Environmental Petition
Date: 27 June 2017

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I hereby submit this petition to the Auditor General of Canada under section 22 of the Auditor General Act.

Signature of the petitioner: via email to - petitions@oag-bvg.gc.ca

Title of the Petition: **Health Canada's Safety Code 6 for Specific Absorption Rate (SAR) actual threshold of excessive heating and other adverse effects, for exposure of the eye, and of early human developmental stages e.g. newborn babies, to radiofrequency/microwave wireless radiation e.g. from baby monitors, cell phones and 5th Generation (5G) technologies.**

I request a response from Health Canada.

BACKGROUND:

Health Canada maintains it uses evidence-based science to set threshold limits in Safety Code 6[1], its guidelines for safe exposure of humans to radiofrequency/microwave (RF/MW) radiation in the 3 kHz to 300 GHz range. This includes the range of 100 MHZ to 300 GHz used for many, if not all wireless telecommunications purposes such as for baby monitors, cell phones, smart meters, tablets, Wi-Fi devices and 2, 3, 4 and 5 G technologies as well as some medical equipment.

On October 6, 2016 the Honourable Jane Philpott signed a response letter[2] saying that:
"Health Canada's recommended human exposure limits are outlined in a document entitled "Safety Code 6 Limits of human exposure to radiofrequency electromagnetic fields in the frequency range 3 kHz to 300 GHz" (Safety Code 6). While the human exposure limits in Safety Code 6 were initially developed for, and applied by, federally-regulated employers, some of the exposure limits in the Code have since been referenced by other federal departments and non-federal jurisdictions. In particular, Innovation, Science and Economic Development Canada (ISEDC) requires compliance with Safety Code 6 as part of its technical standards for radio apparatus."

Later Minister Philpott's letter states:
"Safety Code 6 human exposure limits, established by Health Canada, are designed to provide protection for all age groups, including infants and children, on a continuous basis (24 hours a day/seven days a week). This means that if someone,

1 Safety Code 6 (2015)-Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz. Safety Code 6. http://www.Health Canada-sc.gc.ca/ewh-semt/pubs/radiation/radio_guide-lignes_direct/index-eng.php
2 Response to the 13th report of the House of Commons Standing Committee on Health (HESA). http://www.ourcommons.ca/DocumentViewer/en/42-1/HESA/report-2/response-8512-421-78

including a small child, were to be exposed to RF energy from multiple sources for 24 hours a day, 365 days a year, within the Safety Code 6 limits, there would be no adverse health effects.

On June 8 and June 21, 2017, the Consumer and Clinical Radiation Protection Bureau (CCRPB) of Health Canada, responding to queries3 made May 24 and June 9, 2017, respectively, stated:

Extract from June 8, 2017: *"the recommended peak SAR limit of 1.6 W/kg is not the threshold for the occurrence of adverse health effects. In fact, as a precautionary measure, the peak SAR limit in Safety Code 6 was set more than 50 times below the level at which excessive tissue heating could occur in the most sensitive tissue (the eye). This means that the peak SAR limits in Safety Code 6 would need to be exceeded by more than 50 times before one would see any thermally related adverse health effects."*

Extract from June 21, 2017: "*The peak spatially-averaged specific absorption rate (pk-SAR) limit in Safety Code 6 (SC6) applies to the head, neck and trunk. This limit is 1.6 W/kg, as averaged over any 1 g and for any 6 minute exposure period (reference period – please see Fact Sheet - What is Safety Code 6? for the explanation of the reference period). This limit is based upon avoiding cataract formation in the eye, which has been conservatively estimated to occur at sustained pk-SAR levels of 100-150 W/kg to the eye (as reviewed in Elder, 2003 and IEEE C95.1 (2005)).*[4]

It is important to note that the recommended pk-SAR limit of 1.6 W/kg is not the threshold for the occurrence of adverse health effects. As mentioned in our previous email, the pk-SAR limit was set more than 50 times ***below*** *the level where excessive tissue heating could occur in the eye. This means that the pk-SAR limits in Safety Code 6 (SC6) would need to be exceeded by more than 50 times in the eye before the occurrence of any thermally-related adverse health effects would be possible. Exposures to the body (skin and underlying tissue) at the SC6 pk-SAR limit of 1.6 W/kg would result in a localized temperature increase of less than a few tenths of 1 degree Celsius (Anderson et al., 2010; Moore et al., 2017)."* [5]

To summarize: According to the CCRPB statement the actual threshold, in the frequency range of 100 MHz to 300 GHz, the only established effect on the eye recognized by Health Canada in Safety Code 6 is heating (thermal); and that excessive heating i.e. adverse effects, would not occur until levels were above 80 W/kg.[6]

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3 Relating to the 100 MHz to 300 GHz radiofrequency/microwave range.

4 - Elder JA. Ocular effects of radiofrequency energy. Bioelectromagnetics Suppl. 6:S148-161 (2003).

- Institute of Electrical and Electronics Engineers. Safety Levels with Respect to Human Exposure to Radiofrequency Electromagnetic Fields C95.1, 3 kHz to 300 GHz. New York, USA (2005).

5 - Anderson V, Croft R, McIntosh RL. SAR versus S(inc): What is the appropriate RF exposure metric in the range 1-10 GHz? Part I: Using planar body models. Bioelectromagnetics. 2010 Sep;31(6):454-66.

- Moore SM, McIntosh RL, Iskra S, Lajevardipour A, Wood AW. Effect of adverse environmental conditions and protective clothing on temperature rise in a human body exposed to radiofrequency electromagnetic fields. Bioelectromagnetics. 2017 Mar 24. doi: 10.1002/bem.22048. [E-pub ahead of print]

6 - 1.6 W/kg x 50 (safety margin)

If this is the case, then according to the CCRPB's statements it appears that Health Canada's position is that if the eye is not adversely affected, then even a newborn baby would be unaffected by RF/MW radiation7 at below 80 W/kg. This petition presents information questioning the underlying assumption that the eye is not adversely affected below the Safety Code 6 (2015) safety margin threshold.

The Royal Society of Canada expert panel, when it was contracted by Health Canada to review certain questions regarding proposed revisions to Safety Code 6 (2009), was provided by Health Canada with a draft of a document titled Safety Code 6 (2013) Rationale. An updated version of the rationale, Safety Code 6 (2015) Rationale is available to the public from Health Canada upon request. This petition also presents information indicating that Health Canada has stated in its Safety Code 6 (2015) Rationale that the 50x safety margin for the Safety Code (2015) power density (W/m^2) does not apply in all cases; specifically not to newborn babies with a low Body Mass Index (BMI).

A. The Eye

The level of SAR for the eye has shifted from being most protective in the 1991 version of Safety Code 6 (0.2 W/kg) to the least protective level in the current 2015 version (1.6 W/kg)(Table 1).

Table 1. Specific Absorption Rates (SARs) as set out in each Safety Code 6 version since first published in 1979[8]. The SAR level 50x safety margins are also indicated*.

Health Canada Safety Code 6	Specific Absorption Rate (SAR) for eye (W/kg)	Specific Absorption Rate SAR for the eye (W/kg) x 50 (safety margin)*
1979 (first version)	No value	No value
1991	0.2	10
1993	0.4	20
1999	0.2 (suggested)	10
2009	0.4 (suggested)	20
2015	1.6	80

* assuming that a 50x safety margin applies in all versions.

There is scientific evidence documented in at least four studies (Addendum 1[9]) published since the Royal Society panel's report[10] and Safety Code 6 (2015) Rationale were made available, that indicate adverse effects at below 80 W/kg. Furthermore, there are at least seven additional studies (Addendum 2) showing adverse effects in the eye below 80 W/kg which the Royal Society panel's report and the Safety Code 6 (2015) Rationale did not include in their evaluations.[11]

7 Relating to the 100 MHz to 300 GHz radiofrequency/microwave range.
8 Source: Health Canada
9 Source: PubMed - US National Library of MedicineNational Institutes of Health
10 https://rsc-src.ca/sites/default/files/pdf/SC6_Report_Formatted_1.pdf
11 http://c4st.org/c4st-reviews-ignored-studies/

These adverse effects in the eye, identified in human and animal studies, include:

- alteration in the cornea and lens
- cell proliferation alterations
- blurring of vision
- retinal development derangement in embryos
- oxidative stress changes
- protein expression changes.

B. Early human developmental stages: the embryo, fetus, premature babies and small children

Health Canada's Safety Code 6 (2015) Rationale, on page 33, states:

"It should be pointed out that the estimation formula in Hirata (2010) is approximate and that the discrepancy of it versus the SAR calculation of the newborn model in Dimbylow et al. (2010; having a BMI12 of 14.8 kg/m2) is an underestimation of 11%. Thus the information in Table A-4 and Figure A-3 should be treated with some caution. However, it can be used to arrive at some qualitative conclusions, the most important of which, is the likelihood that ***any future calculations of WBA-SAR[13] on models of premature newborns will likely produce non-compliance of the power density reference levels to the basic restriction.*** *This cannot be prevented without a further reduction of the power density reference levels at the frequencies of isolated, whole-body resonance. Thus, the power density reference levels in SC6 (2015) provide the full margin of safety (50-fold) for most of the population,* ***but not for all population sub-groups (e.g. low BMI newborns)*** *in all worst-case exposure scenarios. The portion of the population that does not receive the full measure of the intended safety margin (50-fold) is a small one, consisting of low BMI, premature newborns who would be unlikely to be exposed to levels of power density anywhere near the SC6 (2015) reference levels under any conceivable scenario."[14]*

The gestational age for the youngest newborn shown in Safety Code 6 (2015) Rationale in Table 4, is listed as 29 weeks and the corresponding Body Mass Index (BMI) appears to be the data used in further determinations in that document. However, it is not uncommon for premature babies to be born and survive at 22 to 23 weeks with considerably lower BMI values. For example, in 2013 a baby was born in McMaster University Medical Centre, Ontario weighing 330 grams and "could easily have fit in her father's hand."[15] The developing fetus, from conception to birth, naturally, is much smaller in body mass early in development - the embryo being miniscule at conception.

Although the Rationale states that the population sub-group is a "small one", it is estimated that 1 in 12 babies in Canada are born prematurely. In Alberta there are over 4,000 premature babies born per year.[16] This is a subgroup that is physiologically fragile and often undergoes highly intensive medical treatment.

12 Body Mass Index
13 WBA-SAR is Whole Body Averaged- Specific Absorption Rate
14 Bolded portions have been added by me.
15 http://www.cbc.ca/news/canada/hamilton/hospital-s-tiniest-preemie-ever-thrives-and-is-now-at-home-1.2101677
16 Canadian Premature Babies Foundation - http://www.cpbf-fbpc.org/

Further adverse exposures as a neonate may have lifelong ramifications and costs for the individual, family, medical system and society.

QUESTIONS:

1) Would Health Canada confirm that it has identified no other adverse effects except excessive heating at Specific Absorption Rates (SARs) at and below 80 W/kg of exposure, in the 100 MHZ to 300 GHz range, in any human or animal studies?

2) If other adverse effects have been identified, what are they?

3) The Safety Code 6 Specific Absorption Rate (SAR) levels are calculated using extrapolations and assumptions. Can Health Canada say with 100% certainty that these assumptions and extrapolations accurately apply to actual small living children (as opposed to computerized models) for both heating and non-heating effects?

4) What data other than extrapolations are used to determine safe levels for an embryo, fetus and newborn child?

5) What is known about the protective capacity of the pregnant woman for her fetus, for example if she were to stream a movie on a tablet or cell phone directly next to her pregnant belly?

5) Given that Safety Code 6 (2015) Rationale states that a newborn child with a low Body Mass Index could be non-compliant of Safety Code 6 power density (W/m^2) safety margins, what would the safety margin be for a newly conceived child (embryo) and for a (premature) newborn baby 330 grams and 20 cm in length?

6) How has Health Canada evaluated, in its weight-of-evidence approach, the eleven studies presented here showing adverse effects to the eye at less than 80 W/kg and which have not been evaluated in the Royal Society of Canada panel report or in the Safety Code 6 (2015) Rationale?

7) What five most credible peer-reviewed studies on living people or animals would Health Canada name which justify the shift in the easing of Safety Code 6 SAR level for the eye from the 1991 level of 0.2 W/kg to the 2009 suggested level of 0.4 W/kg?

8) What five most credible peer-reviewed studies on living people or animals would Health Canada name which justify the shift in the easing of Safety Code 6 SAR from the 2009 suggested level for the eye of 0.4 W/kg to the 2015 level of 1.6 W/kg?

9) What five of the most credible peer-reviewed studies would Health Canada name as ensuring that the human eye, or people in any stage of development, will not be adversely affected from exposures by the proposed widespread roll-out of 5th Generation (5G) technologies that will require intense infrastructure near homes and schools?

Addendum 1. Studies published since the release of the Royal Society of Canada's expert panel report and Health Canada's Safety Code 6 (2015) Rationale indicating adverse effects below Safety Code 6 (2015) safety margin threshold.

1. Effect: Long-term - adverse effects on visual evoked potentials and oxidant/oxidative status

Hidisoglu, E., Kantar Gok, D., Er, H., Akpinar, D., Uysal, F., Akkoyunlu, G., … Yargicoglu, P. (2016). 2100-MHz electromagnetic fields have different effects on visual evoked potentials and oxidant/antioxidant status depending on exposure duration. *Brain Research*, *1635*, 1–11 doi:10.1016/j.brainres.2016.01.018

ABSTRACT: "The purpose of the present study was to investigate the duration effects of 2100-MHz electromagnetic field (EMF) on visual evoked potentials (VEPs) and to assess lipid peroxidation (LPO), nitric oxide (NO) production and antioxidant status of EMF exposed rats. Rats were randomized to following groups: Sham rats (S1 and S10) and rats exposed to 2100-MHz EMF (E1 and E10) for 2h/day for 1 or 10 weeks, respectively. At the end of experimental periods, VEPs were recorded under anesthesia. Brain thiobarbituric acid reactive substances (TBARS) and 4-hydroxy-2-nonenal (4-HNE) levels were significantly decreased in the E1 whereas increased in the E10 compared with their control groups. While brain catalase (CAT), glutathione peroxidase (GSH-Px) activities and NO and glutathione (GSH) levels were significantly increased in the E1, reduction of superoxide dismutase (SOD) activity was detected in the same group compared with the S1. Conversely, decreased CAT, GSH-Px activities and NO levels were observed in the E10 compared with the S10. Latencies of all VEP components were shortened in the E1 compared with the S1, whereas latencies of all VEP components, except P1, were prolonged in the E10 compared with the S10. There was a positive correlation between all VEP latencies and brain TBARS and 4-HNE values. Consequently, it could be concluded that different effects of EMFs on VEPs depend on exposure duration. In addition, our results indicated that short-term EMF could provide protective effects, while long-term EMF could have an adverse effect on VEPs and oxidant/antioxidant status."

https://www.ncbi.nlm.nih.gov/pubmed/26776477

2. Effects: negative impact on ocular symptoms

Kim, J., Hwang, Y., Kang, S., Kim, M., Kim, T.-S., Kim, J., … Park, S. K. (2016). Association between Exposure to Smartphones and Ocular Health in Adolescents. *Ophthalmic Epidemiology*, *23*(4), 269–276 doi:10.3109/09286586.2015.1136652

ABSTRACT: "PURPOSE: Smartphone use has dramatically increased in recent years. Smartphones may have adverse health effects, particularly on the eyes, because users stare at the screen for a much longer time than they do with ordinary mobile phones. The objective of this study was to elucidate the relationship between smartphone use and ocular symptoms among adolescents.METHODS: Information on smartphone use and ocular symptoms (blurring, redness, visual disturbance, secretion, inflammation, lacrimation and dryness) related to eye fatigue and strain from 715 adolescent subjects from three cities in Korea was obtained using a structured questionnaire. Ocular health was scored using number of ocular symptoms. Odds ratios (ORs), 95% confidence intervals (95% CIs) and p-

values for ocular symptoms were calculated with binomial and multinomial logistic regression models.RESULTS: Higher prevalence rates for ocular symptoms were observed in groups with greater exposure to smartphones ($p < 0.05$). Longer daily smartphone use was associated with a higher likelihood of having multiple ocular symptoms (5-7 symptoms out of 7 symptoms; $p = 0.005$). Excessive/intermittent use (>2 hours daily and ≤2 hours continuously) and excessive/persistent use (>2 hours daily and >2 hours continuously) compared to shorter use (<2 hours daily) were associated with multiple ocular symptoms (OR 2.18, 95% CI 1.09-4.39; OR 2.26, 95% CI 1.11-4.57, respectively). A higher lifetime exposure to smartphones was associated with a higher likelihood of having multiple ocular symptoms (OR 3.05, 95% CI 1.51-6.19; $p = 0.001$).CONCLUSION: Increasing exposure to smartphones can have a negative impact on ocular health in adolescents."

https://www.ncbi.nlm.nih.gov/pubmed/27254040

3. Effects: significant association between health problems and mobile phone use.

Stalin, P., Abraham, S. B., Kanimozhy, K., Prasad, R. V., Singh, Z., & Purty, A. J. (2016). Mobile Phone Usage and its Health Effects Among Adults in a Semi-Urban Area of Southern India. *Journal of Clinical and Diagnostic Research: JCDR, 10*(1), LC14-16 doi:10.7860/JCDR/2016/16576.7074

ABSTRACT: "INTRODUCTION: Worldwide, mobile phone usage has been increased dramatically which could affect the health of the people. India has the second largest number of mobile phone users. However there are only few studies conducted in India to assess its effects on health.AIM: To determine the prevalence and pattern of mobile phone usage and to assess the relationship between certain selected health problems and mobile phone usage among adults.SETTINGS AND DESIGN: Community-based cross-sectional study was conducted in Kottakuppam, a town panchayat in Villupuram district of Coastal Tamil Nadu, Southern India. It is a semi-urban area with a population of about 16,000. Majority of the residents are Muslim by religion and belong to different socio economic status.MATERIALS AND METHODS: The study was approved by the Institutional Ethics Committee. A total of 2121 study participants were interviewed by the pre-final medical students through house-to-house survey using a pretested structured questionnaire. The questionnaire included the variables such as socio demographic profile, mobile phone usage and pattern, selected health problems, perceived benefits and threats and blood pressure. Selected health problems included headache, earache, neck pain, tinnitus, painful fingers, restlessness, morning tiredness, tingling fingers, fatigue, eye symptoms, sleep disturbance and hypertension.STATISTICAL ANALYSIS USED: Only 2054 were included for data analysis using SPSS 17 version. Proportions were calculated. Chi-square test was used to measure the p-value. The p-value < 0.05 was considered as statistically significant.RESULTS: The prevalence of mobile phone usage was 70%. Calling facility (94.2%) was used more than the SMS (67.6%). Health problems like headache, earache, tinnitus, painful fingers and restlessness etc., were found to be positively associated with mobile phone usage. There was negative association between hypertension and mobile phone usage.CONCLUSION: The prevalence of mobile phone usage was high. There was significant association between selected health problems and mobile phone usage. In future, higher studies are required to confirm our findings."

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4740623/

4. Effects: oxidative stress

Tök, L., Nazıroğlu, M., Doğan, S., Kahya, M. C., & Tök, O. (2014). Effects of melatonin on Wi-Fi-induced oxidative stress in lens of rats. *Indian Journal of Ophthalmology*, *62*(1), 12–15 doi:10.4103/0301-4738.126166

ABSTRACT: "INTRODUCTION: Melatonin has been considered a potent antioxidant that detoxifies a variety of reactive oxygen species in many pathophysiological states of eye. The present study was designed to determine the effects of Wi-Fi exposure on the lens oxidant, antioxidant redox systems, as well as the possible protective effects of melatonin on the lens injury induced by electromagnetic radiation (EMR).MATERIALS AND METHODS: Thirty-two rats were used in the current study and they were randomly divided into four equal groups as follows: First and second groups were cage-control and sham-control rats. Rats in third group were exposed to Wi-Fi (2.45 GHz) for duration of 60 min/day for 30 days. As in the third group, the fourth group was treated with melatonin. The one-hour exposure to irradiation in second, third and fourth took place at noon each day.RESULTS: Lipid peroxidation levels in the lens were slightly higher in third (Wi-Fi) group than in cage and sham control groups although their concentrations were significantly ($P < 0.05$) decreased by melatonin supplementation. Glutathione peroxidase (GSH-Px) activity was significantly ($P < 0.05$) lower in Wi-Fi group than in cage and sham control groups although GSH-Px ($P < 0.01$) and reduced glutathione ($P < 0.05$) values were significantly higher in Wi-Fi + melatonin group than in Wi-Fi group.CONCLUSIONS: There are poor oxidative toxic effects of one hour of Wi-Fi exposure on the lens in the animals. However, melatonin supplementation in the lens seems to have protective effects on the oxidant system by modulation of GSH-Px activity."

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3955064/

Addendum 2. Studies not evaluated in the Royal Society of Canada's expert panel report nor in Health Canada's Safety Code 6 (2015) Rationale indicating adverse effects below Safety Code 6 (2015) safety margin threshold.

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1. Effects: alterations in rat cornea

Akar, A., Karayiğit, M. Ö., Bolat, D., Gültiken, M. E., Yarim, M., & Castellani, G. (2013). Effects of low level electromagnetic field exposure at 2.45 GHz on rat cornea. *International Journal of Radiation Biology*, *89*(4), 243–249 doi:10.3109/09553002.2013.754557

ABSTRACT: "PURPOSE: To investigate the effects of low level electromagnetic field (low level-EMF) exposure, as frequently encountered in daily life, on the normal rat cornea using histological and stereological method.METHODS: Twenty-two adult male Wistar rats were randomly divided into two groups: Study group ($n = 11$) and control group ($n = 11$). Rats in the study group were exposed to 2.45 GHz microwave (MW) radiation (11.96 ± 0.89 V/m), 0.25 W/kg specific absorption rate (SAR) for 2 hours each day for 21 days. The corneal thickness and the anterior epithelium corneal thickness were measured using two different methods.RESULTS: Using the histological method, the mean corneal thicknesses in the control and study group were 278.9 ± 54.5 µm, and 272.4 ± 85.6 µm, respectively. There was no statistically significant difference between the groups ($p > 0.05$). The anterior corneal epithelium thickness was 28.1 ± 4.9 µm in the control group and 31.7 ± 5.5 µm in the study group. There were statistically differences between the groups with regard to the thickness of anterior epithelium ($p < 0.05$). In the measurement made by the stereological method, the percentage of the cornea occupied by anterior corneal epithelium was 15.94% in the control group and

17.9% in the study group. Despite the fact that there was a relation between increased anterior epithelial area (AEA) and radiation exposure, no statistically significant relationship in area fraction of each compartment was found between the control and study groups.CONCLUSIONS: Results of this preliminary study show that exposure to MW radiation might cause alterations in the rat cornea."

https://www.ncbi.nlm.nih.gov/pubmed/23206266

2. Effect: oxidative stress in rat cornea and lens

Balci, M., Namuslu, M., Devrim, E., & Durak, I. (2009). Effects of computer monitor-emitted radiation on oxidant/antioxidant balance in cornea and lens from rats. *Molecular Vision*, *15*, 2521–2525

ABSTRACT: "PURPOSE: This study aims to investigate the possible effects of computer monitor-emitted radiation on the oxidant/antioxidant balance in corneal and lens tissues and to observe any protective effects of vitamin C (vit C).METHODS: Four groups (PC monitor, PC monitor plus vitamin C, vitamin C, and control) each consisting of ten Wistar rats were studied. The study lasted for three weeks. Vitamin C was administered in oral doses of 250 mg/kg/day. The computer and computer plus vitamin C groups were exposed to computer monitors while the other groups were not. Malondialdehyde (MDA) levels and superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), and catalase (CAT) activities were measured in corneal and lens tissues of the rats.RESULTS: In corneal tissue, MDA levels and CAT activity were found to increase in the computer group compared with the control group. In the computer plus vitamin C group, MDA level, SOD, and GSH-Px activities were higher and CAT activity lower than those in the computer and control groups. Regarding lens tissue, in the computer group, MDA levels and GSH-Px activity were found to increase, as compared to the control and computer plus vitamin C groups, and SOD activity was higher than that of the control group. In the computer plus vitamin C group, SOD activity was found to be higher and CAT activity to be lower than those in the control group.CONCLUSION: The results of this study suggest that computer-monitor radiation leads to oxidative stress in the corneal and lens tissues, and that vitamin C may prevent oxidative effects in the lens."

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2787304/

3. Effects: blurring of vision, inflammation of eyes

Kucer, N. (2009). Some Ocular Symptoms Experienced by Users of Mobile Phones. *Electromagnetic Biology and Medicine*, *27*, 205–209 doi:10.1080/15368370802072174

ABSTRACT: "This survey study was conducted, using a questionnaire, on 229 university students (181 women, 48 men) in Kocaeli, Turkey. Six ocular symptoms experienced during use of mobile phones were studied by means of the chi-square test with Yates correction. The studied symptoms were blurring of vision, redness of the eyes, vision disturbance, secretion of the eyes, inflammation in the eyes, and lachrymation of the eyes. A significant increase in blurring of vision ($p < 0.05$) was reported by users of mobile phone possession >2 years compared to users of mobile phone possession <2 years. In users of mobile phones, women significantly ($p < 0.05$) complained more often of inflammation in the eyes than men."

https://www.ncbi.nlm.nih.gov/pubmed/18568938

4. Effects: oxidative stress
   Ni, S., Yu, Y., Zhang, Y., Wu, W., Lai, K., & Yao, K. (2013). Study of oxidative stress in human lens epithelial cells exposed to 1.8 GHz radiofrequency fields. *PloS One*, *8*(8), e72370 doi:10.1371/journal.pone.0072370

   ABSTRACT: "OBJECTIVES: The aims of the present study were to determine oxidative stress and to explore possible reasons of reactive oxygen species (ROS) increase in human lens epithelial (HLE) B3 cells exposed to low intensity 1.8 GHz radiofrequency fields (RF).METHODS: The HLE B3 cells were divided into RF exposure and RF sham-exposure groups. The RF exposure intensity was at specific absorption rate (SAR) of 2, 3, or 4 W/kg. The ROS levels were measured by a fluorescent probe 2'7'-dichlorofluorescin diacetate (DCFH-DA) assay in the HLE B3 cells exposed to 1.8 GHz RF for 0.5, 1, and 1.5 h. Lipid peroxidation and cellular viability were detected by an MDA test and Cell Counting Kit-8 (CCK-8) assays, respectively, in the HLE B3 cells exposed to 1.8 GHz RF for 6, 12, and 24 h, respectively. The mRNA expression of SOD1, SOD2, CAT, and GPx1 genes and the expression of SOD1, SOD2, CAT, and GPx1 proteins was measured by qRT-PCR and Western blot assays in the HLE B3 cells exposed to 1.8 GHz RF for 1 h.RESULTS: The ROS and MDA levels significantly increased ($P<0.05$) in the RF exposure group and that the cellular viability, mRNA expression of four genes, and expression of four proteins significantly decreased ($P<0.05$) compared with the RF sham-exposure group.CONCLUSIONS: Oxidative stress is present in HLE B3 cells exposed to 1.8 GHz low-intensity RF and that the increased production of ROS may be related to down-regulation of four antioxidant enzyme genes induced by RF exposure."

   https://www.ncbi.nlm.nih.gov/pubmed/23991100

5. Effects: review finds studies on the lens and lens cells showing effects on lens transparency, altered cell proliferation and other adverse effects.

   Yu, Y., & Yao, K. (2010). Non-thermal Cellular Effects of Lowpower Microwave Radiation on the Lens and Lens Epithelial Cells. *The Journal of International Medical Research*, *38*(3), 729–736

   ABSTRACT: "Because of the increased use of modern radiofrequency devices, public concern about the possible health effects of exposure to microwave radiation has arisen in many countries. It is well established that high-power microwave radiation can induce cataracts via its thermal effects. It remains unclear whether low-power microwave radiation, especially at levels below the current exposure limits, is cataractogenic. This review summarizes studies on the biological effects of low-power microwave radiation on lens and lens epithelial cells (LECs). It has been reported that exposure affects lens transparency, alters cell proliferation and apoptosis, inhibits gap junctional intercellular communication, and induces genetic instability and stress responses in LECs. These results raise the question of whether the ambient microwave environment can induce non-thermal effects in the lens and whether such effects have potential health consequences. Further in vivo studies on the effects on the lens of exposure to low-power microwave radiation are needed."

   https://www.ncbi.nlm.nih.gov/pubmed/20819410

6. Effects: deranged epithelial chicken embryo retinal differentiation

   Zareen, N., Khan, M. Y., & Ali Minhas, L. (2009). Derangement of chick embryo retinal differentiation caused by radiofrequency electromagnetic fields. *Congenital Anomalies*, *49*(1), 15–19 doi:10.1111/j.1741-4520.2008.00214.x

   ABSTRACT: "The possible adverse effects of radiofrequency electromagnetic fields (EMF) emitted from mobile phones present a major public concern. Biological electrical activities of the human body are vulnerable to interference from oscillatory aspects of EMF, which affect fundamental cellular activities, in particular, the highly active

development process of embryos. Some studies highlight the possible health hazards of EMF, while others contest the hypothesis of biological impact of EMF. The present study was designed to observe the histomorphological effects of EMF emitted by a mobile phone on the retinae of developing chicken embryos. Fertilized chicken eggs were exposed to a ringing mobile set on silent tone placed in the incubator at different ages of development. After exposure for the scheduled duration the retinae of the embryos were dissected out and processed for histological examination. The control and experimental embryos were statistically compared for retinal thickness and epithelial pigmentation grades. Contrasting effects of EMF on the retinal histomorphology were noticed, depending on the duration of exposure. The embryos exposed for 10 post-incubation days exhibited decreased retinal growth and mild pigmentation of the epithelium. Growth retardation reallocated to growth enhancement on increasing EMF exposure for 15 post-incubation days, with a shift of pigmentation grade from mild to intense. We conclude that EMF emitted by a mobile phone cause derangement of chicken embryo retinal differentiation."

https://www.ncbi.nlm.nih.gov/pubmed/19243412

7. Effects: changes in protein expression in human lens cells

Zhang, Y., Yao, K., Yu, Y., Ni, S., Zhang, L., Wang, W., & Lai, K. (2013). Effects of 1.8 GHz radiofrequency radiation on protein expression in human lens epithelial cells. *Human & Experimental Toxicology*, *32*(8), 797–806 doi:10.1177/0960327112472353

ABSTRACT: "Objective: The aim of the present study was to observe the effects of 1.8 GHz radiofrequency (RF) radiation on the protein expression of human lens epithelial cells (hLECs) in vitro. Methods: The hLECs were exposed and sham-exposed to 1.8 GHz RF radiation (specific absorption rate (SAR) of 4 W/kg) for 2 h. After exposure, the proteins extracted from LECs were loaded on the Ettan MDLC system connected to the LTQ-Orbitrap MS for screening the candidate protein biomarkers induced by RF. The quantitative real-time polymerase chain reaction (qRT-PCR) was used to detect the levels of messenger RNA of candidate biomarkers. After the hLECs were exposed to 1.8 GHz RF (SAR of 2, 3 and 4 W/kg) for 2 h, the Western blot assay was utilized to measure the expression levels of the above-screened candidate protein biomarkers. Results: The results of shotgun proteomic analysis indicated that there were eight proteins with differential expression between exposure and sham exposure groups. The results of qRT-PCR showed that there were three genes with expressional differences (valosin containing protein (VCP), ubiquitin specific peptidase 35 (USP35) and signal recognition particle 68 kDa (SRP68)) between exposure and sham exposure groups. The results of Western blot assay exhibited that the expressional levels of VCP and USP35 proteins significantly increased and the expressional level of protein SRP68 significantly decreased in hLECs exposed to 1.8 GHz RF radiation (SAR of 3 and 4 W/kg) for 2 h when compared with the corresponding sham groups ($p < 0.05$). Conclusion: The shotgun proteomics technique can be applied to screen the proteins with differential expression between hLECs exposed to 1.8 GHz RF and hLECs sham-exposed to 1.8 GHz RF, and three protein biomarkers associated with RF radiation were validated by Western blot assay."

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