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Interactions between radiofrequencies signals and living organisms

Source of funding in experimental studies of mobile phone use on health: Update of systematic review

Sources de financement et études expérimentales sur les effets sur la santé du téléphone mobile : Mise à jour d'une revue systématique

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ABSTRACT

A previous review showed that among 59 studies published in 1995–2005, industry-funded studies were least likely to report effects of controlled exposure to mobile phone radiation on health-related outcomes. We updated literature searches in 2005–2009 and extracted data on funding, conflicts of interest and results. Of 75 additional studies 12% were industry-funded, 44% had public and 19% mixed funding; funding was unclear in 25%. Previous findings were confirmed: industry-sponsored studies were least likely to report results suggesting effects. Interestingly, the proportion of studies indicating effects declined in 1995–2009, regardless of funding source. Source of funding and conflicts of interest are important in this field of research.

RÉSUMÉ

Une précédente revue a montré que, parmi 59 études publiées entre 1995 et 2005, les études financées par l'industrie étaient moins susceptibles de mettre en évidence des effets liés à la santé de l'exposition contrôlée aux émissions radiofréquences de type téléphone mobile. Nous avons mis à jour notre base à partir de la littérature publiée entre 2005 et 2009 et extrait les informations concernant le financement, les conflits d'intérêts et les résultats. Parmi 75 nouvelles études, 12% ont un financement de l'industrie, 44% un financement public et 19% un financement mixte public-privé. Les résultats précédents ont été confirmés : les études financées par l'industrie sont moins susceptibles de suggérer des effets sur la santé. Autre fait intéressant, la proportion d'études indiquant des effets a diminué entre 1995 et 2009, quelque soit le mode de financement. La source de financement et les conflits d'intérêt sont importants à prendre en compte dans ce domaine de recherche.

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1. Introduction

The use of mobile telephone handsets leads to absorption of non-ionizing radiation by the brain of the users, which has generated concerns about potential health effects. Studies into the issue have produced conflicting results. Since a range of the relevant studies were funded by the telecommunication industry, the question was raised whether sponsorship has an effect on the outcome of these studies. In a previous systematic review [1], we reported that source of funding explained part of the heterogeneity between study results. For example, if funded exclusively by industry, studies were substantially less likely to report statistically significant effects on a range of endpoints that might be relevant to health: The odds ratio of reporting any significant effects in the full text section was 0.11 (95% 0.02–0.78) for industry, compared to public funded studies. This estimate was not materially changed when we adjusted for other factors that might affect study results, such as study quality, design or exposure characteristics. In addition, more than a third of the publications had not reported their source of funding and none of the studies had included a statement regarding conflicts of interest.

Over the last years, there have been efforts to improve reporting of conflicts of interest; especially the disclosure of project funding has become common practice in many biomedical journals. Our previous review included studies from 1995 up to February 2005. The aim of the present study was to examine whether there have been changes in the reporting of source of funding and conflicts of interest, and whether we still observe the same effect with regard to the reporting of statistically significant results in the abstract.

2. Methods

2.1. Inclusion/exclusion criteria

We included original articles of human laboratory studies that reported biological effects of controlled exposure with radiofrequency radiation on health related outcomes including electroencephalogram (EEG) recordings, assessments of cognitive or cardiovascular function, hormone levels, subjective symptoms and well-being. We excluded studies that investigated the risk of using mobile phones when driving a motor vehicle or operating machinery as well as studies on electromagnetic field incompatibilities (e.g., pacemakers or hearing aids).

2.2. Search

We searched EMBASE and MEDLINE in September 2009 with the keywords: ‘cell(ular) (tele)phone(s)’, ‘mobile (tele)phone(s)’, ‘umts’ and ‘gsm’. These were combined with: ‘attention’, ‘(pre-)attentive’, ‘learning’, ‘concentration’, ‘reaction’, ‘memory’, ‘cognitive’, ‘health complaint(s)’, ‘symptom(s)’, ‘well(-)being’, ‘vertigo’, ‘nausea’, ‘immunological’, ‘hormone(s)’, ‘hormonal’, ‘melatonin’, ‘sleep’, ‘fertility’, ‘semen’, ‘hearing’, ‘auditory’, ‘audio(-)vestibular’, ‘otoacoustic’, ‘visual’, ‘thermo(-) regulation’, ‘thermo-physiology’, ‘cardiovascular’, ‘circulatory’, ‘heart(-)rate’, ‘blood pressure’, ‘blood’, ‘cerebral blood flow’, ‘CBF’, ‘bioelectric’, ‘brain physiology’, ‘neural’, ‘neurological’, ‘nervous system’, ‘EEG’, ‘electroencephalogram’, ‘neural function’, ‘excitability’, ‘event related potential’, ‘ERP’, ‘PET’, ‘psycho(-)motor’ and ‘hypersensitive’. We limited our search to studies published between January 2005 and September 2009.

2.3. Data extraction

LvN and AH independently selected the articles included for analysis. Both checked the abstracts and acknowledgements of the individual articles on the reported source of funding (industry, public, mixed, not reported), conflicts of interest statement (reported or not, and if reported, whether this was a statement of a conflict or of no conflict), author affiliation and the reporting of health endpoints in the abstract suggesting an effect: If no p-value was cited and no reference to “statistical significance” or “evidence” (for or against) was made, we assessed the suggestion of presence or absence of an effect from the text. An example of an effect reads as follows: “The results show that, under real exposure as compared to baseline and sham conditions, EEG spectral power was influenced in some bins of the alpha band. [...] The present data lend further support to the idea that pulsed high-frequency electromagnetic fields can affect normal brain functioning, [...]” [2], whereas an example of no effect might read: “No effects were found between the different EMF conditions, separate hemisphere exposures, or between the control and experimental group. In conclusion, the current results indicate that normal mobile phones have no discernible effect on human function as measured by behavioural tests” [3]. We also checked the use of indicative or declarative titles, i.e. titles that either only describe the topic of the study or that give the studies main conclusion (no effect or effect), which has been criticised as having the potential to oversimplify or exaggerate study findings [4].

2.4. Statistical method

We used logistic regression models to assess whether the source of funding was associated with the reporting of at least one result suggesting an exposure effect in the abstract of the article. We examined the influence of potential confounders, such as the type of outcome (e.g., EEG: yes vs. no) by adding it to the model, and we also used the publication

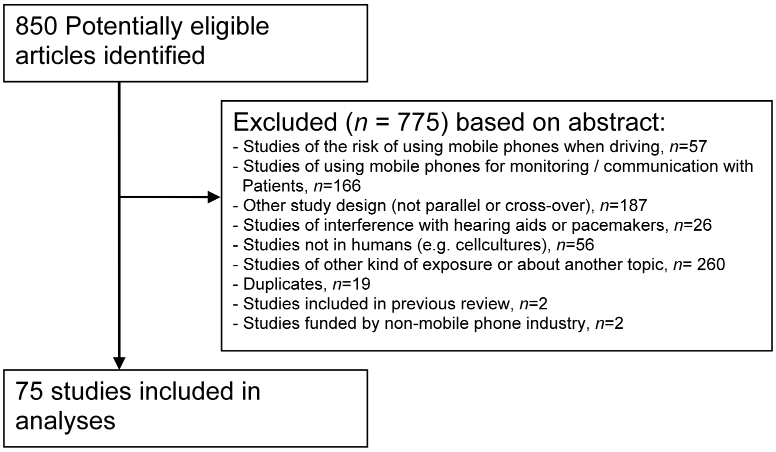

Fig. 1. Identification of eligible studies.

year to explore potential trends over time in our models. Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs).

We conducted separate analyses for the periods before and after 2005 as well as a pooled analysis for the whole period from 1995 to 2009. We tested differences in the reporting of results suggesting exposure effects and the use of indicative or declarative titles between the two time periods of the reviews (1995–2005 and 2005–2009) by means of chi^2 or Fisher's exact tests. All analyses were carried out in Stata (version 10; StataCorp., College Station, TX, USA).

3. Results

We identified 850 studies that were published between 2005 and 2009. Of these, 775 studies were excluded because they did not meet the inclusion criteria (Fig. 1). A total of 75 studies were included in the analysis. Of these, nine (12%) were exclusively funded by the telecommunication industry, 33 (44%) by public agencies, 14 (19%) studies had mixed funding (including industry and industry-independent sources), and in 19 studies (25%) the source of funding was not reported. Compared to the previous review, there were slightly more studies with public funding, and slightly less studies that did not report their funding source (Table 1).

Table 1
Reported source of funding of 75 studies published in 2005–2009, and of 59 experimental studies published between 1995 and 2005.

	Industry	Public	Mixed	Not reported	Total
Feb. 2005–2009	9 (12%)	33 (44%)	14 (19%)	19 (25%)	75 (100%)
1995–Feb. 2005	12 (20%)	11 (19%)	14 (24%)	22 (37%)	59 (100%)
Total	21 (16%)	44 (33%)	28 (21%)	41 (30%)	134 (100%)

Analysed health endpoints were very similar to the previous review: The majority of the 75 studies investigated EEG outcomes (51%) followed by cognitive (32%) and cardiovascular (20%) endpoints. Well-being (13%) and hormonal changes (4%) were less often investigated (Table 2).

Table 2
Health endpoints as reported in the abstract, of experimental studies of mobile phone use in publications from 1995 to Feb. 2005 and from Feb. 2005 to 2009.

Outcomes	1995–2005 $N = 57$[a]	2005–2009 $N = 75$
EEG	31 (54%)	38 (51%)
Cognitive outcomes	17 (30%)	24 (32%)
Hormones	6 (11%)	3 (4%)
Cardiovascular	5 (9%)	15 (20%)
Well-being	2 (4%)	10 (13%)

[a] Of the originally 59 studies, 2 were excluded because they had no abstract.
Studies can assess more than one outcome category so that percentages do not add up to 100.

Eight out of the 75 studies (11%) reported a conflicts of interest statement in which all reported that there were no conflicts of interest. Of these eight studies, there was none funded by the industry, but three mixed, four public funded, and one study where funding was not reported. In seven publications (9%) there was at least one author listed who was affiliated with the telecommunication industry. None of these publications reported any conflicts of interest.

Table 3
Odds ratio of reporting at least one result suggesting an effect of mobile phone exposure in the abstract, by source of funding: ORs (95% CIs) from logistic regression models.

Review	Model	Industry	Public	Mixed	Not reported
2005–2009	Crude	0.33 (0.04–3.06)	1 (referent)	2.00 (0.54–7.39)	3.67 (1.12–12.05)
1995–2005	Crude	0.29 (0.05–1.59)	1 (referent)	1.43 (0.26–7.7)	1.71 (0.35–8.42)
Combined analysis	Crude	0.55 (0.17–1.77)	1 (referent)	2.33 (0.89–6.14)	3.5 (1.41–8.66)
	Adjusted for year of publication	0.20 (0.05–0.85)	1 (referent)	1.89 (0.68–5.27)	3.11 (1.20–8.05)

Twenty-seven (36%) of the studies reported results indicating effects of the exposure. This is much less compared to the last review with 63% (p-value of chi^2 test $= 0.002$). Over all publications from both reviews, the proportion of studies indicating effects decreased with the publication years, and this trend was statistically significant in a logistic regression model (OR per year 0.85, 95% CI 0.76–0.95) and remained when we adjusted for source of funding (OR 0.79, 95% CI 0.69–0.90).

The logistic regression analysis evaluating the influence of source of funding showed that studies which were industry funded were less likely to report at least one significant result with an OR of 0.33 (95% CI 0.04–3.06), which is in line to what we observed in our previous analysis (Table 3). Including both reviews into the analysis, the OR of reporting a significant effect in the abstract was 0.55 (95% CI 0.17–1.77) for the industry funded studies, but this decreased when we adjusted for year of publication to an OR of 0.20 (95% CI 0.05–0.85). In contrast, the studies that did not report their source of funding were much more likely to report results suggesting effects. This result was not substantially changed when we included the topic of the research (EEG studies or studies on cognitive effects, etc.) as a covariate into the model (data not shown). In addition, in the total sample of both reviews, this estimate of OR 3.5 (95% CI 1.41–8.66) was only slightly reduced to 3.11 (95% CI 1.20–8.05), when we adjusted for year of publication.

Fifteen (20%) of the studies had a declarative title, and of these, 8 (53%) reported no effect and 7 (47%) reported an effect. The sample was too small to detect differences by funding source. When we included data from publications from 1995 to 2005 into the analysis, we found that using declarative titles per se was not dependent on source of funding (applied by 28–35% of the studies per funding group, p-value of Fisher's exact test $= 0.9$). However, of these publications, the direction of the statement differed per group: No effects were stated by all industry funded studies (6 of 6, 100%), by 6 of 11 (55%) of studies with public funding, by 4 of 9 (44%) of studies with mixed funding, and by 8 of 11 (75%) of studies that did not report funding source. This group difference is statistically significant (p-value of Fishers exact test $= 0.03$).

4. Discussion

We examined whether source of funding was associated with the reporting of results suggesting health effects in experimental studies investigating mobile phone use. We found that studies funded by industry were less likely to report results suggesting exposure effects, in line with our previous review. In contrast, studies which did not report on source of funding were much more likely to report effects compared to public funded studies. Very few of the publications had included a conflicts of interest statement and all such declarations stated the absence of conflict of interests. Thus, in none of the industry funded studies nor any of the publications that listed authors affiliated with commercial bodies' were conflicts of interests declared.

This study has several limitations in the way that, while it updates our previous analysis, we only assessed information from the abstracts. We might have therefore misclassified studies if statistically significant results reported in the full text section were not mentioned in the abstract. However, published epidemiological investigations have been reported to almost universally highlight associations in the abstract [5]. Our previous review also showed high overlap between significant results presented in the full text section compared to in the abstract. Also, while it might be informative to extend our analysis to animal or cell studies, we repeated our previous analysis restricted to experimental studies in humans in order to maintain a homogenous set of studies where we could pool and compare results between the two reviews.

Two publications [6,7] with funding by the telecommunication industry reported that their university had acted as a firewall between them and their sponsors. In these studies, funders might have had an influence on the design of the study when deciding upon granting funds for a study, but most likely not on the data collection, interpretation and reporting process. We therefore grouped these two studies together with the studies of mixed funding, which would represent the most similar group. Interesting to note, these two studies reported effects in the abstracts. The implementation of a firewall is a new development that we did not observe in the first review, indicating that researchers may find ways to maintain some independence when funded by industry.

Our study cannot determine which type of funding would lead to the most accurate results. However, within the publications published until 2005, we found that studies of mixed funding had the highest quality in terms of adequate randomisation, blinding of investigators and study participants, exposure set-up including estimation of the specific absorption rate, and the statistical methods (accounting for potential confounders). We also found that studies that did not report source of funding scored lowest in all of these quality dimensions. Lower study quality, especially inadequate allocation concealment and lack of blinding has been shown to be associated with exaggerated study results for subjectively assessed outcomes [8]. If such a mechanism was at work in the studies included in our review, this might explain why the studies without reported funding source were so much more likely to report significant effects compared to studies with public funding. Possibly some of these studies without proper funding were small pilot studies that were conducted to generate funding for the conduct of a large scale studies and thus, observed effects have been emphasised in the abstracts. Changes in study quality over time might represent an explanation for the strong trend of reporting fewer significant effects over time. Improved quality of the studies included here might especially relate to better exposure set-ups. Guidelines on exposure designs have been published in recent years [9,10]. Over the past years, improved designs for mobile phone exposure might have enabled proper blinding of study participants if heat or acoustic sensations or electromagnetic incompatibility with other devices were eliminated and thus could have reduced false positive study results.

While the proportion of studies that did not report their source of funding decreased over time, this still translated into a quarter of the studies included in our review that were published after February 2005 which did not report funding source. Even more surprising was the absence of a conflicts of interest statement in the majority of this set of very recent publications, including those with authors with affiliation with commercial bodies. Over the last decades, there have been substantial efforts by journal editors to improve transparency in the reporting of conflicts of interest. This includes the source and conditions of project funding [11]. Reporting of source of funding and declaration of the role of the funders in the study is included in checklists that aim at improving the reporting of studies, such as CONSORT [12] or STROBE [13]. CONSORT for example has been reported to have some effect on improving study reporting quality, but it has also been discussed that it takes time for such checklists to yield the full benefits for which they were intended [14,15].

In conclusion, this review confirmed our previous results that full disclosure statements should be included in studies on health effects of mobile phone use, and that the statements should also include the role of the funders in the design, conduct and reporting of the study. Interpretation of study results might take sponsorship, but also the risk of bias in studies with insufficient study quality or reporting thereof, into account.

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6. Conflicts of interest

The authors declare that they have no competing interests.

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