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Comments on "What is the radiation before 5G? A correlation study between measurements in situ and in real time and epidemiological indicators in Vallecas, Madrid"

Comment

Given the interest of the subject and controversy about the possible effects that Radiofrequency Electromagnetic Fields (RF-EMF) can have on human health, we read with much interest the article by Isabel López, Nazario Félix, Marco Rivera, Adrián Alonso, and Ceferino Maestú entitled "What is the radiation before 5G? A correlation study between measurements in situ and in real time and epidemiological indicators in Vallecas, Madrid" (López et al., 2021). This work already had two other comments questioning part of the experimental design, results, and data analysis (Jalilian et al., 2022; Ramirez-Vazquez et al., 2022). However, due to the social impact of the original article, we consider relevant to highlight other important flaws.

The Title confusingly refers to 5G and does not justify the main study subject. The employed "epidemiological indicators" concept is too general, does not inform about the study object, and confuses the epidemiological indicator concept with a series of nonspecific clinical symptoms that are frequently found in the general population.

The Abstract includes terms like "health indicators and electromagnetic radiation measurements", which are confusing and do not clarify which variables are to be studied or measured. Nor does provide relevant data with comparable (standardized) rates, proportions, or percentages, and does not define the statistical study type. Conversely, we find several p-values, but they do not offer any relevant information. The Abstract also mentions cancer, but cancer is not the study object, and no types of tumors or etiology are indicated, which is confusing and unnecessarily alarming. Its comparison of a sample of 268 participants to the whole Spanish population is completely inappropriate. It indicates that the people exposed to the highest radiation values present a larger number of severe symptoms, but the taken measures and the recorded frequencies or bands are not properly characterized, or these "higher radiation values" are related to maximum values. To conclude, it does not provide suitable information to understand the conducted study, the followed methodology or the analyzed variables. The results included in the Abstract do not provide any information that allows a suitable conclusion to be drawn or the performed study to be described.

The Introduction offers no theoretical background or previous experiences that account for the chosen methodology or the objectives set out. The main objective of this study was to find a possible relation between RF-EMF exposure and some "health indicators" like sleep, headache, and fatigue. These nonspecific self-perceived symptoms were collected by means of a self-designed and nonvalidated survey, completed by a sample of individuals concerned about being close to mobile phone antennae (mobile phone base stations; MPBS). A thorough review of previous studies with similar objectives, as well as methodologies that allow personal exposure in microenvironments to be characterized, is expected to, then, establish and justify a statistical design that permits hypotheses to be compared by controlling for possible confounders. More often than not, the included bibliographic references do not relate to the corresponding statements that they are expected to justify. Otherwise, they are poor-quality references or from non indexed journals, or not from recent studies. On the whole, it is a self-interested, but misinterpreted selection of references (cherry picking).

Some recent works have revised the possible effects of RF-EMF by taking personal exposure measures (Bogers et al., 2018; Bolte et al., 2019; Röösli, 2008; Röösli et al., 2010b). Moreover in the last few years, two systematic reviews have been published about the characterization of personal exposure to RF-EMF (Jalilian et al., 2019; Sagar et al., 2018), which are not cited, and they provide suitable previous information to compare or explain the objectives set out or the obtained results. Other studies evaluate personal exposure under extreme conditions as major events with temporary antennae and a dense public (Ramirez-Vazquez et al., 2019a). Ramírez et al. (2019b) characterize personal exposure in the Spanish city of Albacete, or in Albacete and Alcalá de Henares, and they take complete city exposure measures (Gonzalez-Rubio et al., 2016; Sánchez-Montero et al., 2017) to provide methodologies and data in a similar context. Most studies about characterizing exposure to RF-EMF have used personal exposimeters. This means that frequency band exposure can be determined for a group of individuals using small devices and long measuring sessions. Röösli et al. (2010a) propose a measurements protocol. Experience has been acquired in recent years to allow limitations, biases and uncertainties to be established (Bolte, 2016; Bolte et al., 2011), and all this has been achieved by establishing and comparing different methods to analyze and handle measurements (Najera et al., 2020; Röösli et al., 2008).

Otherwise, the cited study by Renke and Chavan (2014) is in fact about measuring levels of exposure to telephone antenna conducted in India. It was published in a non indexed journal, and not in PubMed or Web of Knowledge. Thus, it cannot be used to state that non ionizing radiation "could affect the cellular functioning and physiology of the human body in terms that are still under study such as trigger oxidative stress". Likewise, the reference made to Wiedemann and Schütz (2011), published in the non indexed journal Wiener Medizinische Wochenschrift in JCR until 2020, aims to justify the idea, albeit an important one, about the need to perform epidemiological studies to compare the possible relation between RF-EMF and health. The study is a narrative review that reaches the conclusion that no evidence appears, or existing evidence is insufficient, to suggest that EMF is a risk factor for children. This reference is used to back an argument that does not correspond to the content in the cited paper.

The text indicates that the International Commission for the

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Protection of Non Ionizing Electromagnetic Radiation (ICNIRP) has sustained lack of scientific evidence for possible effects of RF-EMF exposure since 1998 without indicating that safe exposure levels are established to do so, and that these recommendations have been recently revised (International Commission on Non Ionizing Radiation Protection (ICNIRP), 2020). This incomplete argument is used to warn that the International Agency for Research on Cancer (IACR) classified the EMFs produced by base telephone stations as possible carcinogens for humans (Group 2B). Nevertheless, after reading the press release, the paper and the monograph of IARC10 (pp. 405 and 412), we find that they do not back this statement at all (IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2013). Conversely, this monograph states: "Together, these studies provide no indication that environment exposure to RF radiation increases the risk of brain tumors. No conclusions could be drawn on the risk of leukemia of Lymphomafrom environmental exposure to RF radiation". According to the IARC, evidence for other tumors was misleading (mistaken or ambiguous). The 2B classification was formed according to some results from case-control studies (Ahlbom et al., 2009; INTERPHONE Study Group, 2010), which associated a higher increase of gliomata in users who constantly use mobile phones (essentially those with GSM technology). Therefore, it is not true that the IARC classifies antennae as 2B group-type carcinogenic. In this context, the authors include the following reference of Havas (2017), which is not related to the objective of the paper, but refers to speculation about cell processes deriving from being exposed to mobile phones, and not to antennae. It is not a study that has demonstrated a biophysical mechanism but is, conversely, a letter to the Editor of a journal with opinions not based on evidence or accepted by the scientific community.

The authors indicate that very few studies have been performed to compare perceived symptoms and to take in situ measurements. However, once again, the references provided to back this statement, namely Belpomme et al. (2018), Belyaev et al. (2016) and Navarro et al. (2003), do not correspond to this statement because they neither perform nor suggest anything like this. However, studies with a similar study object exist, but are not cited (Bogers et al., 2018; Bolte et al., 2019; Röösli, 2008; Röösli et al., 2010b).

Being afraid of the presence of antennae and their possible health risks is indicated, but they are neither properly backed nor accompanied by relevant references. Many studies have assessed the perceived risk or the effect of media information on this matter (Domotor et al., 2019; Szemerszky et al., 2021; Szemerszky and Koteles, 2021; Witthöft et al., 2018; Witthöft and Rubin, 2013). These ideas are mixed with the number of mobile phone lines in the world or Internet access is compared to having access to electricity or running water, which is completely irrelevant in this context.

To justify the need for studies that evaluate these "health indicators", the reference to Röösli et al. (2010a) is applied which, as previously explained, proposes a protocol to take measurements using personal exposure meters. Although it has been used to normalize the methodology in many studies that evaluated exposure, it is neither explained nor applied in the paper. Quite the reverse applies because it refers to the CENELEC procedure, but without implementing it into the study. Later it indicates that this procedure is unsuitable but does not go on to provide any justification or discussion to state this. Without providing suitable evidence to justify the methodology, similar previous studies, verified strategies or past experiences, the Introduction ends by stating that "the majority of the studies" that evaluate effects on health include cancer-related parameters, but does not include any citations to back this statement. Nonetheless, it goes on to insinunate a possible relation by providing cancer incidence data in Spain with overall data, but without separating into tumor type or its etiology.

Although the study's lack of justification in the Introduction is evident, the main work limitations appear in its proposed methodological design. Neither the chosen sample size nor the survey design is explained. The same can be stated of the inclusion or exclusion criteria applied to the participating individuals and of the proposed statistical analysis. The methodology selected to take measurements of exposure levels to EMF is not explained. Furthermore, participants' memory risks, previous diseases, or a possible interviewer's bias due to knowledge about exposure or a health problem are not considered.

The proposed methodology does not bear in mind the control of possible selection or confounding biases that can lead the real association to be over- or underestimated. This confounding bias may give way to a non causal association between the variables to be studied or to not observe a real association given the effect of a third uncontrolled variable. The presented survey has not been validated, which merely emphasizes methodological limitations and biases.

The study was performed following the demand of a frightened activist group, which makes it is plausible to think that the participants (neighbors in the area) knew the study objectives. Those participants living close to telephone installations could overestimate the symptoms included in the survey. No alternative variables to EMF are considered, such as age, being unemployed, job, their family's situation, previous diseases, physical activity, occupational exposures, etc. As they have not been included, any observed associations being due to these variables, and not to EMF, cannot be ruled out.

The symptoms indicated in the survey have a marked subjective component, which makes it difficult to quantify and make them visible. One of them is stressed, that of "instability", for being vague and inaccurate, and not being properly explained. Different surveys with a comparable standardized methodology, such as those conducted by the Spanish National Statistics Institute (INE) or the Spanish Ministry of Health of 2017, provide information about chronic or long-term diseases. The 2020 European Health Survey of Spain indicates that people aged over 15 years can have chronic health problems, and they can differ between men and women (Ministerio de Sanidad, Consumo y Bienestar Social, 2020).

The measurement methodology proposed in the paper is not justified, has not been previously referenced and is not properly detailed. Exposure measures were taken at a number of points from different locations in two areas, a "control area" and a "study area", whose selection or delimination criteria are not indicated, and the same can be stated of their selection of measuring points. Measurements are based on recording the peak values taken in 10 minutes during two 3-h periods. The authors do not provide details of the type of EMF or the studied frequency range. This would make its replication complicated and, as it is not based on or compared to previous experiences, its design is its authors' own.

Furthermore, the applied duration of taking measurements by the authors is extremely limited to two 3-h schedules. These periods take place during two periods distant in time between 2018 and 2019. The authors do not explain the possible impacts that these time differences could have on their results. Employing the maximum value is unsuitable for the marked spatio-temporal variability of RF-EMF. This value does not represent personal exposure and not all the frequencies are indicated. So, measurements should offer extremely variable values, and at different frequencies and distinct points, which makes this study, comparison, or management difficult. Another relevant aspect is how the mean is used. The paper does not explain how it was calculated and provides a mean value for all the frequency bands. As it does not discriminate per frequency band, the contribution of each band is unknown. As often found in previous studies, this may lead to one band, or several bands, contributing more than others, and we would only observe a sporadic maximum. Another usual way to present these data is by means of percentiles, which provide information about the recorded data distribution.

The exposure level of many frequency bands is often below the device's threshold measurement value. This is known as a nondetect. This value tends to be the device's minimum measurement value and must be properly processed because it conditions the study. Both Röösli et al. (2008) and Najera et al. (2020) recommend and compare different

techniques, which must be taken into account when analyzing such data. The paper does not indicate having processed these data or what percentage of them was recorded.

Another section of the methodology with some weak points and major limitations is the employed statistical analysis of the results. Persistently using statistical significance too much (p-value), without considering the used statistical tests, does not account for a possible scientific finding. This is why its interpretation must be made and supported by scientific reasoning, and not by a simple conclusive index (Halsey et al., 2015; Wasserstein and Lazar, 2016). This fact comes over far too clearly in the paper because the statistical analysis does not justify the applied methodology. Nor does the paper offer any data about the goodness of fit of the binomial or multinomial model, the likelihood reason, or the standard error or the used model. Nor does it study possible interactions among variables. Finally, the study's small sample size and the limited number of health problems, as well as some of the aforementioned biases, could have led to associations with excessively large effect estimates (odds ratio); e.g., over 10, that are quite unlikely.

An example of not controlling confounding variables is found in Figure 3 in the study. As mentioned before, authors did not explain why the control and study areas were chosen, or why the control area is included in the study area. One of the sources of radiation, as the authors refer to them, is very close to the Valencia Road where traffic is dense, and road, air and noise pollution are the recognized cause of many ailments and diseases (Health Effects Institute, 2010). Conversely, the control area is not near this road, with trees lining houses. This area lies opposite a large urban park. Factors of being exposed to green areas have well-known protective effects on health. Authors did not indicate the direction of the main antennae beams, or if antennae are found in the surrounding areas. For example, if we move in a straight line about 220 m to the south, one antenna is nearer some homes than the antennae considered in the study area (https://geoportal.minetur.gob.es/VCTEL/detalleEstacion.do?emplazamiento=70939).

The way the Results are presented is confusing and not at all clear. Some mistakes appear in the notation of decimal places, and Spanish and English notations are mixed, i.e., using "." and "," to indicate decimals. In other places, the units and numbers of significant figures are mixed, with mixtures of two, three and up to five. The same magnitude (frequency) is expressed with a different number of significant decimals in Tables 2 and 4, which implies lack of knowledge about the measure's uncertainty. The power density of the distances from the far-off field should decline in the free space as the inverse of the square of the distance, and not as the inverse of the distance as the text points out. So, this statement is not theoretically suitable, and is not empirically validated with a strip chart showing the evolution of power density with distance. These errors have been also commented by Ramirez-Vazquez et al. (2022).

The authors set three exposure levels (low, medium, and high), but do not indicate their reason for doing so or provide any type of technical discussion or scientific support for this. The high exposure category includes values up to 5311 $\mu W/m^2$. This value corresponds to the ICNIRP limit of 0.0538%, which does not seem to be well justified and can lead readers to mistaken conclusions.

The text refers to data that do not coincide with those found in the tables. For example, the values shown in Table 2 for the 1810.47 MHz frequency are 3.670 $\mu W/m^2$ (mean [$\mu W/m^2$]) and 278,000 $\mu W/m^2$ (maximum peak [$\mu W/m^2$]), which do not match the values in the text. Similarly, the value 3593.12 $\mu W/m^2$ at a frequency of 943.97 MHz does not appear in Table 3 because, instead, a value of 3593.116 appears at a frequency of 927.14 MHz. Moreover, the value shown in Table 3 at a frequency of 5495.24 MHz is 3095.215 $\mu W/m^2$, and not 3100 $\mu W/m^2$. The 2155.40 MHz frequency and its associated mean and maximum power density do not appear in Table 2. To better understand the paper, it would be worthwhile the authors identifying the measured frequencies in Table 2 and Table 3 with the rendered services (LTE, UMTS, GSM, etc.). In Table 3, the 5217.62 MHz and 5495.24 MHz frequencies do not correspond to the mobile phone services offered in Spain. The provided mean and maximum values were calculated at between 700 MHz and 6 GHz. Therefore, when maximum values are presented, this range includes the typical downlink service bands, DECT or Wi-Fi of homes. So, this mean value could show exposure related to other services than those under study. Thus, a description of the communication systems installed in locations and homes would be worthwhile. The maximum personal exposure value is 13,000 $\mu W/m^2$, which represents 0.32% of the maximum value set by ICNIRP (4.05 W/m^2) in the 809.365 MHz frequency, which is not as alarming as the authors seem to suggest. There is another lack of uniformity that makes some variables difficult to understand. That is the case of the maximum permitted value for Spain, indicated in the introduction, of 450 $\mu W/cm^2$, but attention must be paid to the difference in units: cm^2, and not m^2. If we express the peak value in the same units, this maximum value becomes 1.3 $\mu W/cm^2$. It also seems that an attempt has been made to significantly and artificially enhance the perceived risk of RF-EMF.

Table 7 shows several implausible values for the data about the studied symptoms. For instance, with headache and its relation to mean/high exposures, the same 2.13–16.68 interval is offered despite the different OR values. Something similar occurs with "dizziness" variable, which presents a significant p-value for an OR of 2.59 for the mean exposure, but a non-significant one with an OR of 0.96 for high exposure. Because of all this, the estimations that result from the binomial regression models from this study are not very accurate and the confidence intervals are too wide. Too many comparisons are made. The authors state having conducted 18 studies; that is, 18 comparisons of hypotheses, and each comparison has a likelihood of obtaining a false-positive result of 0.05; then the likelihood of obtaining a false-positive result in the 18 comparisons will be $0.05 \cdot 18 = 0.9$. In short, a 90% likelihood of one of the statistically significant associations that corresponds to a false-positive: a non association between exposure and the symptom. The same can be stated of the variable "exercise makes me tired". Finally, the extremely wide interval 5.19–891.6 for the number of hours of sleep a day is not explained.

Another relevant aspect is the vague and general calculation of the cancer incidence in the study area, which is most interesting when population density is determined by a speculative calculation based on the hypothesis of the number of homes and the number of people living in each one.

The Discussion does not explain these contradictions. This section also presents major limitations and inaccuracies because the methodology, the obtained results or the reason for certain interpretations are not questioned. The Discussion indicates that this work cannot be compared to other studies because the methodology is different but does not hint at why it was selected or designed. It states that the methodology proposed by CENELEC is unsuitable but does not go on to explain the advantage of the methodology presented in the paper. Thus, the citation Fields and EMF, 2019 is incorrect. We understand that it refers to a published leading article by Alicja Bortkiewicz (2019) and falls in line with the speculations set out in the scientifically inadequate Bioinitiative report, which does not help to provide an explanation in the study's Discussion section, and only implies a new inconsistency.

There are other inconsistent references to the possible importance of exposure indoors with Wi-Fi networks. To this end, López el at. cited the study of Foster and Moulder (2013), but they misinterpreted Foster and Moulder's conclusions. These authors point out that "While several studies report biological effects due to Wi-Fi-type exposures, technical limitations prevent drawing conclusions from them about possible health risks of the technology". Likewise, the paper cites Gajsek et al. (2015) to refer to such networks, and determined that in order to contribute to complete exposure to RF-EMF, Wi-Fi represents 82%. However, the authors do not differentiate this type of radiation, and provide maximum or peak values. So, it is impossible to know what proportion of radiation comes from these services and why it is not considered, as mentioned before.

Another mistake in the citations appears when two are made to Bürgi et al. (2008) and (2010), but only the latter is included in the bibliography. In any case, both studies present models to determine radiation, and not experimental measurements. The text indicates that the obtained results fall in line with what these studies propose, and mentions dependence of direction, which is neither indicated in detail nor commented on. So it would seem that distance to an antenna would not be relevant for symptoms and exposure to radiation, and might evidence that the selection of study areas is not suitable. Unfortunately, this aspect is not also discussed.

On the possible relation between exposure and symptoms, lack of control in the methodology conditions any association type that has not been controlled, as previously mentioned. The text indicates that other studies have also confirmed the existence of a relation between some nonspecific symptoms and exposure to RF-EMF (Breckenkamp et al., 2012; Bürgi et al., 2008; Foster and Moulder, 2013; Röösli et al., 2010a), but certainly does not allow this statement to be concluded or accounted for. Conversely, the works by Abdel-Rassoul et al. (2007) and Hutter et al. (2006), which conclude about possible effects, commit similar biases and methodological limitations to those found in this study.

To finish, the Conclusions section includes reflections and views, rather than true conclusions based on data or results. Details of possible associations with symptoms appear which, in exposures terms, are not proven or standardized. It questions the CENELEC methodology, but neither uses nor assesses it. Conversely, the study is based on its own proposal that is yet to be justified. In short, the conclusions do not match the objectives set out, but include irrelevant references to cancer or 5G. These statements and their possible relation to the emergence of the 5th mobile phone generation have caused much reluctance and unfounded fears in the society.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Abdel-Rassoul, G., El-Fateh, O.A., Salem, M.A., Michael, A., Farahat, F., El-Batanouny, M., Salem, E., 2007. Neurobehavioral effects among inhabitants around mobile phone base stations. In: The 9th International Symposium on Neurobehavioral Methods and Effects in Occupational and Environmental Health, vol. 28, pp. 434–440. https://doi.org/10.1016/j.neuro.2006.07.012. NeuroToxicology.

Ahlbom, A., Feychting, M., Green, A., Kheifets, L., Savitz, D.A., Swerdlow, A.J., ICNIRP (International Commission for Non-Ionizing Radiation Protection) Standing Committee on Epidemiology, 2009. Epidemiologic evidence on mobile phones and tumor risk: a review. Epidemiology 20, 639–652. https://doi.org/10.1097/EDE.0b013e3181b0927d.

Belpomme, D., Hardell, L., Belyaev, I., Burgio, E., Carpenter, D.O., 2018. Thermal and non-thermal health effects of low intensity non-ionizing radiation: an international perspective. Environ. Pollut. 242, 643–658. https://doi.org/10.1016/j.envpol.2018.07.019.

Belyaev, I., Dean, A., Eger, H., Hubmann, G., Jandrisovits, R., Kern, M., Kundi, M., Moshammer, H., Lercher, P., Müller, K., Oberfeld, G., Ohnsorge, P., Pelzmann, P., Scheingraber, C., Thill, R., 2016. EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses. Rev. Environ. Health 31, 363–397. https://doi.org/10.1515/reveh-2016-0011.

Bogers, R.P., van Gils, A., Clahsen, S.C.S., Vercruijsse, W., van Kamp, I., Baliatsas, C., Rosmalen, J.G.M., Bolte, J.F.B., 2018. Individual variation in temporal relationships between exposure to radiofrequency electromagnetic fields and non-specific physical symptoms: a new approach in studying 'electrosensitivity. Environ. Int. 121, 297–307. https://doi.org/10.1016/j.envint.2018.08.064.

Bolte, J.F.B., 2016. Lessons learnt on biases and uncertainties in personal exposure measurement surveys of radiofrequency electromagnetic fields with exposimeters. Environ. Int. https://doi.org/10.1016/j.envint.2016.06.023.

Bolte, J.F.B., van der Zande, G., Kamer, J., 2011. Calibration and uncertainties in personal exposure measurements of radiofrequency electromagnetic fields. Bioelectromagnetics. https://doi.org/10.1002/bem.20677.

Bolte, J.F.B., Clahsen, S., Vercruijsse, W., Houtveen, J.H., Schipper, C.M.A., van Kamp, I., Bogers, R., 2019. Ecological momentary assessment study of exposure to radiofrequency electromagnetic fields and non-specific physical symptoms with self-declared electrosensitives. Environ. Int. 131, 104948. https://doi.org/10.1016/j.envint.2019.104948.

Bortkiewicz, A., 2019. Health effects of radiofrequency electromagnetic fields (RF EMF). Ind. Health 57, 403–405. https://doi.org/10.2486/indhealth.57_400.

Breckenkamp, J., Blettner, M., Schüz, J., Bornkessel, C., Schmiedel, S., Schlehofer, B., Berg-Beckhoff, G., 2012. Residential characteristics and radiofrequency electromagnetic field exposures from bedroom measurements in Germany. Radiat. Environ. Biophys. 51, 85–92. https://doi.org/10.1007/s00411-011-0389-2.

Bürgi, A., Theis, G., Siegenthaler, A., Röösli, M., 2008. Exposure modeling of high-frequency electromagnetic fields. J. Expo. Sci. Environ. Epidemiol. 18, 183–191. https://doi.org/10.1038/sj.jes.7500575.

Bürgi, A., Frei, P., Theis, G., Mohler, E., Braun-Fahrländer, C., Fröhlich, J., Neubauer, G., Egger, M., Röösli, M., 2010. A model for radiofrequency electromagnetic field predictions at outdoor and indoor locations in the context of epidemiological research. Bioelectromagnetics 31, 226–236. https://doi.org/10.1002/bem.20552.

Ministerio de Sanidad, Consumo y Bienestar Social, 2020. Ministerio de Sanidad, Consumo y Bienestar Social - Portal Estadístico del SNS - Encuesta Europea de Salud en España 2020 [WWW Document]. URL, 9.30.21. https://www.mscbs.gob.es/estadEstudios/estadisticas/EncuestaEuropea/Enc_Eur_Salud_en_Esp_2020.htm.

Domotor, Z., Nordin, S., Witthoeft, M., Koteles, F., 2019. Modern health worries: a systematic review. J. Psychosom. Res. 124, 109781. https://doi.org/10.1016/j.jpsychores.2019.109781.

Foster, K.R., Moulder, J.E., 2013. Wi-fi and health. Health Phys. 105, 561–575. https://doi.org/10.1097/HP.0b013e31829b49bb.

Gajsek, P., Ravazzani, P., Wiart, J., Grellier, J., Samaras, T., Thuroczy, G., 2015. Electromagnetic field exposure assessment in Europe radiofrequency fields (10 MHz-6 GHz). J. Expo. Sci. Environ. Epidemiol. 25, 37–44. https://doi.org/10.1038/jes.2013.40.

Gonzalez-Rubio, J., Najera, A., Arribas, E., 2016. Comprehensive personal RF-EMF exposure map and its potential use in epidemiological studies. Environ. Res. 149, 105–112. https://doi.org/10.1016/j.envres.2016.05.010.

Halsey, L.G., Curran-Everett, D., Vowler, S.L., Drummond, G.B., 2015. The fickle P value generates irreproducible results. Nat. Methods 12, 179–185. https://doi.org/10.1038/nmeth.3288.

Havas, M., 2017. When theory and observation collide: can non-ionizing radiation cause cancer? Environ. Pollut. 221, 501–505. https://doi.org/10.1016/j.envpol.2016.10.018.

Health Effects Institute, 2010. Traffic-Related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects [WWW Document]. URL. Health Effects Institute, 9.30.21. https://www.healtheffects.org/publication/traffic-related-air-pollution-critical-review-literature-emissions-exposure-and-health.

Hutter, H.-P., Moshammer, H., Wallner, P., Kundi, M., 2006. Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. Occup. Environ. Med. 63, 307–313. https://doi.org/10.1136/oem.2005.020784.

IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, 2013. Non-ionizing radiation, Part 2: radiofrequency electromagnetic fields. IARC Monogr. Eval. Carcinog. Risks Hum. 102, 1–460.

International Commission on Non-Ionizing Radiation Protection (ICNIRP), 2020. Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz). Health Phys. 118, 483–524. https://doi.org/10.1097/HP.0000000000001210.

INTERPHONE Study Group, 2010. Brain tumour risk in relation to mobile telephone use: results of the INTERPHONE international case-control study. Int. J. Epidemiol. 39, 675–694. https://doi.org/10.1093/ije/dyq079.

Jalilian, H., Eeftens, M., Ziaei, M., Röösli, M., 2019. Public exposure to radiofrequency electromagnetic fields in everyday microenvironments: an updated systematic review for Europe. Environ. Res. 176, 108517. https://doi.org/10.1016/j.envres.2019.05.048.

Jalilian, H., Soltanzadeh, A., de Vocht, F., 2022. Response to: "What is the radiation before 5G? A correlation study between measurements in situ and in real time and epidemiological indicators in Vallecas, Madrid. Environ. Res. 208, 112306. https://doi.org/10.1016/j.envres.2021.112306.

López, I., Félix, N., Rivera, M., Alonso, A., Maestú, C., 2021. What is the radiation before 5G?: a correlation study between measurements in situ and in real time and epidemiological indicators in Vallecas. Environ. Res. 110734 https://doi.org/10.1016/j.envres.2021.110734. Madrid.

Najera, A., Ramirez-Vazquez, R., Arribas, E., Gonzalez-Rubio, J., 2020. Comparison of statistic methods for censored personal exposure to RF-EMF data. Environ. Monit. Assess. 192, 77. https://doi.org/10.1007/s10661-019-8021-z.

Navarro, E.A., Segura, J., Portolés, M., Gómez-Perretta de Mateo, C., 2003. The microwave syndrome: a preliminary study in Spain. Electromagn. Biol. Med. 22, 161–169. https://doi.org/10.1081/JBC-120024625.

Ramirez-Vazquez, R., Gonzalez-Rubio, J., Arribas, E., Najera, A., 2019a. Personal RF-EMF exposure from mobile phone base stations during temporary events. Environ. Res. 175, 266–273. https://doi.org/10.1016/j.envres.2019.05.033.

Ramirez-Vazquez, R., Gonzalez-Rubio, J., Arribas, E., Najera, A., 2019b. Characterisation of personal exposure to environmental radiofrequency electromagnetic fields in Albacete (Spain) and assessment of risk perception. Environ. Res. 172, 109–116. https://doi.org/10.1016/j.envres.2019.02.015.

Ramirez-Vazquez, R., Escobar, I., Vargas, F., Arribas, E., 2022. Comment on: what is the radiation before 5G? A correlation study between measurements in situ and in real time and epidemiological indicators in Vallecas. In: López, I., Félix, N., Rivera, M., Alonso, A., Maestú, C. (Eds.), Environ. Res. 207, 112138. https://doi.org/10.1016/j.envres.2021.112138. Madrid.

Renke, A., Chavan, M., 2014. A review on RF field exposure from cellular base stations. Int. J. Comput. Appl. 104, 9–16.

Röösli, M., 2008. Radiofrequency electromagnetic field exposure and non-specific symptoms of ill health: a systematic review. Environ. Res. 107, 277–287. https://doi.org/10.1016/j.envres.2008.02.003.

Röösli, M., Frei, P., Mohler, E., Braun-Fahrländer, C., Bürgi, A., Fröhlich, J., Neubauer, G., Theis, G., Egger, M., 2008. Statistical analysis of personal radiofrequency electromagnetic field measurements with nondetects. Bioelectromagnetics 29, 471–478. https://doi.org/10.1002/bem.20417.

Röösli, M., Frei, P., Bolte, J., Neubauer, G., Cardis, E., Feychting, M., Gajsek, P., Heinrich, S., Joseph, W., Mann, S., Martens, L., Mohler, E., Parslow, R.C., Poulsen, A., Radon, K., Schüz, J., Thuroczy, G., Viel, J.-F., Vrijheid, M., 2010a. Conduct of a personal radiofrequency electromagnetic field measurement study: proposed study protocol. Environ. Health 9, 23. https://doi.org/10.1186/1476-069X-9-23.

Röösli, M., Frei, P., Mohler, E., Hug, K., 2010b. Systematic review on the health effects of exposure to radiofrequency electromagnetic fields from mobile phone base stations. Bull. World Health Organ. 88, 887–896F. https://doi.org/10.2471/BLT.09.071852.

Sagar, S., Dongus, S., Schoeni, A., Roser, K., Eeftens, M., Struchen, B., Foerster, M., Meier, N., Adem, S., Röösli, M., 2018. Radiofrequency electromagnetic field exposure in everyday microenvironments in Europe: a systematic literature review. J. Expo. Sci. Environ. Epidemiol. 28, 147–160. https://doi.org/10.1038/jes.2017.13.

Sánchez-Montero, R., Alén-Cordero, C., López-Espí, P.L., Rigelsford, J.M., Aguilera-Benavente, F., Alpuente-Hermosilla, J., 2017. Long term variations measurement of electromagnetic field exposures in Alcalá de Henares (Spain). Sci. Total Environ. 598, 657–668. https://doi.org/10.1016/j.scitotenv.2017.03.131.

Szemerszky, R., Koteles, F., 2021. Associations between modern health worries, idiopathic environmental intolerance attributed to electromagnetic fields, and paranoia. Int. J. Behav. Med. 28, S57. S57.

Szemerszky, R., Domotor, Z., Witthoeft, M., Koteles, F., 2021. Modern health worries and idiopathic environmental intolerance attributed to electromagnetic fields are associated with paranoid ideation. J. Psychosom. Res. 146, 110501. https://doi.org/10.1016/j.jpsychores.2021.110501.

Wasserstein, R.L., Lazar, N.A., 2016. The ASA statement on p-values: context, process, and purpose. Am. Statistician 70, 129–133. https://doi.org/10.1080/00031305.2016.1154108.

Wiedemann, P., Schütz, H., 2011. Children's health and RF EMF exposure. Views from a risk assessment and risk communication perspective. Wien Med. Wochenschr. 161, 226–232. https://doi.org/10.1007/s10354-011-0881-y.

Witthöft, M., Rubin, G.J., 2013. Are media warnings about the adverse health effects of modern life self-fulfilling? An experimental study on idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF). J. Psychosom. Res. 74, 206–212. https://doi.org/10.1016/j.jpsychores.2012.12.002.

Witthöft, M., Freitag, I., Nußbaum, C., Bräscher, A.-K., Jasper, F., Bailer, J., Rubin, G.J., 2018. On the origin of worries about modern health hazards: experimental evidence for a conjoint influence of media reports and personality traits. Psychol. Health 33, 361–380. https://doi.org/10.1080/08870446.2017.1357814.

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