile Company	*Funded by
Cellular phones	2010	Website	American Cancer Society	American Cancer Society	Inconclusive	NGO	
Electromagnetic fields and public health: mobile telephones and their base stations	2000	Website	World Health Organization	World Health Organization	No	International Organization	
Wireless issues: Radio frequency emissions	2010	Website	Verizon Wireless	Verizon Wireless	No	Mobile Company	
Health and safety information	2010	Website	AT&T	AT&T	No	Mobile Company	

Appendix B – STATA Tabulate Information

. tab affiliation

affiliation	Freq.	Percent	Cum.
-----+-----			
Government	11	22.00	22.00
Mobile Company	7	14.00	36.00
University/Hospital/NGO	18	36.00	72.00
Other	14	28.00	100.00
-----+-----			
Total	50	100.00	

. tab correlation

correlation	Freq.	Percent	Cum.
-----+-----			
No	21	42.00	42.00
Inconclusive	15	30.00	72.00
Yes	14	28.00	100.00
-----+-----			
Total	50	100.00	

. tab year

year	Freq.	Percent	Cum.
-----+-----			
2000	4	8.00	8.00
2001	1	2.00	10.00
2002	1	2.00	12.00
2003	2	4.00	16.00
2004	4	8.00	24.00
2005	4	8.00	32.00
2006	3	6.00	38.00
2008	10	20.00	58.00
2009	18	36.00	94.00
2010	3	6.00	100.00
-----+-----			
Total	50	100.00	

Appendix C – STATA Cross-tabulate Information

```
. tab affiliation correlation, col row
```

```

+-----+
| Key          |
|-----|
| frequency    |
| row percentage |
| column percentage |
+-----+

```

affiliation	correlation			Total
	No	Inconclus	Yes	
Government	9	2	0	11
	81.82	18.18	0.00	100.00
	42.86	13.33	0.00	22.00
Mobile Company	6	0	1	7
	85.71	0.00	14.29	100.00
	28.57	0.00	7.14	14.00
University/Hospital/N	1	5	12	18
	5.56	27.78	66.67	100.00
	4.76	33.33	85.71	36.00
Other	5	8	1	14
	35.71	57.14	7.14	100.00
	23.81	53.33	7.14	28.00
Total	21	15	14	50
	42.00	30.00	28.00	100.00
	100.00	100.00	100.00	100.00

Appendix D – STATA Chi-square Tests

```
. tab affiliation correlation, col chi2 taub
```

```

+-----+
| Key          |
|-----|
| frequency    |
| column percentage |
+-----+

```

affiliation	correlation			Total
	No	Inconclus	Yes	
Government	9	2	0	11
	42.86	13.33	0.00	22.00
Mobile Company	6	0	1	7
	28.57	0.00	7.14	14.00
University/Hospital/N	1	5	12	18
	4.76	33.33	85.71	36.00
Other	5	8	1	14
	23.81	53.33	7.14	28.00
Total	21	15	14	50
	100.00	100.00	100.00	100.00

Pearson chi2(6) = 34.5779 Pr = 0.000

Kendall's tau-b = 0.2521 ASE = 0.114

```
. tab year correlation, col chi2 taub
```

```
+-----+
```

```
| Key |
```

```
|-----|
```

```
| frequency |
```

```
| column percentage |
```

```
+-----+
```

	correlation			
year	No	Inconclus	Yes	Total
2000	3	1	0	4
	14.29	6.67	0.00	8.00
2001	1	0	0	1
	4.76	0.00	0.00	2.00
2002	0	0	1	1
	0.00	0.00	7.14	2.00
2003	1	1	0	2
	4.76	6.67	0.00	4.00

2004		2	1	1		4
		9.52	6.67	7.14		8.00
-----+-----+-----						
2005		3	1	0		4
		14.29	6.67	0.00		8.00
-----+-----+-----						
2006		3	0	0		3
		14.29	0.00	0.00		6.00
-----+-----+-----						
2008		1	5	4		10
		4.76	33.33	28.57		20.00
-----+-----+-----						
2009		5	5	8		18
		23.81	33.33	57.14		36.00
-----+-----+-----						
2010		2	1	0		3
		9.52	6.67	0.00		6.00
-----+-----+-----						
Total		21	15	14		50
		100.00	100.00	100.00		100.00

Pearson chi2(18) = 21.6468 Pr = 0.248

Kendall's tau-b = 0.2175 ASE = 0.117

Appendix E – STATA ANOVA Test

```
. anova correlation year
```

```
Number of obs =      50      R-squared      = 0.3528
```

```
Root MSE      = .741901      Adj R-squared = 0.2072
```

Source	Partial SS	df	MS	F	Prob > F
-----+-----					
Model	12.0033333	9	1.3337037	2.42	0.0266
year	12.0033333	9	1.3337037	2.42	0.0266
Residual	22.0166667	40	.550416667		
-----+-----					
Total	34.02	49	.694285714		

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