

Health and Environmental Impacts of RF Radiation (2019–2026)

Note: Links are embedded in citations. Descriptions emphasize main health or environmental impacts and study interpretation.

In vitro / cellular, oxidative stress, and DNA damage

Linked citation	Health or environmental impact
Meyer et al., 2024	WHO-supported systematic review of experimental in vitro and in vivo evidence on oxidative-stress biomarkers. The review reported mixed evidence overall, but recurring signals of altered ROS pathways, antioxidant depletion, oxidative injury markers, and stress-response biology under some exposure conditions.
Joushomme et al., 2023	Human skin-cell study of 5G-modulated 3.5 GHz exposure. The authors reported no conclusive molecular or genotoxic effects under the tested conditions, underscoring that effects may depend on exposure parameters, cell type, and endpoint selection.
Haidar et al., 2025	In vitro 5G-modulated 3.5 GHz study examining oxidative stress and DNA repair in skin cells. No significant oxidative stress or impaired DNA repair was observed under the tested protocol.
Taha et al., 2025	Human spermatozoa exposed to RF fields showed altered motility and apoptotic-pathway changes. This study is relevant to reproductive biology because sperm are especially sensitive to oxidative and mitochondrial stress.
Kim et al., 2026	Experimental study reporting that 5G RF-EMF exposure modulated UVA-induced genotoxic stress responses. The findings suggest RF exposure may interact with other environmental stressors rather than acting only as an isolated exposure.

In vivo / animal and experimental biology

Linked citation	Health or environmental impact
Mevisen et al., 2025	Systematic review of laboratory animal cancer studies reporting evidence of carcinogenic associations and DNA damage in some RF-exposed animal studies, while emphasizing variability in study quality, exposure systems, and tumor endpoints.
Cordelli et al., 2024	Systematic review of male fertility evidence in non-human mammals and human sperm. The review found uncertain but possible effects on sperm quality and testicular oxidative-stress pathways, while concluding that fecundity effects in rodents were not clearly established.
Pacchierotti et al., 2021	Systematic review of experimental evidence on RF exposure, male fertility, and pregnancy outcomes. The paper is useful for framing reproductive and developmental endpoints in animal evidence.

Clinical and human experimental evidence

Linked citation	Health or environmental impact
Pophof et al., 2024	Systematic review and meta-analysis of short-term RF exposure and cognitive performance in human experimental studies. The review

	found no consistent evidence that acute RF exposure impairs cognitive performance.
Benke et al., 2024	Systematic review and meta-analysis of observational studies on long-term RF exposure and cognition. The review did not identify clear long-term cognitive impairment, but exposure misclassification remains a central limitation.
Sauter et al., 2025/2026	Randomized sham-controlled study in healthy elderly participants. The study reported no measurable adverse cognitive effects from short-term RF-EMF exposure under the tested conditions.

Epidemiology / population studies

Linked citation	Health or environmental impact
Feychting et al., 2024 — COSMOS	Large prospective cohort study reporting no increased incidence of major brain tumours among long-term mobile-phone users. Increased risk evident in those exposed at younger ages, but not analyzed as such!
Karipidis et al., 2024	WHO-commissioned systematic review concluding that available epidemiologic evidence does not demonstrate increased risk for several major tumour types from mobile-phone RF exposure. The review acknowledges limitations in cumulative exposure assessment.
Karipidis et al., 2025	WHO-related review of less-researched neoplasms, including thyroid and other cancers. Useful for documenting evidence gaps beyond brain tumours.
Gulati et al., 2024	Study of biomarkers in residents near telecommunications base stations reporting increased chromosomal aberrations among higher-exposure participants. Study of residents chronically exposed to GSM and LTE base-station radiation. Blood samples were evaluated for oxidative stress biomarkers, DNA damage, micronuclei, chromosomal aberrations, and cancer-related genetic markers. Chromosomal aberration significantly increased in the higher-exposure group and correlated with LTE/GSM exposure intensity and proximity to antennas. Authors concluded the findings were consistent with chronic RF-EMF-associated genomic instability.
Mate et al., 2026	Occupational RF-EMF epidemiology study reporting no evidence of association with glioma risk for studied groups and times.

Children: developmental, psychological, and physiological impacts

Linked citation	Health or environmental impact
Davis et al., 2023	Review focused on wireless technologies and children, emphasizing that children have longer lifetime cumulative exposure, developing tissues, and distinct vulnerability considerations. The paper discusses reproductive, neurological, developmental, and physiological concerns not adequately addressed by thermal-only standards calls for precautionary policies.
Birks et al., 2020	International epidemiologic study of prenatal and early-life mobile-phone exposure and child neurodevelopment. It reported possible

	behavioural and emotional associations, while also noting uncertainty and the need for stronger exposure assessment.
Madigan et al., 2020	Longitudinal pediatric study linking higher screen exposure with poorer developmental screening outcomes. Although not solely an RF exposure study, it is relevant because wireless devices combine RF exposure with digital behavioural and psychological exposures.
WHO RF-EMF review program	WHO review program highlights continuing uncertainty regarding chronic RF exposure, including developmental and neurological outcomes in populations with early-life exposure.

Birds, bats, bees, insects, wildlife, flora, and fauna

Linked citation	Health or environmental impact
Levitt, Lai, Manville & Scarato, 2025	Frontiers in Public Health ecological review addressing RF-EMF effects on flora and fauna, including birds, bats, insects, pollinators, mammals, plants, trees, and aquatic organisms. The review emphasizes that RF-EMF may affect wildlife at ecosystem levels by disrupting geomagnetic orientation, migration, navigation, nesting, pollination, oxidative stress pathways, circadian regulation, reproduction, and habitat behaviour.
Levitt, Lai & Manville, 2022 — Part I	Reviewed mechanisms by which low-level EMF may affect wildlife and plants, including oxidative stress, calcium signalling, circadian disruption, immune effects, and reproductive biology.
Levitt, Lai & Manville, 2022 — Part II	Summarized evidence suggesting effects on avian magnetoreception, migratory orientation, nesting behaviour, pollinator navigation, and biologically mediated environmental sensing.
Levitt, Lai & Manville, 2022 — Part III	Argued that current RF regulatory frameworks are inadequate for ecosystem-level exposure because they focus almost exclusively on human thermal thresholds rather than chronic ecological effects.
Pophof et al., 2023	Review of biological effects of RF-EMF above 100 MHz on flora and fauna. The paper covers behavioural, reproductive, oxidative-stress, and physiological endpoints across plants, insects, birds, and wildlife, while noting methodological variability.
Thill et al., 2023	Honeybee study reporting altered behaviour, oxidative-stress markers, and colony-level physiology following RF exposure. Relevant to pollinator vulnerability in RF-dense environments.

Additional Ecological and Mechanistic Studies

Citation	Study Description
Levitt, Lai, Manville & Scarato, 2025	Expanded Frontiers in Public Health review examining biological and ecological effects of anthropogenic radiofrequency radiation on flora and fauna, including birds, bats, pollinators, insects, mammals, trees, and aquatic organisms. The review emphasized evidence suggesting RF-EMF may affect wildlife at ecosystem levels through disruption of geomagnetic orientation, migration, navigation systems, reproductive biology, oxidative stress pathways, circadian regulation, and habitat behavior.

Multisource RF exposure in the general environment

Linked citation	Health or environmental impact
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Brzozek et al., 2024	Review of anthropogenic RF fields emphasizing that real-world exposures arise from multiple simultaneous sources, including antennas, Wi-Fi, mobile devices, smart infrastructure, and environmental background fields.
Gulati et al., 2024	Base-station study relevant to involuntary environmental exposure. Reported increased chromosomal aberrations among residents exposed to higher RF levels near telecommunications antennas.
Base-station biomarker studies, 2024	Molecular investigations report oxidative imbalance, altered antioxidant enzyme activity, micronucleus formation, genomic instability, and ROS-related biomarkers among populations living near RF-emitting antennas.
Jeladze V et al., 2025	International Journal of Radiation Biology publication addressing RF-induced oxidative stress, genomic instability, altered cellular signalling, and cumulative multisource exposure. It highlights the need for improved biologically based exposure assessment.

Oxidative stress, ROS, and cancer-relevant mechanisms NOT RF specific

Linked citation	Health or environmental impact
ROS signalling and cancer, 2023	Review explaining how oxidative stress can contribute to DNA strand breaks, genomic instability, altered methylation, cellular signalling disruption, and cancer progression.
Oxidative stress and cancer review, 2025	Detailed review describing how ROS may induce chromosomal instability, tumour microenvironment signalling, and oncogenic transformation.
Environmental ROS and cancer	Foundational mechanistic review outlining how environmental ROS sources may promote carcinogenesis through oxidative DNA damage, chromosomal aberrations, and epigenetic alteration.