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Letter to the Editor, Environment International 'Available evidence shows adverse symptoms from acute non-thermal RF-EMF exposure'. Comment on: Bosch-Capblanch X et al., The effects of radiofrequency electromagnetic fields exposure on human self-reported symptoms: A systematic review of human experimental studies, Envir Int. vol. 187, May 2024, 108612☆

This review (Bosch-Capblanch et al., 2024) states in its Interpretation that "available evidence" suggests that acute non-thermal RF-EMF "does not cause symptoms". However, this unqualified broad claim, while arguably valid if it had been limited to the 41 mainly negative studies reviewed, contradicts my experience over the last 16 years as a trustee of the charity Electrosensitivity UK, which since 2003 has sought to help people sensitised to RF-EMF. The review's Interpretation is invalidated in three ways. Firstly, its parameters excluded much available evidence showing positive effects; secondly, the use of averaging hides individual cases which provide positive evidence; and, thirdly, its negative claim is contradicted by positive proof from other sources, including practical, judicial, legal and underwriting.

Firstly, the review's restricted parameters exclude much available evidence showing positive effects, especially because of its limited definitions or unproven assumptions. The review concerned "mobile telephony" yet excluded studies with "more than 10 % of the total signal energy" outside 100 kHz–300 GHz. However, mobile devices expose "significant parts of the human brain and head to extremely low frequency (ELF) magnetic fields (MF)", with some MF levels above Bioinitiative and EUROPAEM guidelines (Misek et al., 2023). Further, RF signals from mobile devices have ELF modulations, where the "biological effects attributed to RF EMFs", such as oxidative stress and DNA damage, can be regarded as "actually due to their ELF components" (Panagopoulos et al., 2021). By not evaluating all available evidence on the ELF and MF effects involved this review also omitted in its discussion a comparison with established sensitivity to geomagnetic disturbances across significant populations (Sarimov et al., 2023), including, for instance, a correlation of geomagnetic activity and migraines (Kuritzky et al., 1987). These and similar examples show the wide range of human sensitivity to EMF exposures (Martel et al., 2023), its consistency with the Microwave Syndrome or Electro-Hypersensitivity (Carpenter, 2015), and its physiological basis in part by reception through magnetite and the radical pair mechanism acting on cryptochromes (Sherrard et al., 2018).

The review also restricted "the outcomes of interest" to "symptoms" assumed to be "typically self-reported". It thus limited "perception" to subjective feelings and not physiological reactions. It did not reference the two most wide-ranging reviews of acute non-thermal RF-EMF symptoms (ICNIRP, 2002; ICBE-EMF, 2022), which both found that some people, but not all, are particularly vulnerable to such symptoms. It also did not reference the Scientific Consensus International Report (Belpomme et al, 2021) by 32 experts which argued that hypersensitivity to EMFs is a "distinct neuropathological disorder" and that "there is no proof that EHS symptoms or EHS itself are caused by psychosomatic or nocebo effects", in direct contradiction to this review's Interpretation of "available evidence". Other studies have shown brain abnormalities in people sensitive to acute RF-EMF exposures (Heuser and Heuser, 2017), while studies on healthy subjects found perception of RF-EMF mobile phone signals with EMF effects in the alpha band (van der Meer et al., 2023) and in the theta band (Wallace et al., 2023). It did not reference potential therapies reducing anxiety caused by RF-EMF exposure, such as drugs working through the endocannabinoid system (Xue et al., 2024).

Secondly, the use of averaging in each study reviewed in the meta-analysis hides individual cases of sensitivity which provide positive evidence. Justification for averaging in turn depends on assumptions about the need to screen subjects before provocation tests, about the characterisation of participants as nonsensitive, sensitive or hypersensitive, and about the consistency of reactions. Some provocation tests showing 100 % positive accuracy in identifying EMF exposures, based on screening participants for whether they were sensitive or hypersensitive, were excluded from this review. For instance, in one study 100 participants reported EMF sensitivity but only 25 % could repeatedly identify EMF and sham challenges accurately (Rea et al, 1991). Further testing of this 25 % showed 16 % of the original 100 participants had autonomic nervous system changes and, when rechallenged at the frequencies to which they were most sensitive, were 100 % accurate in both positive and sham exposures. In contrast, 100 % of controls could not identify challenges accurately. If the participants had not been screened for their sensitivity prior to testing and if the results had been averaged, the study might not have shown 100 % positive results. Similarly, a study which showed 100 % accuracy for subconscious neurological biomarkers first screened the subject for the characteristics of the subject's particular sensitivity and then applied the relevant frequency and on–off transitions to which the participant was subconsciously sensitive to achieve positive results (McCarty et al, 2011). Where provocation tests, such as those selected by this review, have failed to screen participants prior to testing and then averaged the results, even when individual participants scored 100 % accuracy, the positive outcomes have been lost in averaging, especially when a high positive percentage is required for significance. Indeed, some participants most sensitive to RF-EMF were forced by adverse symptoms to withdraw early from some of the studies included in this review, despite achieving 100 % accuracy, and their positive scores were then excluded from the results.

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In contrast to the selection parameters employed by this review, two different types of individual provocation studies have shown positive results. A series of eight environmental provocation studies conducted from 2021 onwards recorded each individual's symptoms separately (Hardell and Nilsson, 2024), confirming RF-EMF as a cause of symptoms in each case. The review excluded these, presumably because they were published after 2022. Likewise, three ecological momentary assessments, where a wide range of exposures and a variety of responses by individual participants were recorded separately for 5–21 days, found single cases supporting the association of acute EMF exposure for both conscious and subconscious symptoms (Bogers et al., 2018; Bolte et al., 2019; Dömötör et al., 2022). These all contradicted this review's Interpretation and confirmed that acute non-thermal RF-EMF does cause symptoms, although not in all people all the time, and with inter-individual differences.

Averaging is often used with another invalidated assumption, that of consistency, as seen, for instance, in a linear dose–response relationship of symptoms to the intensity of the exposure. Although this can occur, there is no proof that it always happens (Buchachenko, 2016) and inconsistent outcomes of electrical experiments have long been known (Desaguliers, 1742). There are windows of effects based on a variety of transduction mechanisms (Blackman et al., 1989). Delayed symptoms, occasionally reported after acute RF-EMF exposure, have been recorded in provocation tests (Havas and Marrongelle, 2021). This matches evidence from other human and animal studies showing inconsistency in EMF reactions in a wide range of different organisms. For instance, a recent review (Zhen et al., 2024) showed changes from EMF exposure in the regulation of iron metabolism, itself associated with neurological and demyelinating effects and GSMT1/GSTT1 null polymorphisms, all found in people sensitive to EMFs where these haplotype variants are up to nearly 10 times more common (De Luca et al. 2014). Similar EMF exposures produced diverse biological effects, ranging from an increase to a decrease or no change. These effects are thus "varied and unstable due to the random effects of magneto-biology", leading to the conclusion that "the effects of EMF on the same type of organism may not be consistent, which makes it difficult to confirm and evaluate the true effects and mechanisms", despite their observable occurrence. Likewise, it has long been known that provocation tests using very similar electrical exposures can give different results, with or without positive symptoms (Feldman et al., 1985), as also with genotoxic outcomes (Jagetia, 2022), and even at a cellular level, where similar frequency, duration, intensity or waveform do not always orchestrate a linear or dose–effect correlation with the biological response (López de Mingo et al., 2024). Such established inconsistencies render impossible any definitive conclusion from the 41 selected provocation tests, in addition to the problems of averaging their results and not screening subjects for EMF sensitivity prior to testing.

Thirdly, the review's claim, which it admitted was based on evidence of a "low level of certainty", contradicts the growing range of positive proof from other sources. In judicial cases higher levels of certainty can be achieved from the available evidence through rigorous analysis and investigation. Thus, since the year 2001, courts across the world have recognised that non-thermal RF-EMF can cause acute adverse symptoms and have required the removal of mobile phones, mobile-phone masts, Wi-Fi and smart meters to protect people and comply with equality and disability legislation. In addition, some courts have imposed compensation or fines for lack of compliance in ensuring the health and safety of everyone from EMF exposures. The classification of RF-EMF as a 2B possible carcinogen (IARC, 2011; IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, 2013) has been corroborated by studies confirming its carcinogenicity (NTP, 2018a; NTP, 2018b) and by people hypersensitive to RF-EMF who report acute RF-EMF conscious symptoms related to the chronic carcinogenic tumour sites. Available evidence showing acute non-thermal RF-EMF symptoms in individual ecological assessments indicates a No Observable Adverse Effect Level (NOAEL) of about 0.05 V/m (Bevington, 2024), with the RF-EMF safety limit set lower by a factor of at least ten times. Moreover, since the 1990s underwriters have either classified EMF as high risk, like other carcinogens such as asbestos, or refused to insure EMF.

In conclusion, the claim that "available evidence" suggests that acute non-thermal RF-EMF "does not cause symptoms" is not substantiated by all the evidence available, including evidence from 1932 onwards when the condition of Radio Wave Sickness was first described, evidence from individuals and screened tests without averaging, and evidence from practical considerations, such as the estimated 0.65 % of the population with restricted access to work because of acute RF-EMF symptoms (Bevington, 2019). The World Health Organization (WHO), which funded this review, in 2004 proposed its unproven hypothesis confounding neuropathological effects with the nocebo response (WHO, 2005), despite the latter being inapplicable to unaware adults and children who can both experience acute RF-EMF symptoms without prior psychological conditioning. A review of acute RF-EMF self-reported symptoms from human experimental studies should use and be in agreement with all "available evidence" (Hardell, 2017), without unwarranted assumptions and averaging, in order to avoid disconnect with other evidence, including scientific, about established non-thermal symptoms.

CRediT authorship contribution statement

Michael Bevington: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

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.

Data availability

No data was used for the research described in the article.

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