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January 23, 2020

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**VIA OVERNIGHT DELIVERY**

Administrative Law Judge Joel H. Cheskis  
Pennsylvania Public Utility Commission  
Office of Administrative Law Judge  
400 North Street 2<sup>nd</sup> Floor West  
Harrisburg, PA 17120

**Re: Judith Hendin v. Metropolitan Edison Company, Docket No. C-2018-3003324**

Dear Judge Cheskis:

Enclosed please find three copies of Judith Hendin's cross Exhibits for the hearing scheduled for tomorrow, January 24, 2020.

Should you have any questions or comments, please feel free to contact me directly.  
Thank you.

Respectfully submitted,



Joanna A. Waldron, Esquire  
CURTIN & HEEFNER LLP

JAW/bya  
Enclosures  
cc: Lauren M. Lepkoski, Esquire  
Tori L. Giesler, Esquire



# American Academy of Environmental Medicine

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Decision Proposed Decision of Commissioner Peevy (Mailed 11/22/2011)  
BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA  
On the proposed decision 11-03-014

Dear Commissioners:

The Board of the American Academy of Environmental Medicine opposes the installation of wireless "smart meters" in homes and schools based on a scientific assessment of the current medical literature (references available on request). Chronic exposure to wireless radiofrequency radiation is a preventable environmental hazard that is sufficiently well documented to warrant immediate preventative public health action.

As representatives of physician specialists in the field of environmental medicine, we have an obligation to urge precaution when sufficient scientific and medical evidence suggests health risks which can potentially affect large populations. The literature raises serious concern regarding the levels of radio frequency (RF - 3KHz – 300 GHz) or extremely low frequency (ELF – 300Hz) exposures produced by "smart meters" to warrant an immediate and complete moratorium on their use and deployment until further study can be performed. The board of the American Board of Environmental Medicine wishes to point out that existing FCC guidelines for RF safety that have been used to justify installation of "smart meters" only look at thermal tissue damage and are obsolete, since many modern studies show metabolic and genomic damage from RF and ELF exposures below the level of intensity which heats tissues. The FCC guidelines are therefore inadequate for use in establishing public health standards. More modern literature shows medically and biologically significant effects of RF and ELF at lower energy densities. These effects accumulate over time, which is an important consideration given the chronic nature of exposure from "smart meters". The current medical literature raises credible questions about genetic and cellular effects, hormonal effects, male fertility, blood/brain barrier damage and increased risk of certain types of cancers from RF or ELF levels similar to those emitted from "smart meters". Children are placed at particular risk for altered brain development, and impaired learning and behavior. Further, EMF/RF adds synergistic effects to the damage observed from a range of toxic chemicals. Given the widespread, chronic, and essentially inescapable ELF/RF exposure of everyone living near a "smart meter", the Board of the American Academy of Environmental Medicine finds it unacceptable from a public health standpoint to implement this technology until these serious medical concerns are resolved. We consider a moratorium on installation of wireless "smart meters" to be an issue of the highest importance.

The Board of the American Academy of Environmental Medicine also wishes to note that the US NIEHS National Toxicology Program in 1999 cited radiofrequency radiation as a potential carcinogen. Existing safety limits for pulsed RF were termed "not protective of public health" by the Radiofrequency Interagency Working Group (a federal interagency working group including the FDA, FCC, OSHA, the EPA and others). Emissions given off by "smart meters" have been *classified by the World Health Organization International Agency for Research on Cancer (IARC) as a Possible Human Carcinogen.*

Hence, we call for:

- An immediate moratorium on "smart meter" installation until these serious public health issues are resolved. Continuing with their installation would be extremely irresponsible.
- Modify the revised proposed decision to include hearings on health impact in the second proceedings, along with cost evaluation and community wide opt-out.
- Provide immediate relief to those requesting it and restore the analog meters.

Members of the Board  
American Academy of Environmental Medicine

# American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™



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## Reply to

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December 12, 2012

The Honorable Dennis Kucinich  
2445 Rayburn House Office Building  
Washington, DC 20515

Dear Representative Kucinich:

On behalf of the American Academy of Pediatrics (AAP), a non-profit professional organization of 60,000 primary care pediatricians, pediatric medical sub-specialists, and pediatric surgical specialists dedicated to the health, safety and well-being of infants, children, adolescents, and young adults, I would like to share our support of H.R. 6358, the *Cell Phone Right to Know Act*.

The AAP strongly supports H.R. 6358's emphasis on examining the effects of radiofrequency (RF) energy on vulnerable populations, including children and pregnant women. In addition, we are pleased that the bill would require the consideration of those effects when developing maximum exposure standards. Children are disproportionately affected by environmental exposures, including cell phone radiation. The differences in bone density and the amount of fluid in a child's brain compared to an adult's brain could allow children to absorb greater quantities of RF energy deeper into their brains than adults. It is essential that any new standards for cell phones or other wireless devices be based on protecting the youngest and most vulnerable populations to ensure they are safeguarded through their lifetimes.

In addition, the AAP supports the product labeling requirements in H.R. 6358. These standards will ensure consumers can make informed choices in selecting mobile phone purchases. They will also enable parents to better understand the potential dangers of RF energy exposure and protect their children.

On July 24, the U.S. Government Accountability Office (GAO) published a report on federal cell phone radiation exposure limits and testing requirements. The GAO noted that the Federal Communications Commission's (FCC) most recent data indicates that the number of estimated mobile phone subscribers has grown from approximately 3.5 million in 1989 to approximately 289 million at the end of 2009. Cell phone use behaviors have also changed during that time. The quantity and duration of cell phone calls has increased, as has the amount of time people use mobile phones, while cell phone and wireless technology has undergone substantial changes. Many more people, especially adolescents and young adults, now use cell phones as their only phone line, and they begin using wireless phones at much younger ages.

Despite these dramatic changes in mobile phone technology and behavior, the FCC has not revisited the standard for cell phone radiation exposure since 1996. The current FCC standard for maximum radiation exposure levels is based on the heat emitted by mobile phones. These guidelines specify exposure limits for hand-held wireless devices in terms of the Specific Absorption Rate (SAR), which measures the rate the body absorbs radiofrequency (RF). The current allowable SAR limit is 1.6 watts per kilogram (W/kg), as averaged over one gram of tissue. Although wireless devices sold in the United States must ensure that they do not exceed the maximum allowable SAR limit when operating at the device's highest possible power level, concerns have been raised that long-term RF energy exposure at this level affects the brain and other tissues and may be connected to types of brain cancer, including glioma and meningioma.

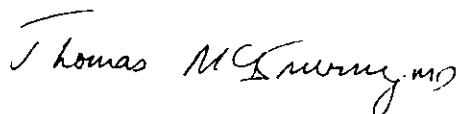
In May 2011, the International Agency for Research on Cancer (IARC), the United Nations' World Health Organization's (WHO) agency promoting international cancer research collaboration, classified RF energy as "possibly carcinogenic to humans." In addition, the National Cancer Institute has stated that although studies have not definitively linked RF energy exposure from cell phones to cancer, more research is required to address rapidly changing cell phone technology and use patterns.

This and other research identified by the GAO demonstrates the need for further research on this issue, and makes clear that exposure standards should be reexamined.

The GAO concluded that the current exposure limits may not reflect the latest research on RF energy, and that current mobile phone testing requirements may not identify maximum RF energy exposure. The GAO proposed that the FCC formally reassess its limit and testing requirements to determine whether they are effective. The AAP commends the activities proposed under H.R. 6358, as they would address this research gap and improve consumer knowledge and safety. Establishing an expanded federal research program as the basis for exposure standards will ensure that consumer protections incorporate the latest research. Currently, the National Institute of Health (NIH), the only federal agency the GAO identified as directly funding research on this topic, provided approximately \$35 million from 2001 to 2011. Given this previous funding level, the AAP supports the \$50 million per fiscal year for seven years that H.R. 6358 would authorize.

The AAP appreciates your recognition of the need for new research and standards for mobile phone radiation, and is pleased to support H.R. 6358. For further assistance, please do not hesitate to contact Sonya Clay, Assistant Director, Department of Federal Affairs, at 202-347-8600 or [sclay@aap.org](mailto:sclay@aap.org).

Sincerely,



Thomas K. McInerney, MD, FAAP  
President

## Lack of Adverse Effects of Whole-Body Exposure to a Mobile Telecommunication Electromagnetic Field on the Rat Fetus

Satoru Takahashi,<sup>a</sup> Norio Imai,<sup>b</sup> Kyoko Nabae,<sup>b</sup> Kanako Wake,<sup>c</sup> Hiroki Kawai,<sup>c</sup> Jianqing Wang,<sup>d</sup> So-ichi Watanabe,<sup>e</sup> Mayumi Kawabe,<sup>b</sup> Osamu Fujiwara,<sup>e</sup> Kumiko Ogawa,<sup>a</sup> Seiko Tamano<sup>b</sup> and Tomoyuki Shirai<sup>a,1</sup>

<sup>a</sup> Department of Experimental Pathology and Tumor Biology, Nagoya City University Graduate School of Medical Sciences, Nagoya, Japan; <sup>b</sup> DIMS Institute of Medical Science, Inc., Ichinomiya, Aichi, Japan; <sup>c</sup> Electromagnetic Compatibility Group, Applied Electromagnetic Research Center, National Institute of Information and Communications Technology, Tokyo, Japan; <sup>d</sup> Department of Computer Science and Engineering, Nagoya Institute of Technology, Nagoya, Japan; and <sup>e</sup> Department of Electrical and Computer Engineering, Nagoya Institute of Technology, Nagoya, Japan

Takahashi, S., Imai, N., Nabae, K., Wake, K., Kawai, H., Wang, J., Watanabe, S., Kawabe, M., Fujiwara, O., Ogawa, K., Tamano, S. and Shirai, T. Lack of Adverse Effects of Whole-Body Exposure to a Mobile Telecommunication Electromagnetic Field on the Rat Fetus. *Radiat. Res.* 173, 362–372 (2010).

The recent steep increase in the number of users of cellular phones is resulting in marked increase of exposure of humans to radiofrequency electromagnetic fields (EMFs). Children are of particular concern. Our goal was to evaluate potential adverse effects of long-term whole-body exposure to EMFs simulating those from base stations for cellular phone communication. Pregnant rats were given low, high or no exposure. At the high level, the average specific absorption rate (SAR) for the dams was 0.066–0.093 W/kg. The SAR for the fetuses and the F<sub>1</sub> progeny was 0.068–0.146 W/kg. At the low level, the SARs were about 43% of these. The 2.14 GHz signals were applied for 20 h per day during the gestation and lactation periods. No abnormal findings were observed in either the dams or the F<sub>1</sub> generation exposed to the EMF or in the F<sub>2</sub> offspring. Parameters evaluated included growth, gestational condition and organ weights for dams and survival rates, development, growth, physical and functional development, hormonal status, memory function and reproductive ability of the F<sub>1</sub> offspring (at 10 weeks of age) along with embryotoxicity and teratogenicity in the F<sub>2</sub> rats. Thus, under our experimental conditions, whole-body exposure to 2.14 GHz for 20 h per day during gestation and lactation did not cause any adverse effects on pregnancy or the development of rats. © 2010 by Radiation Research Society

### INTRODUCTION

The development of wireless communications has brought great social and economic benefits to our

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society, and the numbers of users of cellular telephones and other wireless devices are growing rapidly. This is causing some concern about potential adverse effects of electromagnetic fields (EMFs) in both the general population and the scientific community. There are two types of exposure to EMFs, local (part of body) and systemic (whole-body). The use of terminal devices such as cellular phones causes local exposure, while emissions from base stations results in whole-body exposure. Hutter *et al.* reported a significant relationship between of some symptoms such as headaches and perceptual speed and the measured power density from 10 base stations in randomly selected subjects, but a confounding effect of the subjects' concerns about their exposures on their reports of symptoms could not be excluded (1). Children have been demonstrated to have greater susceptibility to many environmental toxicants and physical agents than adults (2–5). In particular, the central nervous system (CNS) and endocrine and reproductive systems are at risk. The susceptibility of each organ to toxicants appears to depend on the specific time during embryogenesis at which exposure occurs. Concern for the potential vulnerability of the developing nervous system of children to radiofrequency (RF) fields led the World Health Organization (WHO) to hold an expert workshop in Istanbul, Turkey, in June 2004, to evaluate information relevant to the sensitivity of children to both extremely low-frequency (ELF) fields and EMFs. In addition to reviewing the available evidence of the health risk to children from RF fields, the workshop participants developed a research agenda to identify high-priority studies (see <http://www.who.int/peh-emf/research/rf03/en> for more details).

There have been several studies on the relationship between occupational maternal exposure to RF fields and congenital malformations of fetuses, but no specific adverse outcomes have been reported consistently (6). Heynick and Merritt (7) critically reviewed the data

from experimental studies using beetles, birds, rodents and nonhuman primates on the teratogenic effects or developmental abnormalities from exposure to RF fields/EMFs in the frequency range of 3 kHz–300 GHz. They concluded that adverse effects occurred only at exposure levels that caused biologically detrimental increases in body temperature.

The International Mobile Telecommunication 2000 (IMT-2000), a recent standardized new mobile telecommunication system, is the mainstay of the third-generation (3G) technology. Wide-band code division multiple access (W-CDMA), also called the Universal Mobile Telecommunication System (UMTS) in the EU, is now a major digital signal system in Japan. Even at low levels of RF-field exposure, it is important to clarify the potential for effects of whole-body exposure to EMFs on children. The few experimental studies with RF fields that have been performed focused mainly on tumor development (8–10) or effects on the brain (11, 12). The present study was designed to evaluate potential adverse effects of long-term whole-body exposure to EMF signals from a base station for cellular phone communication during the gestation and lactation periods.

## MATERIALS AND METHODS

### Animals

A total of 36 pregnant Crl:CD(SD) (specific-pathogen-free) 10-week-old rats with certification of the gestational day (second gestational day) were purchased from Charles River Japan (Shiga, Japan) at three different times. All animals were allowed a 5-day quarantine and acclimation period, and only after confirmation of normal health status were the animals entered into experiments. If a rat died during the experiments, dummy pregnant rats were used to fill any vacancies in the EMF exposure box to keep the exposure conditions unchanged.

Three identical independent experiments were performed. For each experiment, the pregnant rats were divided into three groups of four rats each. Group 1 received sham exposure, and groups 2 and 3 were exposed to the EMF at the low and high levels, respectively. All pregnant rats were placed in individual translucent acrylic cages in the three exposure boxes. Four days after delivery, eight F<sub>1</sub> rats per dam, four males and four females, were also selected for continuous exposure.

### Exposure Apparatus for EMF

The exposure boxes used for earlier experiments with the 1.95 GHz EMF (13) were modified for whole-body exposure (Fig. 1a and b) to the 2.14 GHz used for down-link signals from base stations with the W-CDMA system in Japan (14). The insides of the exposure boxes (90 × 90 × 40 cm outside, 70 × 70 × 34 cm inside) with the exception of the ceilings were covered with a 6-cm-thick planar RF-field absorber. The ceiling of the exposure box was metal mesh and was covered with a translucent acrylic plate (4.2 mm thick), and two fluorescent light tubes were placed 32 cm above the ceiling of each exposure box and used to maintain a 12-h light/dark cycle was maintained during the 20-h exposure. Four translucent acrylic cages in a 90° fan shape were set on the floor of each box (Fig. 2a and b). Each cage had a removable translucent acrylic cover, and holes in the cover and side of each cage allowed ventilation (Fig. 2a). Each cage was 200 mm deep

× 190 mm high with 690.8 cm<sup>2</sup> of floor space (Fig. 2c). Air was blown into the center of the exposure box using an electric fan. A plastic water bottle was placed in the center side of each cage (Fig. 2a–c). Whole-body exposure delivered using two crossing 3/2-wavelength dipole antennas (180 mm long) covered with an ABS (15) with the exposure box in the center. The two antennas intersected at a right angle and had a phase difference of 90°. The antenna axial ratio was found to be approximately 1 dB in the exposure direction toward the rats, which indicated a circular polarization. For an electromagnetic field at a distance  $r$  from the antenna, the static-field ( $1/r^2$ ) and reactive-field ( $1/r^3$ ) terms dominate very close to the antenna. As one moves further from the antenna, the radiate-field ( $1/r$ ) term dominates. The boundary between the near and the far field (15) occurs at a distance of  $2D^2/\lambda$ , where  $D$  is the antenna dimension and  $\lambda$  is the wavelength. The present setup therefore provided a radiate-field exposure, because the distance between the antennas and the cages was 1.4–1.8 wavelengths, while the boundary was 0.5 wavelengths. Measurement using an electric-field probe (SPEAGER3DV4R) showed that the electric-field distribution in each cage had a standard deviation of 12% with respect to the average field level, which was smaller than the actual variation of the base station field distribution inside the room.

### EMF Exposure Protocol and Dosimetry

Three exposure chambers were used, one for each of the two EMF exposure groups and one for sham exposure.

A 2.14 GHz (Downlink) W-CDMA signal was used. Exposure of the 10-week-old pregnant rats was started at gestational day 7 and continued for 20 h per day until weaning of F<sub>1</sub> rats (Fig. 3). The three exposure chambers were rotated randomly among the three groups each day so that no group was restricted to a specific exposure chamber. All exposures were controlled with a computer. During the 20-h exposure (starting from 10 to 11 a.m.), a 12-h light/dark cycle (7 a.m. to 7 p.m. for lighting) and environmental conditions of  $22 \pm 3^\circ\text{C}$  and  $55 \pm 15\%$  humidity were maintained. The antenna input power had a variation within  $\pm 5\%$ . The SARs in the dams are summarized in Table 1. At the high level, the average SAR for the dams was 0.066–0.093 W/kg, and those for the fetuses and the F<sub>1</sub> progeny were 0.068–0.146 W/kg. At the low level, however, the SARs were about 43% of the values for the high level. Since the rats moved freely inside each cage, we first monitored the location patterns of rats inside each cage by taking pictures. Based on these monitoring data, we extracted almost 40 typical rat location patterns. Then we created numerical models for all the typical rat locations and calculated SARs using the FDTD method. The data in Table 1 are based on the statistical averages of typical rat locations. The standard deviations were found to be maintained within  $\pm 60\%$  relative to the average SAR. This value is within the daily variation of SAR from base stations. In Table 1, the SARs were also summarized at representative stages or pregnancy and growth such as 7 and 16 days of pregnancy and 1 week, 2 weeks and 3 weeks after delivery or birth. However, since we at first used an ellipsoid model for the F<sub>1</sub> rats to set the antenna input power and then performed more precise SAR analysis with more realistic F<sub>1</sub> models (14), the whole-body averaged SAR for dams under the high exposure condition exceeded 0.08 W/kg, which is the value for the INCIRP basic restriction on the whole-body average SAR for the general public. For the low-level condition, the whole-body SARs for the dams, fetuses and F<sub>1</sub> progeny were always below the 0.08 W/kg limit.

### Animal Handling and Termination of the Experiment

All cages contained wood-chip bedding, and animals in the exposure chambers were allowed free access to irradiated (6.0 kGy) pelleted diet (MF, Oriental Yeast Co., Ltd., Tokyo, Japan) and drinking water. Four days after delivery, eight F<sub>1</sub> rats, usually four

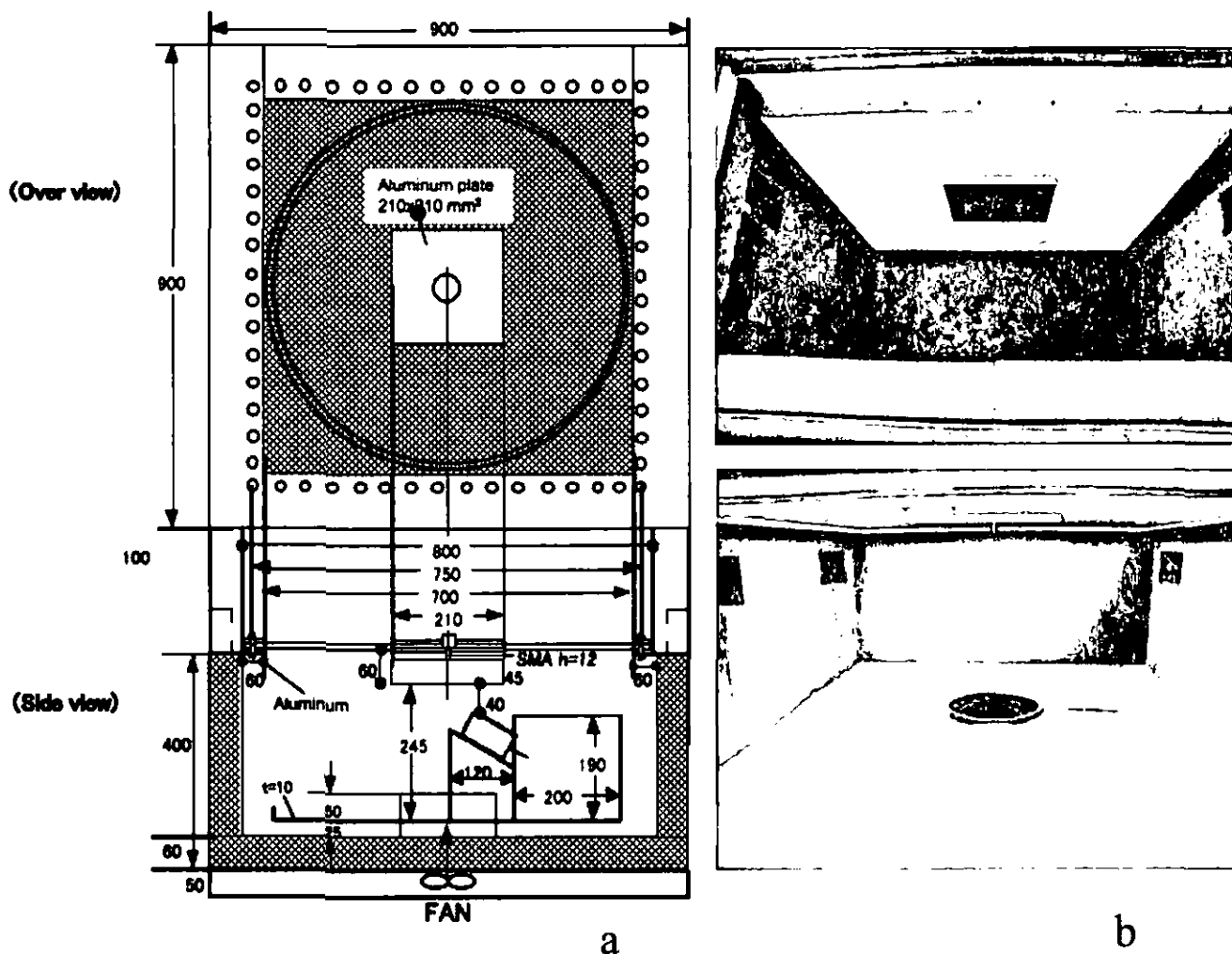


FIG. 1. Design of the exposure boxes with an outer size of  $90 \times 90 \times 60$  cm. The insides were covered with a 6-cm-thick planar RF-field absorber, except for the ceilings, which were made of metal mesh to prevent leakage of the radio waves to the outside. Panel a: Schematic of an exposure box; panel b: inside view of an exposure box without animal cages.

males and four females, were selected for continuous exposure (Fig. 3). After weaning,  $F_1$  rats were removed from the exposure boxes and kept in cages on wood-chip bedding in an air-conditioned animal room maintained on a 12-h light/dark cycle at  $22 \pm 2^\circ\text{C}$  and  $55 \pm 10\%$  humidity and were allowed free access to pelleted diet and drinking water. At 10 weeks of age, randomly selected male and female  $F_1$  rats were mated overnight, and then females were caged individually (Fig. 3). At gestational day 20, all  $F_1$  dams were killed humanely, the fetuses were removed, and reproductive and embryotoxic parameters were assayed.

Dams and  $F_1$  rats were observed clinically each morning during the exposure period for symptoms and mortality. Body weights were measured each day for dams until gestation day 20 and after delivery on days 0, 4, 7, 14 and 21 (both dams and  $F_1$  rats) and after weaning weekly for  $F_1$  animals until the end of the experiment.

#### Parameters Evaluated for Effects of Whole-Body Exposure to EMF

Parameters evaluated, included growth, gestational condition and organ weights for dams, the survival rates, physical and functional development, hormonal status, memory function and reproductive ability the  $F_1$  offspring, and embryotoxicity and teratogenicity in the

$F_2$  rats. The parameters examined are listed in Table 2. In addition to changes in the body weights of dams and offspring ( $F_1$ ) and food consumption was measured. At weaning, dams were killed, major organs were weighed, and macroscopic and histological examinations were performed. To assess reproductive function, the number of implantations in the uteri of dams was examined, and the delivery index, live birth index and numbers of live and dead offspring were recorded. The physical development of the offspring ( $F_1$  pups) was assessed by monitoring pinna unfolding, emergence of hair, eruption of incisors and eyelid opening at the times indicated. Tests for the functional development of offspring included response to pain, pinna reflex, Preyer's reflex (ear "jump"), corneal reflex, pupillary reflex, mid-air righting reflex, surface righting reflex and negative geotaxis reflex. The open-field test was used as a behavioral assay in the offspring. A water maze test was carried out to assess learning function.

Surface righting reflex: The pup was placed supine on a plywood surface, and the time (latency) required for the pup to right itself to the prone position was measured. Each pup underwent this test once per day on postnatal days 6–10: a maximum of 5 s per trial was allowed. Negative geotaxis reflex: Negative geotaxis was tested on a  $25^\circ$  inclined piece of plywood (45 cm  $\times$  45 cm). The pup was placed

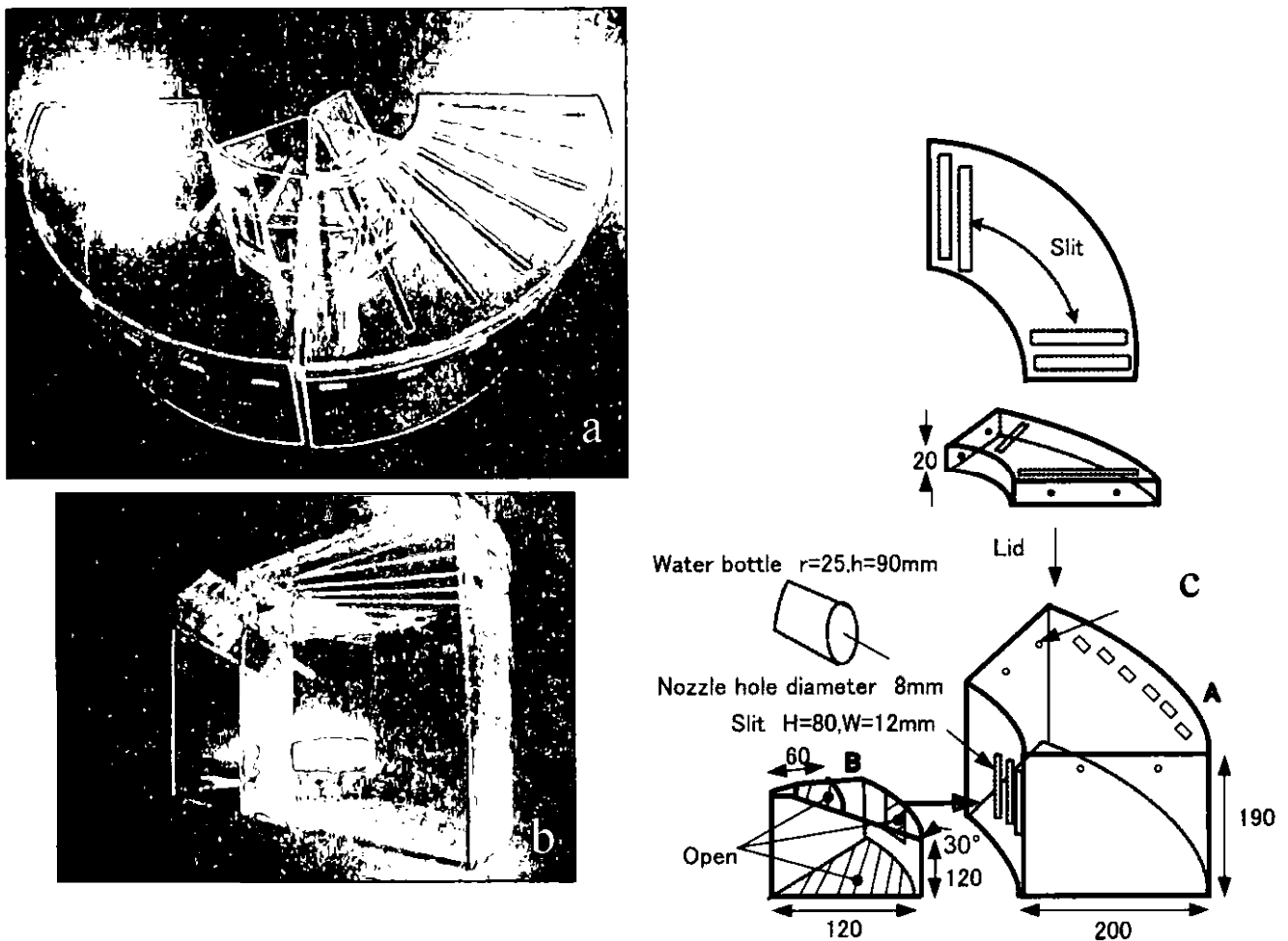


FIG. 2. Animal cages in an exposure box. Four acrylic cages with a 90° fan shape were placed on the floor of the box. Panels a and b are overhead and side views, respectively. Panel c is a schematic showing the setup of a cage.

head down on the center of the board and the response time (latency) to rotate 180° and turn its head up was recorded. Each pup was given the test once per day on postnatal days 6–12. A maximum of 30 s per trial was allowed. Unsuccessful pups were given a score of 30 s. Mid-air righting reflex: The pup was dropped from a height of 30 cm in the supine position onto a cushion with a flat surface. A positive response

was assigned when the pup landed on all four feet. Each pup was tested once per day on postnatal days 13–19. The successful response rate for all pups of the litter on each day was determined.

**Open-field test:** The open-field apparatus used was a black square (60 × 60 × 30 cm) with 200–300 lux lighting from a fluorescent lamp at the center of the field. During the test, white noise was produced at the level of about 60 dB in the center of the field. The open-field test was carried out on 5- and 8-week-old animals placed in the center of the field. The number of ambulations, latency, number of rearing and grooming movements, and incidences of urination and defecation were recorded. The observations were made on 3 consecutive days for 10 min per day.

**Water maze test:** Nine-week-old rats were trained in a water maze. The apparatus consisted of a circular tank (1.5 m in diameter) of water (0.3 m deep, 25 ± 2°C) made opaque by the addition of black ink. A transparent platform (12 cm in diameter) for escape was submerged 1 cm below the water surface. Several salient cues were placed around the testing room to enable the rats to learn the platform location. A video camera was set above the center of the pool and connected to a color videotracking system (CAT-10, Muromachi, Japan) and video recorder that allowed on- and offline automated tracking of the swim path of the rat in the pool. During the hidden platform test, the system automatically measured the time, swim distance and swim path of each rat until the rat climbed onto the platform. These data were recorded in a computer (Muromachi,

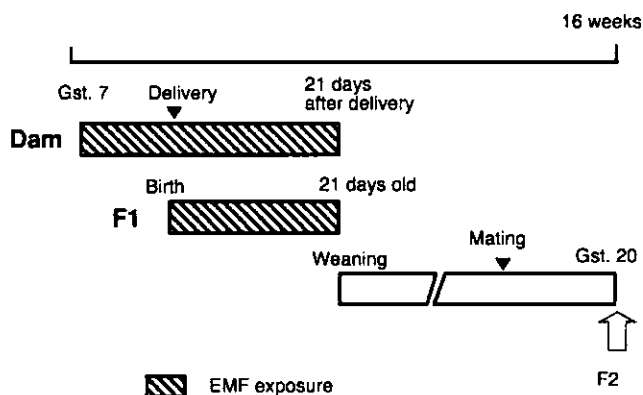


FIG. 3. Experimental design. EMF signals of 2.14 GHz (Down-link) W-CDMA were generated for 20 h/day.

**TABLE 1**  
**Specific Absorption Rate Conditions**

Model	High-level condition <sup>a</sup>		Low-level condition <sup>b</sup>	
	Dam (W/kg)	Fetus/F <sub>1</sub> (W/kg)	Dam (W/kg)	Fetus/F <sub>1</sub> (W/kg)
Gestation day 7	0.071		0.031	
Gestation day 16	0.066	0.068	0.028	0.029
Soon after the delivery, 1 week	0.093	0.156	0.040	0.067
Late after the delivery (clumped), 2 weeks	0.093	0.155	0.040	0.067
Late after the delivery (clumped), 3 weeks	0.093	0.143	0.040	0.061

<sup>a</sup> Dam's whole-body SAR <0.08 W/kg. Two dipole antennae sum of input: 1.898 W.

<sup>b</sup> Dam's whole-body SAR <0.08 W/kg. Two dipole antennae sum of input: 0.818 W.

Model DVT-II). Rats were first trained to find the hidden platform and escape onto the platform fixed in the center of one of the four quadrants of the pool. They received three trials per day with an intertrial interval of 1 min over 5 consecutive days. At each trial, the rat was placed into the pool, facing the side wall. The start positions were selected semi-randomly from three of four equally spaced wall locations, excluding the point nearest the platform. The rats were allowed to swim until they climbed on to the platform. If a rat successfully reached the platform, it was left on the platform for 30 s and then returned to its cage. If a rat did not find the platform within 120 s, it was placed on the platform by hand and left there for 30 s. A

prove test was given 30 min after the last training trial. For this test, the platform was removed from the pool, and the rat was allowed to swim freely for 60 s. The time spent in each of the quadrants and the swim path was measured by the tracking system.

Estrus cycle and fertility were investigated as markers of reproductive function. The fertility of male and female F<sub>1</sub> offspring was examined to determine the number of successful copulations (copulation index). The number of days required for copulation was also recorded.

All organs of F<sub>1</sub> dams were examined macroscopically and the number of corpus luteum gravitates was recorded. Ovaries, uterus and vagina were fixed with 10% buffered formalin for further histological examination. The other items examined were number of implantations, number of live fetuses, number of dead embryos (early and late resorption sites), sex ratio, body weights of live fetuses, placental weights and number of fetuses with external abnormalities.

#### Data Analysis Methods

Since the experiments were repeated three times to obtain enough dams and fetuses for investigation, homoscedasticity was analyzed by an *F* test. The parameters were body weight and consumption of diet for dams, the number of implantations, and the number of pups delivered per litter. If they had the same variance, the data were analyzed with Student's *t* test and if not they were analyzed with the Welch test. Statistical comparisons between sham-exposed rats (group 1) and exposed groups 2 and 3 for average data (dams: body weight, consumption of diet, gestation period, number of implantations and organ weight; F<sub>1</sub> animals: number delivered, number of live or dead offspring, body weight, time in functional development, open-field test, water maze test, organ weight and number of days for copulation; F<sub>1</sub> pregnant: body weight, number of corpora lutea, number of implantations, number of live fetus, body weight of live

**TABLE 2**  
**List of Parameters Examined**

Body weight curves of dams during gestation and lactation periods	Open-field test of offspring at the times examined
Reproductive findings for dams	Ambulation
No. of dams	Latency
Gestation period	Rearing
No. of implantations	Grooming
Delivery index	Defecation
Live birth index	Urination
No. of pups delivered per litter	Water maze test of offspring—hidden platform test
No. of live offspring per litter	Latency (day 1–5)
No. of dead offspring per litter	Water maze test of offspring—prove test
Sex ratio	Crossing of target (no. of animals)
No. of live offspring with external abnormalities	Time in quadrant (training, opposite, adjacent left, adjacent right)
Body weight data for offspring during lactation period	Organ to body weight ration of offspring
Body weight data for offspring after weaning	Estrus cycle data of offspring
Viability index of offspring	No. of animals with abnormal estrus cycle
Before culling: no. of live offspring (viability index)	Male and female fertility of offspring
After culling: no. of live offspring (weaning index)	No. of males with successful copulation (copulation index of males)
Physical development of offspring	No. of females with successful copulation (copulation index of females)
Pinna unfolding	Fertility index (%)
Emergence of hair	No. of days for copulation
Eruption of incisor	Body weights of females offspring during pregnancy
Eyelid opening	Cesarean section of F <sub>1</sub> (F <sub>2</sub> )
Functional development of offspring	No. of corpora lutea (total and mean/litter)
Response to pain	No. of implantations (total and mean/litter)
Pinna reflex	No. of dead fetuses (early and late resorption sites)
Preyer's reflex	No. of live fetuses (total and mean/litter)
Corneal reflex	Sex ratio (male/females)
Pupillary reflex	Body weight of live fetuses
Mid-air righting reflex	Placental weight
Righting reflex on surface	No. of fetuses with abnormality

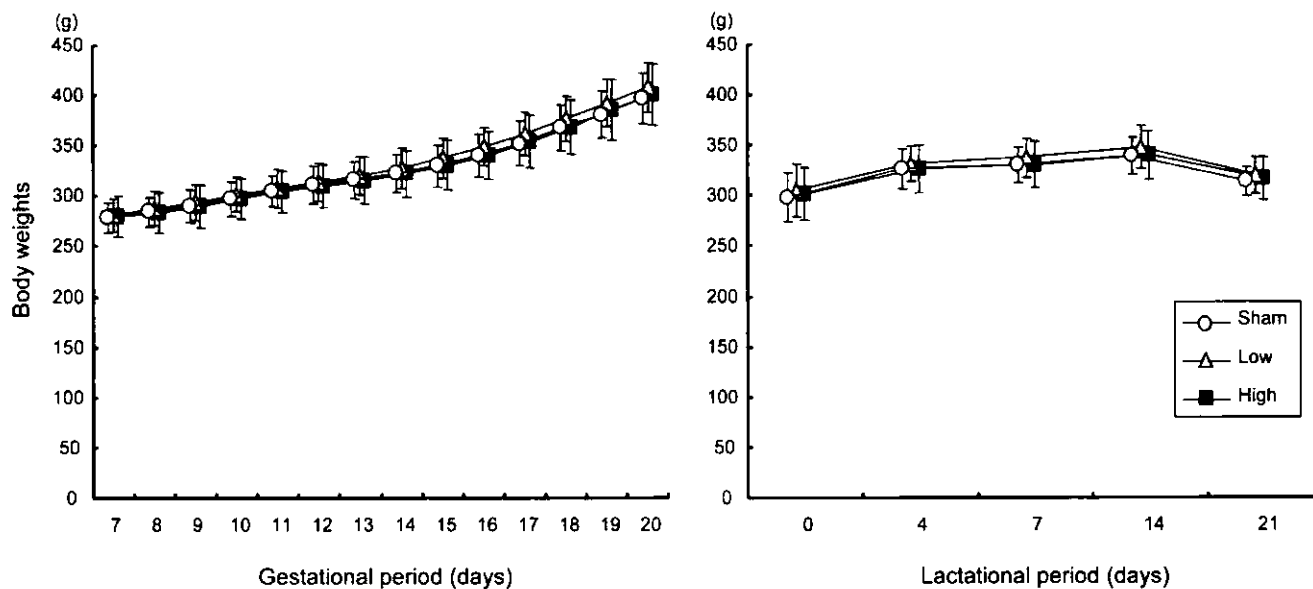


FIG. 4. Growth curves of dams exposed to EMF during gestation (left panel) and lactation (right panel). Points are means  $\pm$  SD.

fetuses and placental weight) were performed using Bartlett's test at  $P < 0.05$ . If data were normally distributed, one-way analysis of variance was used. When significant differences were observed, Dunnett's multiple parametric comparison test was applied. When a normal distribution was not confirmed, the Kruskal-Wallis test was applied instead. When significant differences were observed, Dunnett's multiple non-parametric comparison test was applied.

The significances of intergroup differences in average values (dams: live birth index;  $F_1$ : sex ratio, external abnormalities, viability index, weaning index, physical development, appearance ratio in functional development;  $F_1$  pregnant: incidence of dead fetuses, sex ratio of fetus and fetuses with abnormality) were assessed using the Kruskal-Wallis test. When significant differences were observed, Dunnett's multiple non-parametric comparison test was applied.

The significance of intergroup differences in incidences of delivery index of dams and mating or fertility index of  $F_1$  pregnant was analyzed using Fisher's exact probability test. The significance of intergroup differences in incidences of gross pathological examination was also performed using Fisher's exact test (one-sided) and in the grade of lesions using the Wilcoxon rank sum test (two-sided).

In all cases, significance was set at  $P < 0.05$ .

#### Animal Care and Protocols

The experiment was planned by the Committee of the Study on Human Exposure to EMF in Japan, which was established in 1997 with the aim to clarify the effects of radio waves from mobile telephone terminals on the human body.

The animal facilities at the DIMS Institute Medical Science, Inc. where the tests were conducted are fully accredited as compliant with the GLP Standards by the Ministry of Health and Welfare of Japan, the Organization for Pharmaceutical Safety and Research and the Ministry of Agriculture, Forestry and Fisheries of Japan.

## RESULTS

### Homoscedasticity of the Three Experiments

Except for a significant decrease in food consumption by dams during lactation days 12 to 14 days in experiment 3 compared with experiment 1, there were

no significant differences in the dams' body weights, the number of implantations or the number of deliveries per litter. Thus there was no appreciable variation among the three experiments.

### Dams

No adverse effects were observed on general condition, body weight changes (Fig. 4), and food consumption (data not shown). As to reproductive activity, no significant differences were noted for the gestational period, number of implantations, delivery index, liver birth index, litter size, number of live offspring per litter, number of dead embryos per litter, sex ratio of offspring and external abnormalities (Table 3). No macroscopic

TABLE 3  
Reproductive Findings for Dams

	Group			
	Exposure level	1 Sham	2 Low	3 High
No. of dams		12	11 <sup>d</sup>	12
Gestation period		22.2 $\pm$ 0.4	22.0 $\pm$ 0.0	22.0 $\pm$ 0.0
No. of implantations		14.3 $\pm$ 1.7	14.6 $\pm$ 1.4	14.5 $\pm$ 1.4
Delivery index <sup>a</sup> (%)		100	100	100
Live birth index <sup>b</sup> (%)		90.8 $\pm$ 7.2	94.5 $\pm$ 9.0	94.4 $\pm$ 4.6
No. of pups delivered per litter		12.9 $\pm$ 1.8	13.8 $\pm$ 1.7	13.7 $\pm$ 1.2
No. of live offspring per litter		12.9 $\pm$ 1.8	13.8 $\pm$ 1.7	13.7 $\pm$ 1.2
No. of dead offspring per litter		0	0	0
Sex ratio <sup>c</sup>		47.9 $\pm$ 10.9	59.5 $\pm$ 18.4	47.9 $\pm$ 19.6
No. of live offspring with external abnormalities		0	1 (0.6 $\pm$ 2.1) <sup>e</sup>	0

<sup>a</sup> (No. of dams/no. of pregnancies)  $\times$  100.

<sup>b</sup> (No. of live offspring/no. of implantation site)  $\times$  100.

<sup>c</sup> (No. of live male offspring/no. of live offspring)  $\times$  100.

<sup>d</sup> One female was omitted due to not being pregnant.

<sup>e</sup> Loss of tail.

TABLE 4  
Sexual Development of Offspring

Sex Group Exposure level	Male			Female		
	1 Sham	2 Low	3 High	4 Sham	5 Low	6 High
No. examined	48	46	45	48	42	45
Opening of vagina	—	—	—	33.4 ± 1.9	34.0 ± 2.3	32.9 ± 2.9
Cleavage of the balanopreputial gland	42.4 ± 1.8	43.2 ± 3.4	42.8 ± 3.5	—	—	—
Descent of testis	21.5 ± 0.5	21.7 ± 0.5	21.5 ± 0.5	—	—	—

abnormalities were found in any dams exposed to the EMF. None of the organs showed significant changes in weight (brain, pituitary, thyroid, lungs, heart, thymus, liver, kidneys, spleen, adrenals, ovaries and uterus; data not shown).

#### F<sub>1</sub> Rats

In both the lactation and weaning periods, no effects on the general condition of F<sub>1</sub> rats were observed. One female and one male died 1 day and 3 days after birth, respectively. There were no F<sub>1</sub> rats with any external abnormalities, except for one lacking a tail, which was assumed to be caused by mechanical effects at delivery.

Although there were no significant differences in the body weights during the lactation period, between 4 to 7 weeks after weaning, the values for males but not females receiving EMF exposure were significantly increased over the control value. The viability indices at day 4 after the delivery, when F<sub>1</sub> rats were culled to four per dam, were 100, 100 and 98.8% in the sham, low-level and high-level groups, respectively; the differences in these values were not statistically significant. Weaning indices were also 100% in all three groups.

The seven tests for physiological development of F<sub>1</sub> rats (Table 4) revealed no significant changes except for pinna unfolding, which was found to be delayed in the high-exposure group only at day 2.

As indicators of the functional development of offspring, response to pain, pinna reflex, Preyer's reflex (ear "jump"), corneal reflex, pupillary reflex, mid-air righting reflex, surface righting reflex and negative geotaxis reflex were tested. The numbers of offspring tested were 96, 80 and 96 in groups 1, 2 and 3, respectively. All rats demonstrated good responses to the first five tests (data not shown). Figure 5 illustrates the age-dependent responses in the mid-air righting reflex; there were no significant differences among the groups. Figure 6 illustrates age-dependent responses in the righting reflex on the surface (Fig. 6a) and in the negative geotaxis (Fig. 6b) with no significant differences among the groups. Six items in the open-field test, ambulation, latency, rearing, grooming, defecation and urination, were monitored, but none demonstrated changes due to the EMF exposure at either time

examined (only data for ambulation are shown in Table 5).

Water maze tests performed to assess the offspring functional development of offspring revealed no significant intergroup variations in achievement times (Fig. 7). In the trial, there was no difference in achievement time. The time spent in the training quadrant was increased for males exposed to the EMF at low and high levels (Fig. 8).

One nephroblastoma was observed in a female receiving the high dose of the EMF. Sporadic minimal lesions at low incidences were observed in all groups, but there were no statistically significant differences between groups (data not shown).

There were no significant differences in histopathological findings among the groups in any of the 10 organs examined (Table 6).

Persistent estrus and prolongation of the estrus cycle were observed in one female exposed to the high EMF, but there was no problem with mating. No obvious changes were evident in the offspring in indices of male and female fertility such as copulation indices in both males and females and fertility indices in the females and days required until successful copulation. There were no observable macroscopic alterations in any organs of rats used for the fertility tests. In pregnant F<sub>1</sub> females, no particular abnormalities in general condition were

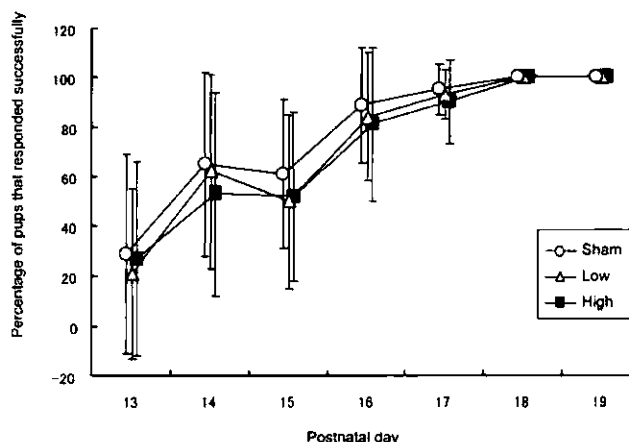


FIG. 5. Successful mid-air righting reflex as a function of postnatal day. Points are means ± SD. There were no differences in the reflex at any day examined.

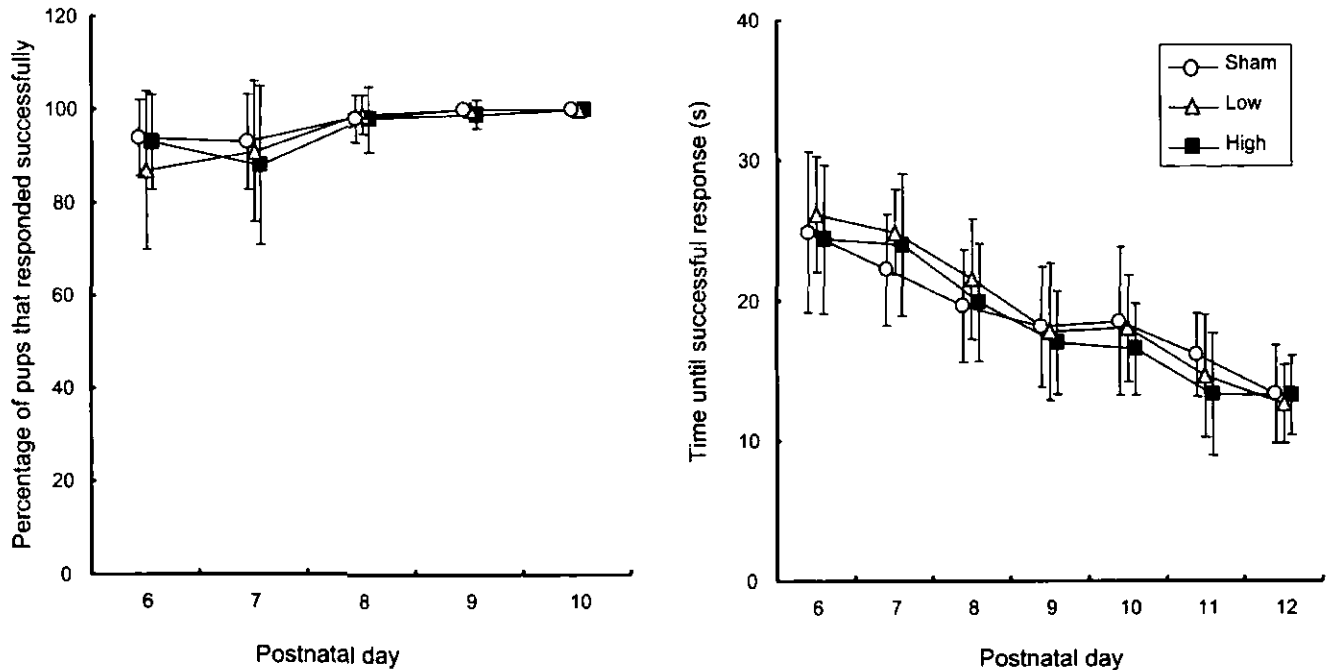


FIG. 6. Righting reflex (left panel) and negative geotaxis (right panel) as a function of postnatal day. For the surface righting reflex, the percentages of pups that successfully righted themselves within 5 s are shown. The data for negative geotaxis represent the response time required to rotate 180° and turn the head up. Points are means  $\pm$  SD. No statistically differences were found in either test.

evident during the gestation period, and body weight gain did not vary among the groups (Table 7).

The examination of pregnant  $F_1$  females revealed that the number of corpora lutea was decreased and the body weights of live fetuses were increased in the low- but not the high-exposure group (Table 8).

## DISCUSSION

Overall, the present study did not identify any adverse effects of exposure to a 2.14 GHz (Downlink) W-CDMA signal for 20 h/day. The value of the present negative results, however, could be limited by the lack of a positive control. The data from intensive investigations of dams and  $F_1$  and  $F_2$  generations presented here did demonstrate some statistically significant differences between the EMF sham-exposure and exposure groups.

For example, the body weights of males exposed to the EMF were increased. However, such changes were transient and were not considered to be due to the EMF exposure. Among seven physiological development indicators, delay of pinna unfolding was demonstrated in the high-exposure group at day 2 but not at day 3. Furthermore, while the number of corpora lutea in the pregnant  $F_1$  females was found to be decreased in the low-exposure group, a decrease was not present in the high-exposure group. Thus none of the experimental results demonstrated any consistent adverse biological effects of whole-body exposure to the EMF on gestation and lactation in either dams or  $F_1$  rats under our experimental conditions.

The potential vulnerability of children to RF fields has been emphasized. On a theoretical basis, it is reasonable to assume that tissues and/or organs in the

TABLE 5  
Open Field Testing of Offspring

Exposure level	No. of rats examined	5 weeks			8 weeks		
		First day	Second day	Third day	First day	Second day	Third day
<b>Male</b>							
Sham	24	304 $\pm$ 54	217 $\pm$ 61	217 $\pm$ 57	224 $\pm$ 64	224 $\pm$ 51	246 $\pm$ 54
Low	22	313 $\pm$ 64	235 $\pm$ 76	243 $\pm$ 75	243 $\pm$ 78	217 $\pm$ 66	239 $\pm$ 76
High	23	314 $\pm$ 66	240 $\pm$ 59	232 $\pm$ 72	238 $\pm$ 75	216 $\pm$ 58	236 $\pm$ 62
<b>Female</b>							
Sham	24	349 $\pm$ 43	279 $\pm$ 72	269 $\pm$ 75	303 $\pm$ 77	287 $\pm$ 66	302 $\pm$ 62
Low	22	377 $\pm$ 65	293 $\pm$ 77	288 $\pm$ 79	305 $\pm$ 67	286 $\pm$ 81	269 $\pm$ 78
High	24	373 $\pm$ 61	298 $\pm$ 79	287 $\pm$ 0	287 $\pm$ 101	315 $\pm$ 79	307 $\pm$ 78

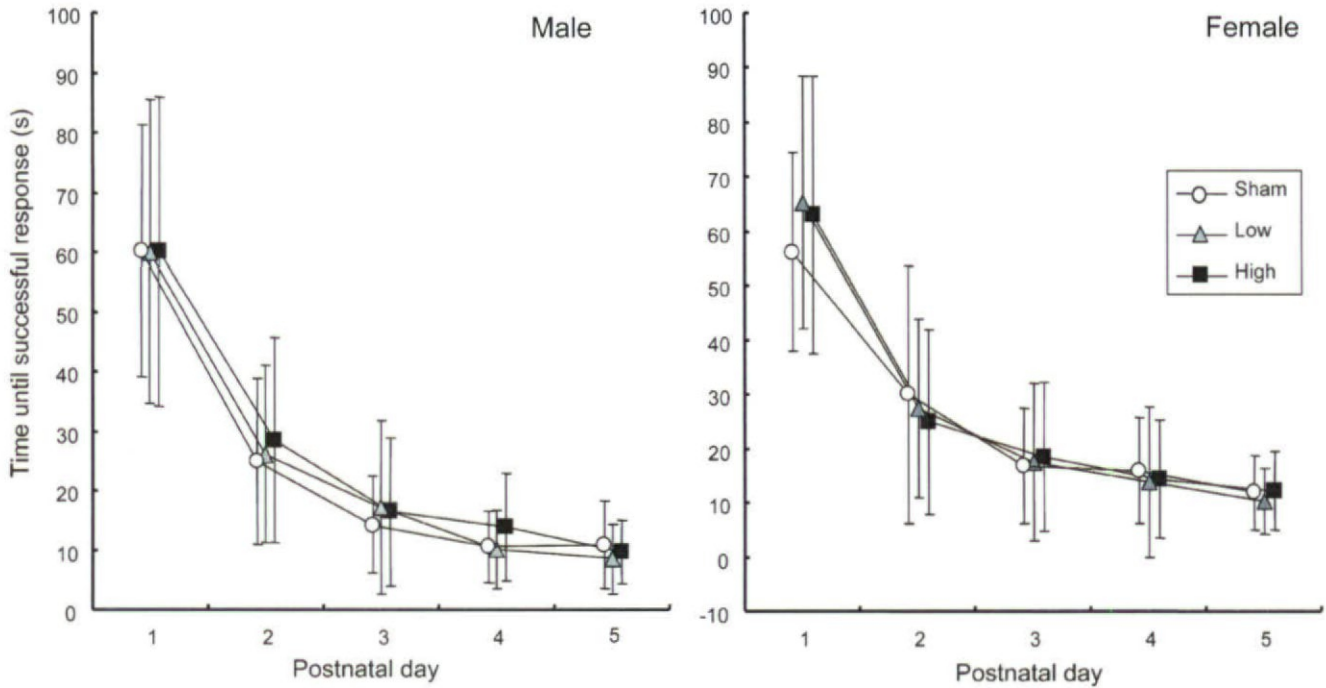


FIG. 7. Water maze test results for male and female offspring. Neither males nor females demonstrated any effects of EMF exposure. The numbers of rats examined in the sham, low and high groups were 24, 22 and 23 for the males and 24, 22 and 24 for females, respectively. Points are means  $\pm$  SD.

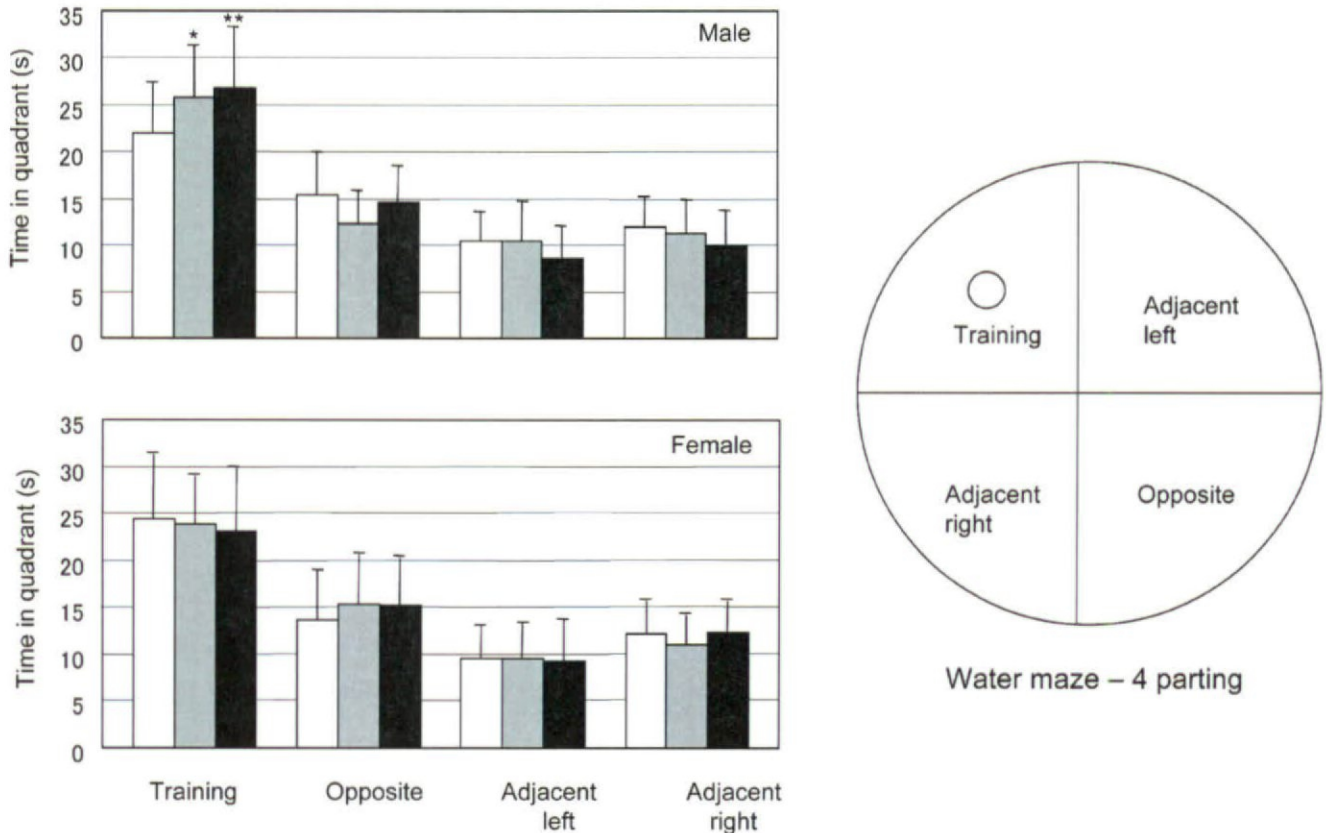


FIG. 8. Water maze test of male and female offspring in the prove form. There were no differences in the time to reach the right place in either males or females except for low- and high-dose EMF in Training and low-dose EMF in Opposite. The numbers of rats examined in sham, low and high groups were 24, 22 and 23 for the males and 24, 22 and 24 for females, respectively. Points are means  $\pm$  SD. \*, \*\*: Significantly different from control group at  $P < 0.05, 0.01$ , respectively.

TABLE 6  
Mean Relative Organ Weights in F<sub>1</sub> Rats

Group	EMF levels	No. of rats	Brain	Pituitary	Heart	Lung	Liver	Kidney	Spleen	Thymus	Testis/ovary	Prostate
Males												
1	Sham	36	0.46	0.0029	0.31	0.31	4.106	0.68	0.17	0.126	0.700	0.144
2	Low	36	0.45	0.0029	0.30	0.30	4.106	0.70	0.17	0.110**	0.684	0.145
3	High	34	0.44	0.0030	0.32	0.30	4.088	0.68	0.17	0.115*	0.663	0.143
Females												
1	Sham	36	0.69	0.0055	0.34	0.39	3.809	0.71	0.19	0.186	0.044	—
2	Low	32	0.69	0.0056	0.35	0.39	3.827	0.72	0.20	0.167*	0.044	—
3	High	39	0.67	0.0054	0.35	0.39	3.809	0.72	0.20	0.173	0.045	—

Note. \*, \*\* $P < 0.05, 0.01$ , respectively (Bartlett's test and one-way analysis of variance or Kruskal-Wallis's test).

developmental and differentiation period would be more sensitive to various physical stimuli like EMFs, as is the case with elevated toxicities of various chemicals (2-4). However, there have been a few studies with premature experimental animals, and no specific type of malformation or other adverse outcome has been reported consistently (6). Mjoen *et al.* (16) investigated reproductive outcomes derived from the Medical Birth Registry of Norway and found that paternal occupational exposure to EMFs was positively associated with preterm birth and some defects but was negatively associated with risk of cleft lip and gastrointestinal defects. Thus the data were inconsistent. Haarala *et al.* reported that there was no effect on the cognitive function of 10-14 year-old-children after exposure to a standard 902 MHz global system for mobile communication mobile phones (17). Experimentally, exposure of pregnant rats and fetuses to a 900 MHz cellular phone EMF at 17.5 and 75 W/kg whole-body average SAR did not cause any adverse effects on operant-behavior performance assayed after the offspring reached adulthood (18).

Recently, the group of Odaci published experimental data showing that prenatal or postnatal local exposure of the whole brain to a near field of 900 MHz EMF at 2 W/kg SAR for 60 min/day caused cellular loss in the hippocampus in rats (19, 20). In particular, the finding

TABLE 7  
Fertility Data for Offspring

Group	1	2	3
Exposure level	Sham	Low	High
No. of males examined	12	10	11
No. of males with successful copulation	12	10	11
Copulation index (%)	100	100	100
No. of females examined	12	10	12
No. of females with successful copulation	12	10	11
Copulation index (%)	100	100	92
Fertility index	100	100	100
No. of days for copulation	2.8 ± 1.7	2.7 ± 1.4	3.5 ± 2.5

that fetuses of maternally exposed rats developed abnormalities in the hippocampus appears to be important (19). Although they did not mention the SARs for the fetuses, they can be assumed to be very low, because the peak SAR was 2 W/kg at each dam's nose. Their results conflict with the data from our recent study (21) and the present work, and their positive results should be confirmed by other researchers. Positive controls might also be included in future studies, but the selection of appropriate controls should be made carefully.

To our knowledge, the present study of the effects of whole-body exposure of dams and pups during gestation and lactation examining a large number of end point is the most comprehensive to date. Based on our results, we conclude that 20 h continuous whole-body exposure per day of pregnant rats and newborns did not cause any

TABLE 8  
Data for Offspring of Pregnant F<sub>1</sub> Females

Group	1	2	3
Exposure level	Sham	Low	High
No. rats examined	12	10	11
No. of corpora lutea	20.7 ± 4.6	16.9 ± 1.8*	20.6 ± 3.2
No. of implantations	14.4 ± 2.2	14.9 ± 1.8	15.4 ± 2.8
No. of dead fetuses			
Total (%)	10 (6.2 ± 6.9)	9 (6.0 ± 6.3)	6 (3.4 ± 5.1)
Early resorption sites (%)	10 (6.2 ± 6.9)	9 (6.0 ± 6.3)	6 (3.4 ± 5.1)
Late resorption sites (%)	0	0	0
No. of live fetuses	13. ± 2.6	14.0 ± 1.9	14.8 ± 2.7
Sex ratio (males/females)	1.09 ± 0.56	1.45 ± 1.26	1.24 ± 0.91
Body weight of live fetuses (g)	3.56 ± 0.26	4.00 ± 0.50**	3.70 ± 0.35
Placental weight (g)	0.46 ± 0.05	0.46 ± 0.04	0.49 ± 0.08
No. fetuses with abnormality (%)	3 (2.8 ± 9.6) <sup>a</sup>	0	1 (0.7 ± 2.3) <sup>b</sup>

Note. \*, \*\* $P < 0.05, 0.01$ , respectively (the Bartlett's test and one-way analysis of variance or the Kruskal-Wallis's test).

<sup>a</sup> Two fetuses, dwarf; 1 fetus, dwarf, omphalocele and subcutaneous hemorrhage.

<sup>b</sup> Subcutaneous hemorrhage.

adverse effects on dams and F<sub>1</sub> rats under our experimental conditions. Extrapolation of the present data to humans is not simple, because there are clearly differences between rats and humans. As discussed, although the value of the present negative results may be limited by the lack of a positive control, the data are valuable for evaluation of the potential risk of whole-body exposure to EMFs and suggest that under similar conditions pregnant human mothers and their children would not be affected by whole-body exposure to mobile telecommunication EMFs from a base station.

#### ACKNOWLEDGMENT

This work was supported by a Grant from the Ministry of Internal Affairs and Communications, Japan, for 2006 and 2007.

Received: October 15, 2008; accepted: October 23, 2009; published online: December 23, 2009

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# United States Department of the Interior

OFFICE OF THE SECRETARY  
WASHINGTON, D.C. 20240

FEB - 7 2014



In Reply Refer To: (ER 14/0001) (ER 14/0004).

Mr. Eli Veenendaal  
National Telecommunications and Information  
Administration  
U.S. Department of Commerce  
1401 Constitution Avenue, N.W.  
Washington, D.C. 20230

Dear Mr. Veenendaal:

The Department of the Interior (Department) has reviewed the above referenced proposal and submits the following comments and attachment for consideration. Because the First Responder Network Authority (FirstNet) is a newly created entity, we commend the U.S. Department of Commerce for its timely proposals for NEPA implementing procedures.

The Department believes that some of the proposed procedures are not consistent with Executive Order 13186 Responsibilities of Federal Agencies to Protect Migratory Birds, which specifically requires federal agencies to develop and use principles, standards, and practices that will lessen the amount of unintentional take reasonably attributed to agency actions. The Department, through the Fish and Wildlife Service (FWS), finds that the proposals lack provisions necessary to conserve migratory bird resources, including eagles. The proposals also do not reflect current information regarding the effects of communication towers to birds. Our comments are intended to further clarify specific issues and address provisions in the proposals.

The Department recommends revisions to the proposed procedures to better reflect the impacts to resources under our jurisdiction from communication towers. The placement and operation of communication towers, including un-guyed, unlit, monopole or lattice-designed structures, impact protected migratory birds in two significant ways. The first is by injury, crippling loss, and death from collisions with towers and their supporting guy-wire infrastructure, where present. The second significant issue associated with communication towers involves impacts from non-ionizing electromagnetic radiation emitted by them (See Attachment).

In addition to the 147 Birds of Conservation Concern (BCC) species, the FWS has listed an additional 92 species as endangered or threatened under the Endangered Species Act. Together with the bald and golden eagle, this represents 241 species of birds whose populations are in trouble or otherwise merit special protection, according to the varying criteria of these lists. The Department suggests that FirstNet consider preparing a programmatic environmental impact statement (see attachment) to determine and address cumulative impacts from authorizing FirstNet projects on those 241 species for which the incremental impact of tower mortality, when

added to other past, present, and reasonably foreseeable future actions, is most likely significant, given their overall imperiled status. Notwithstanding the proposed implementing procedures, a programmatic NEPA document might be the most effective and efficient method for establishing best management practices for individual projects, reducing the burden to individual applicants, and addressing cumulative impacts.

#### *Categorical Exclusions*

The Department has identified 13 of the proposed categorical exclusions (A-6, A-7, A-8, A-9, A-10, A-11, A-12, A-13, A-14 A-15, A-16, A-17, and A-19) as having the potential to significantly affect wildlife and the biological environment. Given this potential, we want to underscore the importance of our comments on FirstNet's procedural guidance under Environmental Review and Consultation Requirements for NEPA Reviews and its list of extraordinary circumstances in Appendix D.

#### *Environmental Review and Consultation Requirements for NEPA Reviews*

To ensure there are no potentially significant impacts on birds from projects that may otherwise be categorically excluded, the Department recommends including the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act to the list of requirements in this section.

#### *Extraordinary Circumstances*

To avoid potentially significant impacts on birds from projects that may otherwise be categorically excluded, the Department recommends including species covered under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act to the list of environmentally sensitive resources. Additionally, adding important resources to migratory birds such as sites in the Western Hemisphere Shorebird Reserve Network and Audubon Important Bird Areas to the paragraph on areas having special designation or recognition would help ensure their consideration when contemplating use of a categorical exclusion.

#### *Developing the Purpose and Need*

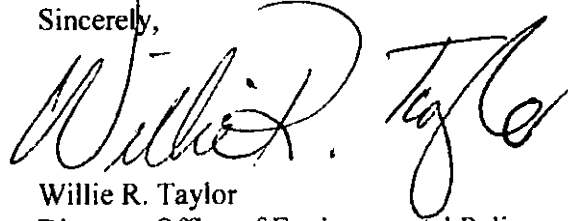
The Department recommends inclusion of language that would ensure consideration of all other authorities to which NEPA is supplemental as opposed to simply the FirstNet mission. As currently written, the procedures are limited to ensuring the purpose and need considers the FirstNet mission. If strictly applied, this approach would severely limit the range of reasonable alternatives, and likely preclude consideration of more environmentally benign locations or construction practices.

#### *Environmental Review Process. Apply NEPA Early in the Process, Where Action is by Non-Federal Entity*

The Department recommends that FirstNet be required to coordinate with federal agencies having jurisdiction by law or special expertise on construction and lighting of its network of towers.

Thank you for the opportunity to comment on the draft document. If you have any questions concerning the comments, please contact Diana Whittington, NEPA Migratory Bird lead, at (703) 358-2010. If you have any questions regarding Departmental NEPA procedures, contact Lisa Treichel, Office of Environmental Policy and Compliance at (202) 208-7116.

Sincerely,

A handwritten signature in black ink, appearing to read "Willie R. Taylor". The signature is written in a cursive style with a large initial "W" and a long, sweeping tail.

Willie R. Taylor  
Director, Office of Environmental Policy  
and Compliance

Enclosure

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## Enclosure A

### Background

The placement and operation of communication towers, including un-guyed, unlit, monopole or lattice-designed structures, impact protected migratory birds in two significant ways.

The first is by injury, crippling loss, and death from collisions with towers and their supporting guy-wire infrastructure, where present. Mass mortality events tend to occur during periods of peak spring and fall songbird migration when inclement weather events coincide with migration, and frequently where lights (either on the towers and/or on adjacent outbuildings) are also present. This situation has been well documented in the U.S. since 1948 in the published literature (Aronoff 1949, see Manville 2007a for a critique). The tallest communication towers tend to be the most problematic (Gehring *et al.* 2011). However, mid-range (~400-ft) towers as proposed by the First Responder Network Authority (FirstNet, a newly created entity under the Department of Commerce) can also significantly impact protected migratory birds, as can un-guyed and unlit lattice and monopole towers (Gehring *et al.* 2009, Manville 2007a, 2009, 2013a). Mass mortalities (more than several hundred birds per night) at un-guyed, unlit monopole and lattice towers were documented in fall 2005 and 2011 in the Northeast and North Central U.S. (*e.g.*, Manville 2007a). It has been argued that communication towers including “short” towers do not impact migratory birds, including at the population level (*e.g.*, Arnold and Zink 2011), but recent findings have contradicted that assertion (Manville 2007a, 2013a, Longcore *et al.* 2012, 2013).

The second significant issue associated with communication towers involves impacts from non-ionizing electromagnetic radiation emitted by these structures. Radiation studies at cellular communication towers were begun circa 2000 in Europe and continue today on wild nesting birds. Study results have documented nest and site abandonment, plumage deterioration, locomotion problems, reduced survivorship, and death (*e.g.*, Balmori 2005, Balmori and Hallberg 2007, and Everaert and Bauwens 2007). Nesting migratory birds and their offspring have apparently been affected by the radiation from cellular phone towers in the 900 and 1800 MHz frequency ranges – 915 MHz is the standard cellular phone frequency used in the United States. However, the electromagnetic radiation standards used by the Federal Communications Commission (FCC) continue to be based on thermal heating, a criterion now nearly 30 years out of date and inapplicable today. This is primarily due to the lower levels of radiation output from microwave-powered communication devices such as cellular telephones and other sources of point-to-point communications; levels typically lower than from microwave ovens. The problem, however, appears to focus on very low levels of non-ionizing electromagnetic radiation. For example, in laboratory studies, T. Litovitz (personal communication) and DiCarlo *et al.* (2002) raised concerns about impacts of low-level, non-thermal electromagnetic radiation from the standard 915 MHz cell phone frequency on domestic chicken embryos – with some lethal results (Manville 2009, 2013a). Radiation at extremely low levels (0.0001 the level emitted by the average digital cellular telephone) caused heart attacks and the deaths of some chicken embryos subjected to hypoxic conditions in the laboratory while controls subjected to hypoxia were unaffected (DiCarlo *et al.* 2002). To date, no independent, third-party field studies have been conducted in North America on impacts of tower electromagnetic radiation on migratory birds. With the European field and U.S. laboratory evidence already available,

independent, third-party peer-reviewed studies need to be conducted in the U.S. to begin examining the effects from radiation on migratory birds and other trust species.

## **Discussion**

### ***Collision Deaths and Categorical Exclusions***

Attempts to estimate bird-collision mortality at communication towers in the U.S. resulted in figures of 4-5 million bird deaths per year (Manville 2005, 2009). A meta-review of the published literature now suggests, based on statistically determined parameters, that mortality may be 6.8 million birds per year in Canada and the U.S.; the vast majority in the United States (Longcore *et al.* 2012). Up to 350 species of birds have been killed at communication towers (Manville 2007a, 2009). The Service's Division of Migratory Bird Management has updated its voluntary, 2000 communication tower guidelines to reflect some of the more recent research findings (Manville 2013b). However, the level of estimated mortality alone suggests at a minimum that FirstNet prepare an environmental assessment to estimate and assess the cumulative effects of tower mortality to protected migratory birds.

A second meta-review of the published mortality data from scientific studies conducted in the U.S. and Canada (Longcore *et al.* 2013) strongly correlates population effects to at least 13 species of Birds of Conservation Concern (BCC, USFWS 2008). These are mortalities to BCC species based solely on documented collisions with communication towers in the U.S. and Canada, ranging from estimated annual levels of mortality of 1 to 9% of their estimated total population. Among these where mortality at communication towers was estimated at over 2% annually are the Yellow Rail, Swainson's Warbler, Pied-billed Grebe, Bay-breasted Warbler, Golden-winged Warbler, Prairie Warbler, and Ovenbird. Longcore *et al.* (2013) emphasized that avian mortality associated with anthropogenic sources is almost always reported in the aggregate, *i.e.*, "number of birds killed," which cannot detect species-level effects necessary to make effective and meaningful conservation assessments, including determining cumulative effects. These new findings strongly suggest the need for at least an environmental assessment by FirstNet, or more likely, an environmental impact statement.

### ***Radiation Impacts and Categorical Exclusions***

There is a growing level of anecdotal evidence linking effects of non-thermal, non-ionizing electromagnetic radiation from communication towers on nesting and roosting wild birds and other wildlife in the U.S. Independent, third-party studies have yet to be conducted in the U.S. or Canada, although a peer-reviewed research protocol developed for the U.S. Forest Service by the Service's Division of Migratory Bird Management is available to study both collision and radiation impacts (Manville 2002).

As previously mentioned, Balmori (2005) found strong negative correlations between levels of tower-emitted microwave radiation and bird breeding, nesting, and roosting in the vicinity of electromagnetic fields in Spain. He documented nest and site abandonment, plumage deterioration, locomotion problems, reduced survivorship, and death in House Sparrows, White Storks, Rock Doves, Magpies, Collared Doves, and other species. Though these species had historically been documented to roost and nest in these areas, Balmori (2005) did not observe these symptoms prior to construction and operation of the cellular phone towers. Balmori and Hallberg (2007) and Everaert and Bauwens (2007) found similar strong negative correlations

among male House Sparrows. Under laboratory conditions, DiCarlo *et al.* (2002) raised troubling concerns about impacts of low-level, non-thermal electromagnetic radiation from the standard 915 MHz cell phone frequency on domestic chicken embryos – with some lethal results (Manville 2009). Given the findings of the studies mentioned above, field studies should be conducted in North America to validate potential impacts of communication tower radiation – both direct and indirect – to migratory birds and other trust wildlife species.

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Bioelectromagnetics. 2004 Feb;25(2):73-83.

## Cellular phone use does not acutely affect blood pressure or heart rate of humans.

Tahvanainen K<sup>1</sup>, Niño J, Halonen P, Kuusela T, Laitinen T, Länsimies E, Hartikainen J, Hietanen M, Lindholm H.

### Author information

### Abstract

A recent study raised concern about increase of resting blood pressure after a 35 min exposure to the radiofrequency (RF) field emitted by a 900 MHz cellular phone. In this randomized, double blind, placebo controlled crossover trial, 32 healthy subjects were submitted to 900 MHz (2 W), 1800 MHz (1 W) cellular phone exposure, and to sham exposure in separate sessions. Arterial blood pressure (arm cuff method) and heart rate were measured during and after the 35 min RF and sham exposure sessions. We evaluated cardiovascular responses in terms of blood pressure and heart rate during controlled breathing, spontaneous breathing, head-up tilt table test, Valsalva manoeuvre and deep breathing test. Arterial blood pressure and heart rate did not change significantly during or after the 35 min RF exposures at 900 MHz or 1800 MHz, compared to sham exposure. The results of this study indicate that exposure to a cellular phone, using 900 MHz or 1800 MHz with maximal allowed antenna powers, does not acutely change arterial blood pressure and heart rate.

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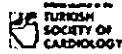
PMID: 14735556 DOI: [10.1002/bem.10165](https://doi.org/10.1002/bem.10165)

[Indexed for MEDLINE]

### Publication types, MeSH terms

### LinkOut - more resources





Anatol J Cardiol. 2016 Nov; 16(11): 833–838.

PMCID: PMC5324882

Published online 2016 Apr 7. doi: [10.14744/AnatolJCardiol.2016.6717](https://doi.org/10.14744/AnatolJCardiol.2016.6717)

PMID: [27109242](https://pubmed.ncbi.nlm.nih.gov/27109242/)

## The effects of the duration of mobile phone use on heart rate variability parameters in healthy subjects

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Accepted 2016 Jan 26.

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### Abstract

#### Objective:

This study aimed to estimate the influence of the duration of mobile phone use on heart rate variability (HRV) in healthy individuals.

#### Methods:

One hundred forty-eight individuals without any established systemic disease and who had undergone 24-h ambulatory ECG monitoring were included in the case-control study. All the individuals had been using mobile phones for more than 10 years. Three-channel 24-h Holter monitoring was performed to derive the mean heart rate, standard deviation of normal NN intervals (SDNN), standard deviation of 5-min (m) mean NN intervals (SDANN), the proportion of NN50 divided by the total number of NNs (pNN50), the root mean square differences of successive NN intervals (RMSSD), high (HF)-, low (LF)-, very low (VLF)-frequency power, total power components, and the LF/HF ratio. Individuals were divided into four groups according to their duration of mobile phone use [no mobile phone use (Control group), <30 min/day (Group 1), 30–60 min/day (Group 2), and >60 min/day (Group 3)].

#### Results:

All the groups had similar features with regard to demographic and clinical characteristics. No significant arrhythmias were observed in any of the groups. The LF/HF ratio was higher, whereas the SDNN, SDANN, RMSSD, and pNN50 values were lower in the study groups than in the control group ( $p < 0.05$ ). No significant differences were identified among groups with respect to heart rate, VLF, and total power values ( $p > 0.05$ ).

#### Conclusion:

In this study, it was shown that the duration of mobile phone use may affect the autonomic balance in healthy subjects. The electromagnetic field created by mobile phone use may induce HRV changes in the long term.

**Keywords:** electromagnetic field, heart rate variability, mobile phone

## Introduction

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Mobile phone (MP) technology has grown significantly over the past decade and has become an essential part of our everyday lives. However, due to the widespread exposure to electromagnetic fields (EMF) from mobile communication systems, there may be some negative effects on health in the living environment. It is possible that EMF generated by MPs may have an influence on the autonomic nervous system (ANS), which modulates the function of the circulatory system (1). The assessment of heart rate variability (HRV) is one of the most popular methods for evaluating autonomic modulations of the heart. It reflects the normalizing autonomic function and identifies the cardiac autonomic regulation. Increasing evidence has suggested that EMF emitted by MPs interacts with the human organism because they represent a potential source of electromagnetic interference. Thus, the cardiovascular system may be a potential target for the EMF emitted by MPs (2). HRV analysis is a non-invasive method for assessing autonomic imbalance, where a low HRV is correlated with a high cardiovascular risk (3). Nowadays, MPs are almost ubiquitously used as communication tools, so *knowing their effects on humans, especially on the autonomic nervous system, is very important*. However, there are only a limited number of studies on the effects of the duration of MP use on HRV parameters in healthy subjects. The aim of the study was therefore to estimate the influence of the duration of MP use on HRV in healthy subjects. Time and frequency domain HRV analyses were performed to assess the changes in sympathovagal balance in a group of 148 healthy individuals with a normal electrocardiogram and echocardiogram at rest.

## Methods

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### Participants and the study design

The sample was derived from a population of 251 consecutive volunteers who underwent 24-h ambulatory ECG monitoring for the study purposes. These volunteers were recruited from the hospital staff with no known diseases, healthy friends and relatives of the hospital staff, and healthy volunteers who presented to the blood bank unit of the hospital (three participants) for blood donation. The HRV analyses of the three participants were done 1 week after blood donation in order not to affect the results. The inclusion criteria were age >18 years, an interference-free 24-h Holter ECG monitoring, and the patient's consent. All the participants were healthy, and none of them were on pharmacological treatment. Also, the investigated persons underwent 12-lead electrocardiographic (ECG) examination and echocardiography at rest. Patients with coronary heart disease, heart failure, congenital heart disease, fever, hypoxia, a history of arrhythmia, neurological disease, endocrine disorder, and hypertension at the time of HRV measurement were not included in the study. The physical activity level and sedentary behavior of the participants were evaluated by an experienced physical therapist using the short-form International Physical Activity Questionnaire (IPAQ), calculated in metabolic equivalent units per week. Participants who had a high or moderate level of physical activity were excluded, while those who had a low level of physical activity were included in the study (4). In all the individuals, systolic and diastolic functions of the left ventricle assessed by transthoracic echocardiography were normal. The median ejection fraction was 64.0 (61.0–65.0), and no hemodynamically significant valvular pathologies were found. In total, 103 patients were excluded because they met the exclusion criteria (n=77) or did not fulfill the inclusion criteria (n=26). Finally, 148 subjects (85 women and 63 men) with no established systemic disease were included in the study. All the participants (except the controls) had been using MPs for >10 years prior to the study. The

durations of mobile phone use were determined retrospectively from the individuals' telephone billing records. Daily durations of mobile phone use were calculated automatically by dividing the total duration of calls (total min within a month) into the number of telephone calls (total number within a month). This study protocol was approved by the local Ethics Committee, Ankara, Turkey, and was conducted in accordance with the rules of the Declaration of Helsinki. Written and oral information was given to all patients before testing. All the participants gave their written informed consent for participation. We performed 24-h ECG monitoring using a three-channel amplitude-modulated tape recorder (DMS 300-3A Digital Holter Recorder, California, USA). The whole period of 24-h Holter recordings were used to determine the HRV parameters. The program specified and tagged each QRS complex automatically, with an exact determination of the reference points for the QRS complexes. The consecutive RR intervals from the 24-h ECG Holter monitoring were visually evaluated for identifying and eliminating artifacts, as has been previously described in the literature, and then estimation of the time and frequency domain characteristics of HRV was performed (5). All the tapes were subsequently analyzed by measuring HRV in the time and frequency domain, using a commercially available program. The time domain analysis of HRV included the standard deviation of N–Ns (SDNN), the standard deviation of the 5-min mean values of N–Ns (SDANN), the root mean square successive difference of N–Ns (RMSSD), and the percentage of successive N–N differences >50 ms for each 5-min interval (pNN50%). The frequency domain analysis of HRV included very low-frequency power (VLF: 0.003–0.04 Hz), low-frequency power (LF: 0.04–0.15 Hz), high-frequency power (HF: 0.16–0.40 Hz), total power (0.01–1.00 Hz) components, and the LF/HF ratio (6–8). Although the parasympathetic mechanisms probably contribute to the power comprised in the LF band, LF/HF is a simple and accepted tool that allows a description of the balance between the two limbs of the autonomic nervous system (9). The individuals were divided into four groups according to the duration of MP use: no mobile phone use (Control group), <30 m/day (Group 1), 30–60 m/day (Group 2), and >60 m/day (Group 3).

### Statistical analysis

The data were analyzed with the IBM SPSS Statistics 21 program for Windows. The normal distribution of variables was verified with the Kolmogorov–Smirnov test. Spearman's rho correlation was used when one or both of the variables were not normally distributed. We used the Kruskal–Wallis test for the differences among groups. The Conover–Inman test was used to analyze the specific sample pairs for the significant differences. A chi-square ( $\chi^2$ ) test was used to investigate whether the distributions of the categorical variables differed within the groups. Moreover, binary logistic regression analyses were conducted according to age, sex, and BMI. The patients' characteristics were summarized as medians (25<sup>th</sup>–75<sup>th</sup> percentile) or as percentages. A p value <0.05 was considered statistically significant.

### Results

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The median age of the study population was 30.0 (24.0–39.0) years, and 42.6% of the participants were male. LF/HF ratio was significantly greater in the study groups than in the control subjects, which may reflect a change in sympathovagal balance in favor of an increased sympathetic tone (Tables 1, 2, Fig. 1,  $p<0.001$ ). Similarly, a significant positive correlation was found between the LF/HF ratio and the total duration of calls (Fig. 2,  $p<0.001$ ,  $r=0.757$ ). Also, negative correlations were found between the total duration of calls and SDNN, SDANN, RMSSD, and pNN50 parameters ( $p<0.001$ ,  $r=-0.335$ ;  $p<0.001$ ,  $r=-0.354$ ;  $p<0.001$ ,  $r=-0.491$ ; and  $p<0.001$ ,  $r=-0.499$ , respectively). Likewise, SDNN, SDANN, RMSSD, and pNN50 were lower in Groups 1–3 than in the control group ( $p<0.05$ ). After adjustment for age, sex, and BMI, the relationship between the duration of MP use to LF/HF ratio maintained its significance [ $p<0.001$ ; adjusted OR=1.667 (95% CI, 1.319–2.108)]. Table 1 shows the baseline characteristics according to the duration of the MP use groups. Men were using MPs longer than

women in our study ( $p < 0.001$ ). Also, higher LF/HF ratios and SDNN values were calculated in men than in women [3.8 (2.3–6.6); 2.3 (1.8–4.3) and 146.0 (122.0–178.0); 129.0 (108.0–158.0), respectively] ( $p = 0.001$  and  $p = 0.037$ , respectively). According to the duration of MP use, 35 of the patients (23.6%) were not using MPs (the controls), 37 of the patients (25%) were using a MP for less than 30 min (Group I), 37 of them (25%) were using a MP for 30–60 min (Group II), and 39 of them (26.4) were using a MP for longer than 60 min per day. The median LF/HF ratios were 1.9 (1.6–2.8) in the control group; 2.2 (1.6–3.0) in Group I; 3.7 (2.2–5.9) in Group II, and 5.4 (3.6–7.9) in Group III (Table 1). According to Spearman's rho analysis, positive statistically significant correlations between the LF/HF ratio and age and the LF/HF ratio and BMI were determined ( $p < 0.001$ ,  $r = 0.284$ ;  $p = 0.002$ ,  $r = 0.254$ , respectively). The binary comparisons according to the duration of mobile phone use are shown in Table 2.

Table 1

Baseline characteristics according to the duration of mobile phone use

	Controls (n=35)	Group I (n=37)	Group II (n=37)	Group III (n=39)	P
Age, years	28.0 (23.0–33.0)	27.0 (22.0–37.5)	31.0 (26.0–40.0)	33.0 (25.0–40.0)	0.133
BMI, kg/m <sup>2</sup>	23.4 (21.1–27.8)	24.0 (21.3–27.4)	27.5 (22.5–32.0)	25.9 (23.0–28.4)	0.078
Telephone calls, n. per month	0.0 (0.0–0.0) <sup>a,b,c</sup>	101.0 (96.0–108.5) <sup>a,d,e</sup>	161.0 (131.1–198.2) <sup>b,d,f</sup>	279.0 (230.1–345.3) <sup>c,e,f</sup>	<0.001
TDC, min. per month	0.0 (0.0–0.0) <sup>a,b,c</sup>	161.2 (126.2–209.5) <sup>a,d,e</sup>	429.0 (329.1–537.2) <sup>b,d,f</sup>	1050.0 (743.2–1458.0) <sup>c,e,f</sup>	<0.001
ETCD, min	0.0 (0.0–0.0) <sup>a,b,c</sup>	1.2 (0.8–1.6) <sup>a,d,e</sup>	2.0 (1.5–3.1) <sup>b,d,f</sup>	3.2 (2.9–4.2) <sup>c,e,f</sup>	<0.001
SDNN	149.0 (125.0–178.0) <sup>b,c,e</sup>	139.5 (125.2–172.2) <sup>e</sup>	129.0 (111.2–161.7)	125.0 (99.0–159.0) <sup>e</sup>	0.016
SDANN	135.0 (110.0–164.0) <sup>b,c,e</sup>	122.0 (111.2–156.5) <sup>e</sup>	116.0 (97.2–148.5)	107.5 (87.0–131.7) <sup>e</sup>	0.007
RMSSD	37.0 (27.0–48.0) <sup>b,c</sup>	37.5 (29.2–48.0) <sup>d,e</sup>	27.5 (21.0–44.0) <sup>b,d,f</sup>	25.0 (17.0–31.2) <sup>c,e,f</sup>	<0.001
pNN50	15.0 (7.0–23.0) <sup>b,c,d,e,f</sup>	13.5 (8.0–22.5) <sup>d,e</sup>	7.5 (2.0–21.0) <sup>b,d,f</sup>	5.0 (1.0–10.0) <sup>c,e,f</sup>	<0.001
Min HR	47.5 (43.2–51.7)	46.0 (44.0–51.0)	48.0 (43.0–52.0)	49.0 (43.0–55.0)	0.663
Max HR	145.5 (124.5–157.0)	145.0 (128.0–154.0)	137.0 (125.0–148.0)	139.0 (129.0–148.0)	0.296
Av HR	78.0 (71.0–82.0)	79.0 (73.0–84.5)	77.0 (70.5–84.0)	77.0 (72.0–85.0)	0.779
LF	876.2 (576.3–1310.5)	847.5 (610.6–1223.1)	856.1 (501.1–1206.6)	736.3 (455.1–1147.2)	0.675
HF	406.7 (233.2–640.5) <sup>b,c</sup>	390.8 (243.7–598.4) <sup>e</sup>	201.2 (117.9–437.0) <sup>b</sup>	144.6 (70.2–241.9) <sup>c,e</sup>	<0.001
LF/HF ratio	1.9 (1.6–2.8) <sup>b,c</sup>	2.2 (1.6–3.0)	3.7 (2.2–5.9) <sup>b</sup>	5.4 (3.6–7.9) <sup>c</sup>	<0.001
VLF	3038.2±1658.3	2274.4 (1655.9–3755.3)	2226.0 (1530.9–3587.8)	2316.9 (1289.7–3387.4)	0.387
Total power	3704.9 (2612.4–5892.2)	3623.5 (2652.1–5580.3)	3251.0 (2230.8–5342.1)	3186.8 (2106.3–4395.3)	0.186

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The groups were determined by the duration of mobile phone use (Control group: not using mobile phone, Group I: <30 min/day, Group II: 30–60 min/day, Group III: >60 min/day). Average: BMI - body mass index; ETCD - each telephone call duration; HF - high-frequency power; HR - heart rate; LF - low-frequency power; Max - maximum; Min - minimum; pNN50 - the percentage of successive N–N differences >50 ms for each 5-min interval; RMSSD - the root mean square successive difference of N–Ns; SDANN - the standard deviation of 5 min mean values of N–Ns; SDNN - the standard deviation of N–Ns; TDC - total duration of calls; VLF - very

low frequency power. Kruskal–Wallis test was used for the differences among groups. Conover–Inman test was performed for the binary comparisons among the groups and the *P* value was set at 0.05. Significant differences were found between: a - control vs. group I; b - control vs. group II; c - control vs. group III; d - group I vs. group II; e - group I vs. group III; f - group II vs. group III

Table 2

Binary comparisons according to the duration of mobile phone use

	Controls- Group I <i>P</i>	Controls- Group II <i>P</i>	Controls- Group III <i>P</i>
Age, years	0.986	0.133	0.074
BMI, kg/m <sup>2</sup>	0.537	<b>0.024</b>	0.052
SDNN	0.414	<b>0.044</b>	<b>0.003</b>
SDANN	0.337	<b>0.032</b>	<b>0.001</b>
RMSSD	0.681	<b>0.015</b>	<b>&lt;0.001</b>
pNN50	0.734	<b>0.019</b>	<b>&lt;0.001</b>
Min. HR	0.785	0.798	0.367
Max. HR	0.920	0.134	0.309
Av. HR	0.324	0.789	0.585
LF/HF ratio	0.510	<b>&lt;0.001</b>	<b>&lt;0.001</b>
VLF	0.639	0.242	0.111
Total power	0.871	0.241	0.055

The groups were determined by the duration of mobile phone use (Control group: not using mobile phone, Group I: <30 min/day, Group II: 30–60 min/day, Group III: >60 min/day). Av - average; BMI - body mass index; HF - high-frequency power; HR - heart rate; LF - low-frequency power; Max - maximum; Min - minimum; pNN50 - the percentage of successive N–N differences >50 ms for each 5-min interval; RMSSD - the root mean square successive difference of N–Ns; SDANN - the standard deviation of 5 min mean values of N–Ns; SDNN - the standard deviation of N–Ns; VLF - very low frequency power. Conover–Inman test was performed for the binary comparisons among the groups and the *P* value was set at 0.05

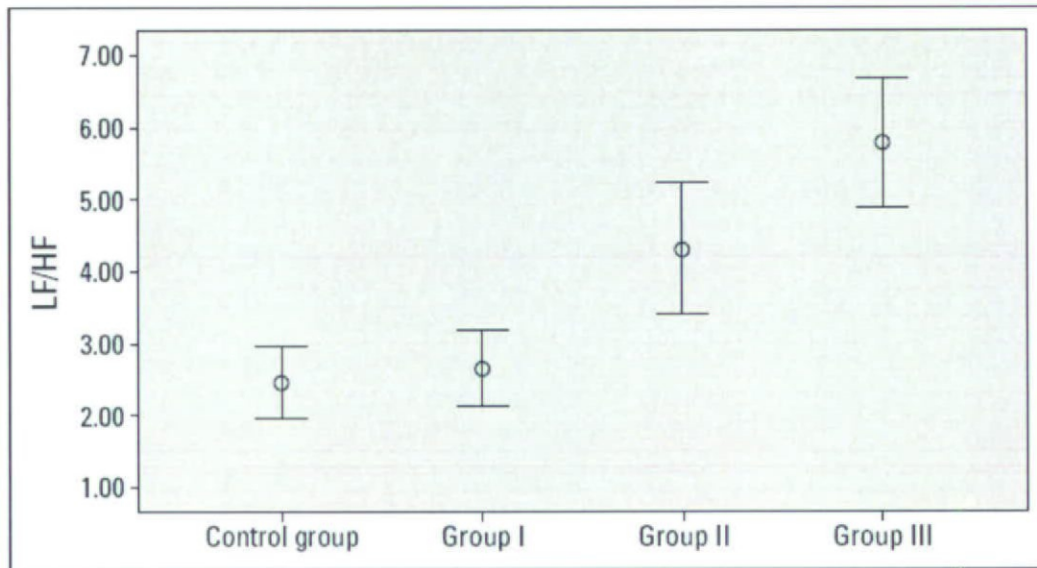
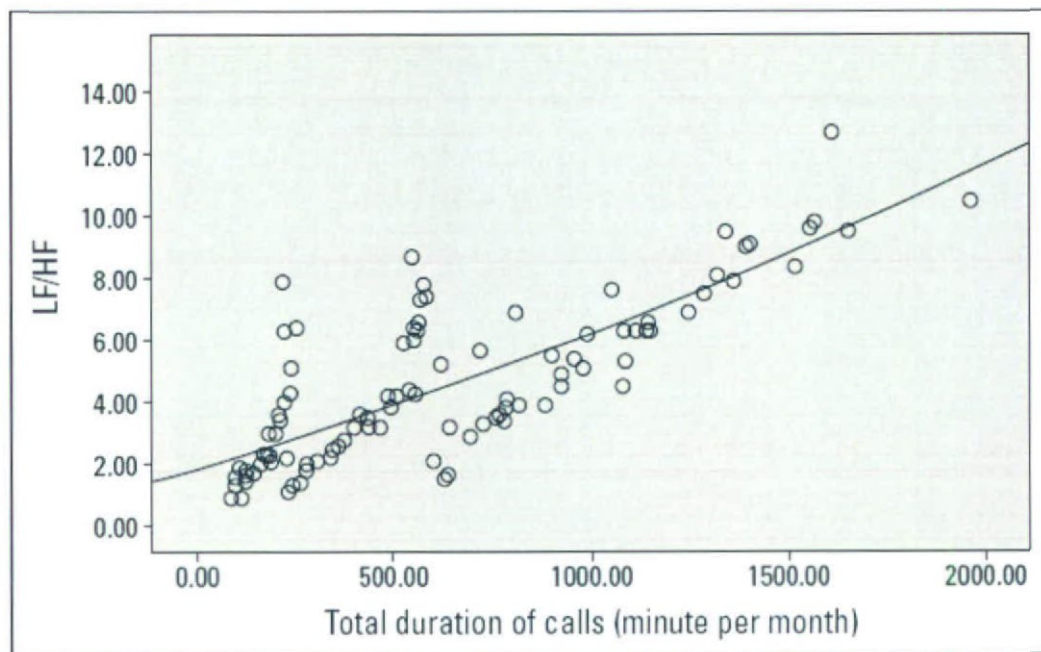


Figure 1

LF/HF ratios according to the duration of mobile phone use. HF - high-frequency power; LF - low-frequency power. The groups were determined by the duration of mobile phone use (Control group: not using mobile phone, Group I: <30 min/day, Group II: 30–60 min/day, and Group III: >60 min/day). For this figure, the error bar graphic was used



**Figure 2**

According to Spearman's rank correlation, the positive correlation between the LF/HF ratio and total duration of calls ( $P < 0.001$ ,  $r = 0.757$ ) is shown. HF - high-frequency power; LF - low-frequency power

## Discussion

In our study, we found a negative correlation between the HRV parameters and the duration of mobile phone use. According to these findings, long-term MP use may reduce the HRV parameters and increase the sympathetic activity. In mobile phone use, the GSM transmits and receives microwave radiation at a frequency of  $\approx 900$  and 1.800 MHz, respectively, and these frequencies excite the rotations of water molecules and some organic molecules and have been associated with thermal and non-thermal effects on the human body (10–13). The emission of these microwaves has been associated with the development of symptoms such as headaches, a sensation of burning skin, fatigue, hot ears, extreme irritation, an increase in carelessness, forgetfulness, a decrease in reflexes, a clicking sound in the ears, and an increase in arterial blood pressure (10). However, despite these well-known effects of MPs, their long-term effect on cardiac electrical activity has not been extensively studied and, to the best of our knowledge, whether MPs alter autonomic regulation of the cardiovascular system has not yet been extensively analyzed.

HRV is a physiological phenomenon that reflects the influence of the autonomic nervous system on sinus node activity, through changes in the length of consecutive RR intervals by breathing and in the heart rate when performing daily activities. It is known that the efferent vagal activity is a major contributor to the HF component, while LF is a marker reflecting both sympathetic and vagal activity, and the LF/HF ratio is considered to mirror the sympathovagal balance or reflect the sympathetic modulations (14). Likewise, it has been reported that RMSSD and PNN50 reflect short-term HRV and are predominantly influenced by the parasympathetic tone, whereas SDNN and SDANN are influenced by both the sympathetic and parasympathetic tone and express long-term HRV. A decreased HRV is found to be a risk factor for the onset of malignant arrhythmias in cardiac patients, related to their sympathetic overactivity (15).

Generally, as MPs are held close to the head, this might affect the autonomic nervous system by their close brain heart connection, which modulates the cardiac pacemaker and provides beat-to-beat regulation of the cardiovascular rhythm (16). Some studies investigating the effect of MP use on cardiac autonomic activity by using HRV analysis are available in the literature. The results of these studies, however, are contradictory. Increased HRV parameters, such as SDNN, SDANN, and VLF, LF, and HF values, and decreased LF/HF ratios have been previously reported with short-term MP use (1). On the contrary, Yıldız et al. (17) reported no significant association between the LF/HF ratio and MP use. It was also reported that the occupational exposition to EMF can cause fluctuations in heart rate and HRV parameters (18). However, Parazzini et al. (19) demonstrated that no statistically significant effect was caused by EMF exposure both on the main (i.e., RR mean) and most of the other HRV parameters. Barutçu et al. (2) showed that short-time exposure to EMF emitted by MPs does not affect cardiac autonomic modulation in healthy subjects. Also, Choi et al. (20) demonstrated that short-term RF radiation emitted by MBs has no effect on either adult or teenager subjects. Likewise, Tamer et al. (21) reported that EMF due to MP use does not affect cardiac electrical activity. Differently, we found an inverse relationship between the duration of MP use and HRV parameters such as SDNN, SDANN, RMSSD, and pNN50. In this case, we can speculate that long-term MP use may cause decreased parasympathetic activity.

Also, the influence of MPs on heart rate and arterial blood pressure is still controversial. Vangelova et al. (22) found that electromagnetic radiation exposure increased blood pressure. Some authors have reported that no relationship between the use of MPs and changes in circulatory system exists. Tahvanainen et al. (23) demonstrated no significant changes in arterial blood pressure and heart rate during or after the RF exposures to 900 MHz or 1800 MHz cellular phones. Also, Braune et al. (24) reported that changes in heart rate were independent of the EMF exposure with the use of MPs. Saini et al. (25) demonstrated no significant changes in terms of the mean, maximum, and minimum heart rates due to MP use. Likewise, we did not find any significant changes between the groups in terms of heart rate in the present study.

The novelty our work was to study the effects of long-term exposure to MPs on the cardiac electrical activity rather than studying the effects of MPs while talking. There was a negative association between the time domain HRV parameters, such as SDNN and SDANN, and the duration of MP use in our study. RMSSD and pNN50, which are supposed to be markers of parasympathetic activity, were also decreased in subjects using a MP for a long time. Although most of the other studies in the literature have reported changes in HRV that were compatible with increased parasympathetic activity during talking on the phone, we found that overall the long-term effects on HRV were in favor of an increased sympathovagal balance. Increased sympathetic activity and decreased parasympathetic tone could be detrimental and could contribute to a higher risk of affecting the cardiac electrical activity. The clinical long-term consequences should be further investigated.

### Study limitations

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Our study has some limitations. First, the study population was relatively small. A larger study population would provide a higher statistical power. Second, HRV analyses were not performed before, during, and after MP conversation in the current study. However, our aim was to investigate the overall HRV consequences rather than searching the effects of a particular talk situation. Third, the MP models used in this study are not standard and we did not measure the specific absorption rate value (W/kg), which is a measure of the amount of radio-frequency energy absorbed by the human body when using a MP.

### Conclusion

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In conclusion, the results of the present study demonstrate that a long-term duration of MP use may influence HRV and change the autonomic balance in favor of an increased sympathetic tone. An increase in the sympathetic tone concomitant with a decrease in the parasympathetic tone measured indirectly by analysis of HRV was observed in long-term MP users. EMF generated by the long-term use of MPs was the tentative explanation for the detrimental changes in HRV. Although in this study, no statistically significant difference was found between the groups. BMI differences can affect the results. So, this should also be taken into account in further studies. Large-scale prospective randomized clinical trials are needed to test the probable clinical consequences of HRV changes using different MP models.

## Footnotes

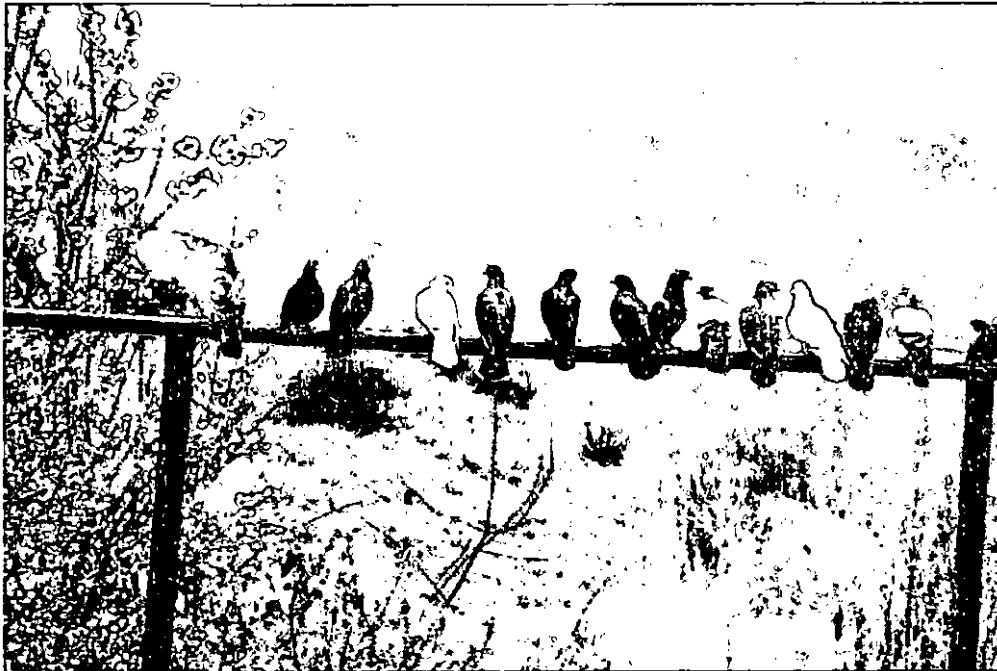
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**Conflict of interest:** None declared.

**Peer-review:** Externally peer-reviewed.

**Authorship contributions:** Concept – B.E.; Design – B.E.; Supervision – E.D., A.T.; Resource – B.E., E.D.; Materials – G.E., B.E.; Data collection &/or processing – B.E., G.E.; Analysis &/or interpretation – G.E., A.T.; Literature search – B.E., A.T.; Writing – B.E., E.D.; Critical review – G.E., B.E.

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Biochemist, MD. Meral Eguz's collections

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Articles from *Anatolian Journal of Cardiology* are provided here courtesy of **Turkish Society of Cardiology**

## Cardiovascular disease: Time to identify emerging environmental risk factors

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European Journal of Preventive  
Cardiology  
2017, Vol. 24(17) 1819–1823  
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DOI: 10.1177/2047487317734898  
journals.sagepub.com/home/ejpc



Vernon et al.<sup>1</sup> recently reported a significant increase in the proportion of first-time ST elevation myocardial infarction (STEMI) patients without standard modifiable cardiovascular risk factors (hypercholesterolaemia, hypertension, diabetes and smoking). While the authors correctly highlighted the need for discovering new mechanisms of coronary heart disease based on theirs and other complementing data, we would like to draw the attention of researchers in cardiovascular disease (CVD) to emerging environmental risk factors, focusing here on microwave radiofrequency electromagnetic radiation (RF-EMR).

Human exposure to RF-EMR has exponentially increased over the past three decades due to rapid and widespread deployment of wireless communication and surveillance infrastructure and the use of personal wireless devices. Public exposures have increased from extremely low natural radiofrequency levels<sup>2</sup> below  $10^{-15}$  W/m<sup>2</sup>, to above  $10^{-2}$  W/m<sup>2</sup> now.<sup>3,4</sup> RF-EMR is an environmental pollutant with cytotoxic effects.<sup>5,6</sup>

Despite the European Academy for Environmental Medicine (EUROPAEM)<sup>7</sup> and the American Academy of Environmental Medicine (AAEM)<sup>8</sup> publishing evidence linking RF-EMR to adverse health effects and calling for exposure reduction, there is widespread ignorance about the scientific evidence of radiofrequency-induced biological/health effects within the medical fraternity. This appears to be largely due to the controversial approach by the International EMF Project at the World Health Organization (WHO),<sup>4</sup> which has ignored the calls by a large group of international electromagnetic field (EMF) scientists<sup>9</sup> for improved exposure regulation.

The WHO's International Agency for Research on Cancer (IARC) appointed an expert panel to examine the evidence related to cancer in 2011 which classified RF-EMR as a group 2B possible carcinogen.<sup>10</sup> The new scientific evidence that has emerged since then, particularly epidemiological evidence linking mobile/cordless phone use to brain tumours<sup>11,12</sup> and experimental evidence of genotoxicity and carcinogenicity<sup>6,13</sup> warrants an update to this classification.<sup>14</sup> However, no

such evaluation of CVD risk has been carried out. Furthermore, there are serious shortcomings in the few panel reports that have so far evaluated biological/health effects.<sup>15</sup>

In our latest review, 242 RF-EMR studies that investigated experimental endpoints related to oxidative stress (OS)<sup>16</sup> were identified. A staggering 216 (89%) of them found significant effects related to OS, similar to a previous review.<sup>17</sup> These are being further analysed following presentation at the recent Australasian Radiation Protection Society conference.<sup>18</sup> Mostly in-vivo animal studies and in-vitro studies have demonstrated increased markers of endogenous OS and/or affected antioxidant levels in different tissue/cell types upon exposure to RF-EMR. Some studies have further demonstrated amelioration of RF-induced OS upon treatment with various antioxidants. Limited human studies at this stage complement these studies demonstrating OS and/or reduced antioxidant status upon acute radiofrequency exposure under experimental settings,<sup>19</sup> in mobile phone users<sup>20</sup> and residents near mobile phone base stations.<sup>21</sup> Renowned physical scientists have recently presented experimental evidence and a theoretical explanation on how low-intensity RF-EMR can generate OS.<sup>22</sup>

OS is known to be implicated in CVD<sup>23,24</sup> and therefore RF-EMR, a new ubiquitous environmental exposure, may contribute to CVD by maintaining chronic OS, and thereby causing oxidative damage to cellular constituents and altering signal transduction pathways.

Acute RF-EMR exposure has been shown to increase blood pressure under experimental conditions,<sup>25</sup> while chronic exposure has been found to be associated with an increased CVD risk<sup>26</sup> as well as alteration in the diurnal rhythms of blood pressure

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and heart rate<sup>27</sup> in studies investigating clinical, anthropometric, behavioural, environmental and socio-economic parameters.

Research on biological/health effects of RF-EMR started mostly within the military due to RF use in radar,<sup>28</sup> with former Soviet Bloc countries conducting the most. A US Army medical intelligence document<sup>29</sup> reporting on Soviet research stated:

Comparison of a group of engineers and administrative officials who were exposed to microwaves for a period of years and an unexposed control group revealed a significantly higher incidence of coronary disease, hypertension, and disturbances of lipid metabolism among the exposed individuals. Hereditary predisposition to heart disease was approximately the same for both groups, but overt disorders developed much more frequently in the previously exposed group. It was concluded that microwaves may act as a nonspecific factor which, under certain conditions, interferes with adaptation to unfavorable influences. Exposure may, therefore, promote an earlier onset of cardiovascular disease in susceptible individuals.

However, despite substantial evidence of biological effects and some evidence of adverse health effects even back in the 1970s, the west did not stringently control public exposure as did the Soviet Bloc countries, and conflicts of interest are apparent in same military report:

If the more advanced nations of the West are more stringent in the enforcement of stringent exposure standards, there could be unfavorable effects on industrial output and military functions.

This divergent approach to recognition of radiofrequency-induced health effects and exposure regulation still continues today between the USA and Russia and their allies.

Early epidemiological evidence from chronically exposed populations near radiofrequency transmitters (radio/TV/radar towers) before RF-EMR emitters became common everyday gadgets is extremely valuable. Now everyone is exposed and, therefore, it is very difficult to obtain reliable epidemiological data. However, there is still great variation in the level of exposure which can be assessed only by individual measurement in controlled studies. A 1994 US Air Force report<sup>30</sup> gives important insights on early epidemiological evidence:

In response to earlier Soviet reports, the World Health Organization (WHO) decided to conduct a comprehensive study on the biological effects of exposure to RF/

MW radiation. In 1976, M. Zaret published the results of the study (reference found in [8]). The WHO investigation focused on the population of North Karelia, a remote area of Finland that borders the Soviet Union. This region was selected because of its close proximity to a then Soviet early warning radar station. North Karelia is geographically located in the path of inter-continental ballistic missiles that would originate from the midwest United States. To detect these missiles, the Soviets constructed a number of high power tropospheric scattering radar units adjacent to nearby Lake Ladoga. The operation of these units exposes the residents of North Karelia to large doses of ground and scatter radiation. The WHO investigation found evidence linking exposure of RF/MW radiation to cardiovascular disease and cancer. The North Karelian population suffered from an unusually high number of heart attacks and cases of cancer. In addition, it was found that the affliction rate of these diseases was much higher among residents living closest to the radar site.

Although the success of the North Karelia project lifestyle intervention programme that reduced the CVD mortality is well known,<sup>31</sup> how many are aware of this reported CVD risk identified by the WHO related to chronic RF-EMR exposure? While a PubMed search with 'North Karelia' and 'cardiovascular' picked up 191 publications, 'North Karelia' and 'radar/radiofrequency/radiation' picked up none (on 2 September 2017). We therefore assume that this WHO/military knowledge about RF-EMR risk in CVD was not passed on to the scientific community for investigation. The success of the North Karelia project by increasing the consumption of fruit and vegetables, i.e. antioxidant therapy, supports our hypothesis that chronic exposure to RF-EMR causes CVD via redox mechanisms of OS which can be countered, albeit not fully, with increased dietary intake of antioxidants. However, what about measures to reduce exposure? While regular use of/being close to personal wireless devices such as phones, computers and WiFi routers as well as living close to wireless infrastructure such as mobile phone base stations can greatly increase one's exposure, the common habit of carrying a connected mobile phone in a shirt pocket is of particular concern regarding radiofrequency exposure to the heart.

As for recovery from STEMI, restoration of myocardial perfusion can be compromised by changes of endothelial integrity, platelet aggregation, neutrophil infiltration and inflammation after an acute thrombotic coronary occlusion. At a cellular level, these processes are controlled by redox mechanisms/signalling pathways and therefore, actively reducing exposure to

RF-EMR warrants consideration as part of post-STEMI patient management. Indeed, we require high quality clinical studies to investigate if such an approach is effective.

Radiofrequency exposure may also contribute to standard modifiable cardiovascular risk factors. The risk of hypertension, hypercholesterolaemia and truncal obesity was significantly higher in the occupationally radiofrequency-exposed radio/TV station operators (mean age 47.9 years) compared to their occupationally unexposed colleagues in a study by researchers at the Bulgarian National Centre of Public Health Protection.<sup>26</sup> This was despite a lower incidence of smoking in the radiofrequency-exposed group. Similar to several other studies, these researchers also found increased excretion rates of stress hormones: cortisol, adrenaline and noradrenaline in the radiofrequency-exposed.<sup>32</sup> It is very concerning that the occupational RF-EMR exposure levels of this group of radio and TV station workers are now common in the general public due to widespread wireless technologies, with little investigation of the health consequences.

Apart from an OS-mediated chronic effect in coronary heart disease, there may be chronic and acute effects involving OS/other mechanisms on cardiac electrophysiology. Dysregulation of the autonomic control of the cardiovascular system in healthy men (under 50 years) occupationally exposed to RF-EMR has been reported<sup>27,33</sup> compared to their unexposed colleagues, as well as altered heart rate variability under acute experimental exposure to cordless and mobile phones.<sup>34,35</sup> There is also evidence for immediate responses of voltage-gated ion channels, particularly Ca<sup>2+</sup> channels (VGCC) upon radiofrequency exposure.<sup>36</sup> The downstream effects of VGCC disruption may involve alteration of important functions of Ca<sup>2+</sup>/calmodulin-dependent enzymes (such as nitric oxide synthase and protein kinase II), influencing the pathophysiology of CVD.<sup>37</sup> Chronic disturbance of ion channels directly/via OS by persistent RF-EMR exposure may lead to pathologies of the heart muscle similar to primary electrical diseases (i.e. channelopathies). While the manufacturers of pacemakers have developed shielding to prevent electromagnetic interference from RF-EMR over the years, we note that the natural cardiac electrical network remains susceptible to interference by common RF-EMR emitters.

Although a few western countries have recently taken steps to reduce public exposure to RF-EMR, particularly of children, such as discouraging the use of wireless devices by children and banning/restricting WiFi in schools,<sup>38,39</sup> there is largely inaction at this stage. Intriguingly, a professor in public health at the University of California recently went to court and

accessed the cell phone safety 'fact sheet' (on health risks with instructions to reduce exposure) prepared by the Californian Department of Public Health.<sup>40</sup> It is reported that this document, originally prepared in 2009 and revised 27 times up to 2014, was abandoned due to influences from vested interests. Meanwhile in France, a physician took legal action to access data from government testing of mobile phones<sup>41</sup> revealing that most phones would not even pass the entirely thermally based (tissue heating) current exposure standards if held directly against the body, such as in a garment pocket.

It is clearly time to investigate the potential role of RF-EMR exposure from common wireless device use on CVD. Noting that existing research findings are influenced by the funding source,<sup>42</sup> fresh directives are necessary for objective high quality research to expand current primary and secondary prevention strategies.<sup>43</sup>

#### Author contribution

PB drafted the manuscript. PB and SW jointly conducted the review of studies on OS and both agreed on the final version of this research communication.

#### Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

#### Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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