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## Electromagnetic field induced biological effects in humans

### Efekty biologiczne indukowane oddziaływaniem pola elektromagnetycznego na ludzi

Exposure to artificial radio frequency electromagnetic fields (EMFs) has increased significantly in recent decades. Therefore, there is a growing scientific and social interest in its influence on health, even upon exposure significantly below the applicable standards. The intensity of electromagnetic radiation in human environment is increasing and currently reaches astronomical levels that had never before experienced on our planet. The most influential process of EMF impact on living organisms, is its direct tissue penetration.

The current established standards of exposure to EMFs in Poland and in the rest of the world are based on the thermal effect. It is well known that weak EMF could cause all sorts of dramatic non-thermal effects in body cells, tissues and organs. The observed symptoms are hardly to assign to other environmental factors occurring simultaneously in the human environment. Although, there are still ongoing discussions on non-thermal effects of EMF influence, on May 31, 2011 - International Agency for Research on Cancer (IARC) – Agenda of World Health Organization (WHO) has classified radio electromagnetic fields, to a category 2B as potentially carcinogenic. Electromagnetic fields can be dangerous not only because of the risk of cancer, but also other health problems, including electromagnetic hypersensitivity (EHS). Electromagnetic hypersensitivity (EHS) is a phenomenon characterized by the appearance of symptoms after exposure of people to electromagnetic fields, generated by EHS is characterized as a syndrome with a broad spectrum of non-specific multiple organ symptoms including both acute and chronic inflammatory processes located mainly in the skin and nervous systems, as well as in respiratory, cardiovascular systems, and musculoskeletal system. WHO does not consider the EHS as a disease - defined on the basis of medical diagnosis and symptoms associated with any known syndrome.

The symptoms may be associated with a single source of EMF or be

Ekspozycja ludzi na nienaturalne pole elektromagnetyczne (PEM) znacząco wzrosła w ciągu ostatnich dekad. Stąd też istnieje rosnące naukowe i społeczne zainteresowanie wpływem pola elektromagnetycznego na zdrowie ludzkie, nawet przy ekspozycji na dawki promieniowania poniżej dopuszczonych przepisami wartości. Intensywność promieniowania elektromagnetycznego w otoczeniu człowieka wzrasta i obecnie osiąga astronomiczne poziomy, które nigdy dotąd nie występowały na naszej planecie. Największy wpływ wywiera pole elektromagnetyczne na żyjące organizmy przez bezpośrednią penetrację tkanek.

Obowiązujące standardy ekspozycji na pole elektromagnetyczne w Polsce i na świecie są oparte na wywoływanych przez PEM efektach termicznych. Powszechnie wiadomo, że nawet słabe PEM może wywoływać cały szereg zmian w tkankach i organach. Obserwowane objawy trudno powiązać z działaniem innych czynników środowiskowych występujących w otoczeniu człowieka. Chociaż ciągle trwają rozważania na temat wpływu nietermicznych efektów oddziaływania PEM, 31 maja 2011 roku Międzynarodowa Agencja Badań nad Rakiem (IARC) – Agenda Międzynarodowej Organizacji Zdrowia (WHO) zaklasyfikowała pola radio elektromagnetyczne do kategorii 2B jako potencjalnie kancerogenne. Pola elektromagnetyczne są niebezpieczne dla zdrowia nie tylko z powodu ryzyka rozwoju nowotworów, ale również wystąpienia innych dolegliwości włączając wystąpienie nadwrażliwości elektromagnetycznej (EHS). EHS jest zjawiskiem charakteryzującym się pojawieniem się objawów po ekspozycji na pole elektromagnetyczne i jest określane jako syndrom z szerokim spektrum objawów niespecyficznych, pochodzących z wielu narządów włączając ostre i przewlekłe procesy zapalne zlokalizowane głównie w skórze i w układzie nerwowym, ale występujące także drogach oddechowych, układzie sercowo-naczyniowym czy mięśniowo-szkieletowym. WHO nie klasyfikuje

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derived from a combination of many sources. Reported symptoms associated with electromagnetic fields are characterized by the overlapping effect with other individuals with these symptoms exhibited a broad spectrum of clinical manifestations, related to exposure to a single or multiple sources of EMF. The phenomenon of electromagnetic hypersensitivity in the form of dermatological disease is associated with mastocytosis. The biopsies taken from skin lesions of patients with EHS indicated on infiltration of the skin layers of the epidermis with mastocytes and their degranulation, as well as on release anaphylactic reaction mediators such as histamine, chymase and tryptase. The number of people suffering from EHS in the world is growing describing themselves as severely dysfunctional, showing multi organ non-specific symptoms upon exposure to low doses of electromagnetic radiation, often associated with hypersensitivity to many chemical agents (Multiple Chemical Sensitivity-MCS) and/or other environmental intolerances (Sensitivity Related Illness-SRI).

#### EMF nature

Exposure to artificial radio frequency electromagnetic fields (EMFs) has increased significantly in recent decades. Therefore, there is a growing scientific and social interest in its influence on health, even upon exposure significantly below the applicable standards [1,2]. Non-ionizing electromagnetic radiation as well as nuclear radiation is not experienced, heard, tasted or felt by the human sensory systems. The widespread occurrence in the environment of artificial EMFs (via the use of mobile phones and next-generation base stations (2G, 3G, 4G) in standards: Global System for Mobile (GSM), Universal Mobile Telecommunications System (UMTS) and Long Term Evolution (LTE), microwave radio lines, standard Digital Enhanced Cordless Telephony (DECT) cordless phones, laptops, tablets, e-readers, wireless Internet network: Wi-Fi, Wireless Local Area Network (WLAN), Worldwide Interoperability for Microwave Access (WiMAX), etc., wireless professional connection Terrestrial Trunked Radio (TETRA), wireless meters of water and gas usage (Smart Meters) is an example of a broad spectrum of wireless technology and may pose a threat to human health [3].

The intensity of electromagnetic radiation in human environment is increasing and currently reaches astronomical levels that had never before experienced on our planet. Extensively noticed by developed societies of Western Europe, investigating the problem for at least two decades. Today's maximum exposure, standard EMFs are  $10^{15}$  to  $10^{18}$  times higher than the natural Earth electromagnetic field [4]. As it can be seen from the mentioned above data, the current phase of environmental degradation by artificial microwave frequency electromagnetic fields have become dangerous for biological life. The most influential process of EMF impact on living organisms, is its direct tissue penetration.

The biological EMF effects can be divided into groups; thermal and non-thermal [5]. The earliest established fact and to this day undisputed is the thermal effect, which is the transmission of electromagnetic energy to the tissues, where it is converted into heat energy. Such a situation arises when human

EHS jako konkretnej jednostki chorobowej, ale zespół objawów, które mogą być konsekwencją oddziaływania PEM pochodzącego z jednego lub wielu źródeł oddziaływania. Objawy związane z działaniem PEM na organizm mogą nakładać się z innymi dolegliwościami i obejmować szerokie spektrum klinicznych manifestacji.

Zjawisko EHS w postaci zmian dermatologicznych jest związane z mastocytozą skóry, co potwierdzały biopsje ze skóry, pobierane od osób z EHS. Analiza bioptatów wykazywała infiltrację wszystkich warstw skóry właściwej mastocytami, ich degranulację z uwalnianiem mediatorów reakcji anafilaktycznej takich jak histamina, chymaza czy tryptaza.

Na świecie stale rośnie liczba osób cierpiących na EHS, określających się jako dysfunkcyjni, z wielonarządowymi niespecyficznymi objawami, które pojawiają się nawet po ekspozycji na małe dawki promieniowania elektromagnetycznego. Często symptomy EHS są związane z występowaniem nadwrażliwości na substancje chemiczne (MCS), i/lub inne czynniki środowiskowe (SRI).

organism is under the influence of high intensity EMF and it is very dangerous for the body proteins. The current established standards of exposure to EMFs in Poland and in the rest of the world are based on the thermal effect. However, there is no scientific consensus on the non-thermal biological action of EMF. It is well known that weak EMF could cause all sorts of dramatic non-thermal effects in body cells, tissues and organs. Nonetheless, the effects are difficult to determine and measure. The observed symptoms are hardly to assign to other environmental factors occurring simultaneously in the human environment. Another important issue of EMF caused bio-effects is their dependency on EMFs' parameters such as intensity, frequency, signal waveform, and/or repetition frequency of impulses. For instance, the biological reaction could vary due to stimulation/inhibition the natural nerve activity which controls various functions of the body. Important is also the exposure time (effects of EMF are additive), distance from the EMF source or individual organism and/or organ homeostatic abilities [6,7].

Although, there are still ongoing discussions on non-thermal interaction effects of EMF influence, on May 31, 2011 - International Agency for Research on Cancer (IARC) – Agenda of World Health Organization (WHO) has classified radio electromagnetic fields, to a category 2B as potentially carcinogenic [8]. Electromagnetic fields can be dangerous not only because of the risk of cancer but also other health problems, including electromagnetic hypersensitivity (EHS). This makes the following question still alive: Isn't the health of present and future generations endangered?

#### Electromagnetic hypersensitivity phenomenon

Electromagnetic hypersensitivity (EHS) is a phenomenon characterized by the appearance of symptoms after exposure of people to electromagnetic fields, generated by a variety of commonly used surrounding devices. The term of electromagnetic hypersensitivity is a broad concept, in relation to clinical conditions characterized by a complexity of symptoms occurred typically after exposure to the "artificial" electroma-

gnetic fields (with subsequent resolution of symptoms by the total isolation from EMFs), even below the permitted standards [9,10].

EHS is characterized as a syndrome with a broad spectrum of non-specific multiple organ symptoms including both acute and chronic inflammatory processes located mainly in the skin and nervous systems, as well as in respiratory, cardiovascular systems, and musculoskeletal system. In the most cases, no pathological objective signs are present apart from skin manifestations [11].

WHO does not consider the EHS as a disease - defined on the basis of medical diagnosis and symptoms associated with any known syndrome. In the case of long-term symptoms of people suffering from EHS, it is appropriate for physicians to adapt therapeutic treatment to individual needs, and not just focusing on the reduction of EMF intensity. Majority of reported EHS symptoms are still considered by scientists to be psychogenic subjective feelings [12-14].

The official term, used by WHO to determine the health effects as a result of impact in the vicinity of devices that emit electrical, magnetic or electromagnetic fields, is Idiopathic Environmental Intolerance to Electromagnetic Field (IEI-EMF). Until today, there is no consensus on the criteria for the identification of people with IEI-EMF [15,16]. The first reports were published in 1970 [17,18]. Currently, a spectrum of EHS symptoms is associated with a variety of devices emitting EMFs [7]. The symptoms may be associated with a single source of EMF or be derived from a combination of many sources. Reported symptoms associated with electromagnetic fields are characterized by the overlapping effect with other environmental factors such as hypersensitivity to many chemicals and/or building stress syndrome (multiple chemical sensitivity and sick building syndrome) [19].

In the years 2011-2012 in Finland a detailed analysis of people describing themselves as suffering from EHS was performed. Previous studies concerning EHS were mostly related to the incidence of inflammatory changes on skin, face and chest, and

neurovegetative disease. In these studies, the list was expanded to 68 different symptoms including general symptoms, which are usually not associated with EHS. Symptoms were grouped into 10 different categories covering nervous system, dermatological symptoms, symptoms located on the head - ocular, ear and mouth area, symptoms of cardiovascular and respiratory systems (heart and lungs), musculo-articular and other problems [12].

Individuals with these symptoms exhibited a broad spectrum of clinical manifestations related to exposure to a single or multiple sources of EMF. The heterogeneity of the signs were related to the incidence of the phenomenon in terms of symptoms, as well as parameters of the electromagnetic field [20,21].

On the other hand, surveys associated with the occurrence of symptoms and the risk of their experiencing carried out in the Dutch population in 2013, distinguished between 3 groups of people recruited via the Internet to the research program. The studied population was defined as a people sensitive (first group), insensitive (second group) and showing symptoms caused by EMFs (third group). Risk of EMF's bio-effects occurrence in these patients was evaluated by administration of a particular source of electromagnetic radiation: wireless phones of Digital Enhanced Cordless Telecommunications (DECT) standard, mobile phones, microwaves, base stations standard Global System for Mobile Communications (GSM), standard base stations of Universal Mobile Telecommunications System (UMTS). In a population of susceptible individuals, the share of symptoms for the EMF was positively correlated with the intensity of these symptoms and perceived risk EHS [15].

The phenomenon of electromagnetic hypersensitivity in the form of dermatological disease associated with mastocytosis, is illustrated also by the published case report of the patient in Germany [22].

Italian researchers tested a panel of 12 blood parameters associated with the oxidoreductive potentials and polymorphisms of genes of selected toxins, metabolizing enzymes e.g. glutathione peroxidase/transferase or erythrocyte catalase. They were the first to describe and publish in 2014 existence of pro-oxidant/pro-inflammatory metabolic changes in EHS with co-existing increase in plasma coenzyme Q10. In patients with Multiple Chemical Sensitivity (MCS) a sharp decrease in polyunsaturated fatty acids in erythrocyte membrane was observed, compared with an increase of omega6/omega3 fatty acid ratio, which did not occur in patients with EHS. Researchers have also identified significantly altered distribution-versus-control of the polymorphism of P450 cytochrome (CYP2C19\*1/\*2 SNP) variants in EHS, and a 9.7-fold increased risk of EHS developing for the haplotype (null)GSTT1 + (null)GSTM1 variants. Altogether, results on MCS and EHS strengthen the proposal to adopt this blood metabolic/genetic biomarkers' panel as suitable diagnostic tool for Sensitivity Related Illness (SRI) [23].

Studies carried out in 2005 by Holmboe

and Johansson et al. in Sweden, involving patients with EHS aiming to characterize and record the condition of EHS according to WHO and its International Statistical Classification of Diseases and Related Health Problems (ICD-10), have shown skin and mucosal symptoms include: itching, pain, redness, feeling of warmth, edema, papules and pustules. In contrast, symptoms from the central nervous system are mainly headaches, dizziness and chronic fatigue. The biopsies taken from skin lesions of patients with EHS indicated on infiltration of the skin layers of the epidermis with mastocytes and their degranulation, as well as on release anaphylactic reaction mediators such as histamine, chymase and tryptase. These factors are probably responsible for their pathomechanism. Among the 22 patients with dominant skin changes, 19 patients, also claimed symptoms from gastrointestinal tract. All of them had elevated levels of total IgE, as well as other biological markers e.g. calcitonin gene peptide (CGRP), somatostatin (SOM), peptide histidine-isoleucine amide (PHI), vasoactive intestinal polypeptide (VIP), neuron-specific enolase (NSE), protein gene product (PGP) and phenylaminomethyl transferase (PNMT) [5,24-28].

Up to now, many efforts have been made to assess whether there is a relationship between exposure to electromagnetic field and the occurrence of symptoms, and to identify possible biological pathomechanism of this syndrome [29-32]. Despite the growing multitude of evidence collected in vitro and in vivo studies on animal models, human case data and a double-control study groups data trying to find a relationship between exposure to EMFs and clinical symptoms have been controversial so far [33-35]. Currently, there is still a gap in understanding the EHS, which most often is neglected by the medical community or reduced to a psychogenic etiology and treatment [36,37]. With continued lack of pathogenic mechanism of electromagnetic hypersensitivity and clinical consensus concerning proposed diagnostic and therapeutic approaches, there is no guidance on safe and effective treatment available for patients around the world [38,39].

The number of people suffering from EHS in the world is growing describing themselves as severely dysfunctional, showing multi organ non-specific symptoms upon exposure to low doses of electromagnetic radiation, often associated with hypersensitivity to many chemical agents (Multiple Chemical Sensitivity-MCS) and/or other environmental intolerances (Sensitivity Related Illness-SRI). These collections of chronic inflammatory diseases still lack working out hypothesis, considering mechanisms and diagnostic biomarkers and medical management schedule. SRI is not simple a psychogenic disorder, but it shows the organic determinants of impaired detoxification commonly present as a response to the environmental physical-chemical stressors.

Epidemiological studies concerning the occurrence and spreading of EHS phenomenon in various nations, showed that this phenomenon occurs in Sweden in 1.5% [39], in Switzerland in 5%, in California in 3.2%,

in Austria in 3.5%, and in 4% of the United Kingdom population. Surprisingly, high values were obtained in Taiwan (13.3% of the population). The presented data suggest that ethnicity may play role of a risk factor for EHS occurrence [21,23,41-44].

### **Poland and other countries adopted EMF power densities**

In Poland adopted standard power density of the microwave electromagnetic field is 0.1 W/m<sup>2</sup> and concerns areas accessible to the people. However, it does not settle the issue of protection of the population against negative non-thermal effects due to exposure to EMF. The phenomenon of electromagnetic hypersensitivity in humans is not studied. It is important to emphasize, however, that in Poland and the so-called countries of Eastern Bloc in the 60s and 70s very extensive researches of the impact of electromagnetic field on living organisms were carried out. Studying the non-thermal effects of EMFs was noted, that big differences in the sensitivity to EMFs occurred between the individuals. Sensitivity varies in the range 1:100. This means, that individuals can respond to the varying intensity of EMF between 1 to 100-fold. From the wide range of subjective and objective symptoms described, elevated levels of histamine and digestive ailments (e.g. abdominal pain, nausea and diarrhea) should be distinguished [45,46].

In summary, the current research in the world on the influence of EMF on human beings, encompasses:

- the prevalence and diversity of sources of artificial electromagnetic fields in the environment associated with the daily usage of EMFs emitting devices (mobile phones, Wi-Fi, tablets, smartphones, etc.);
- the number of people with electromagnetic hypersensitivity reporting various health problems associated with the exposure to EMFs of intensity below the applicable standards is growing;
- there is no consensus in the field of electromagnetic hypersensitivity designation. Reported symptoms are often considered to be psychogenic, subjective feelings difficult to confirm through tests and other medical criteria;
- difficulty in assessing the actual impact of EMFs on electromagnetically hypersensitive individuals associated with the inability to isolate the effect of EMFs itself, from other environmental factors;
- lack of the proper description studies concerning the conditions of individual exposure to EMFs;
- calls for urgent and deliberate attempt to make use of the objective laboratory method(-s) that will allow for the appropriate identification of people hypersensitive to electromagnetic field.

Mobile communication has been classified by the WHO as a potential threat, assigned to a category 2B. Support of the request for such classification means, that there is a likelihood of increasing cancer risk by this type of physical factor and further studies of this issue should be performed.

It seems that adopted in Poland accep-

ted power density value of EMF is relatively low compared to some countries in Western Europe or North America, contrary to the few other countries or provinces (regions), listed in Table I.

Taking into consideration overview table content values, one can draw the conclusion, that Poland does not stand out with very restrictive adoption of the standard compared to other countries (or regions), where legal solutions were modified much further in order to reduce the EMF exposure limit value for the population.

### EMF affects peripheral and central nervous system

Extensive research constituting case studies and epidemiological ones (in vitro and in vivo) carried out in Denmark have shown:

1) the negative effect of EMF on the release of neurotransmitters such as serotonin, acetylcholine, GABA, glutamate, adrenaline, noradrenaline, or neuromodulator PEA [47-49];

2) children whose mothers during pregnancy have used mobile phones have a 54% higher risk of malformations such as attention deficit disorder or hyperactivity characteristic for ADHD. In children using mobile phones to 7 years of age, the risk of the development of these disorders increases up to 80% [50,51];

3) exposure to EMF opens the blood-brain barrier for large molecules (albumin, viruses, toxins), which consequently leads to the damage of cerebral cortex, hypothalamus. Base coils in experimental animals and in humans electro hypersensitive increased levels of a marker S100B in the blood [52-56];

4) electromagnetic radiation causes calcium flux from the brain in humans and animals, which is responsible for the altered neurosecretion [57];

5) structural changes in the brain with enhancing demyelination and rapid growth of glial cells, and increase of the myelin antibodies levels in the blood of people with EHS [47,56];

6) the brain cells are the most sensitive to the effects of electromagnetic radiation that damages their DNA, alters the activity and induces their death. Brain tissue and glial cells undergo malignant transformation under the influence of radiation from mobile phones [58-60];

7) changes in the metabolism of neurotransmitters and brain cell membranes [61,62];

8) changes in cerebral blood flow in patients with EHS in the limbic area affecting emotions [56,63];

9) changed brain metabolic activity, after 50 minutes of using a mobile phone, PET scans showed an increase in glucose consumption on the side of the brain on which the phone was held [64];

10) damaged spatial orientation and memory in mice exposed to radiation from GSM 900 MHz mobile phone [65];

11) reduced melatonin synthesis (essential for sleep, heart rhythm and antioxi-

Table I

Recommended permissible levels of EMF power density for GSM1800 system in various countries and regions for 1800 MHz frequency.

Zalecane dopuszczalne poziomy gęstości mocy PEM dla systemu GSM w różnych krajach i regionach przy częstotliwości 1800 MHz.

Location	Power density in $\mu\text{W}/\text{m}^2$ (microwatt per square meter)	Equivalent – intensity of electric field in V/m (volt per meter)
FCC/ANSI – USA OET-65	10 000 000 (10 W/m <sup>2</sup> )	61
ICNIRP (1998), WHO, Great Britain, Germany	9 000 000 (9 W/m <sup>2</sup> )	58
Belgium (without Wallonia)	1 115 000 (1 115 W/m <sup>2</sup> )	21
Russia, China	100 000 (0.1 W/m <sup>2</sup> )	6
Italy (sum of frequencies)	100 000 (0.1 W/m <sup>2</sup> )	6
<b>Poland</b>	<b>100 000 (0.1 W/m<sup>2</sup>)</b>	<b>7</b>
Switzerland, Lichtenstein, Luxemburg	95 000	6
Belgium – Wallonia	24 000	3
Vienna - Austria (GSM sum)	10 000	1.9
Italy (single frequency)	1 000	0.6
Salzburg – Austria 1998 (GSM sum)	1 000	0.6
EU-Parl. GD Wissenschaft, STOA GSM (2001)	100	0.2
Salzburg – Austria GSM/UMTS outside apartments (2002)	10	0.06
Salzburg - Austria GSM/UMTS inside apartments (2002)	1	0.02
Burgerforum BRD proposal, area of activity (1999)	1	0.02
Burgerforum BRD proposal, area of rest- sleep (1999)	0.01	0.002
Sufficient level of EMF for the correct operations of the portable terminal (mobile phone, smartphone, etc.) in the range of voice transmission services	0.000 002	0.000 03
The average power density of the EM radiation from the radio range originating from the space at a frequency of 1800 MHz (according to MAES 2000)	0.000 001	0.000 02

\*Table elaborated by authors.

dant factor) in patients with breast cancer, Alzheimer's disease and those with EHS [66];

12) stimulation of the peripheral nervous system by electromagnetic radiation, which raises the electrical activity in the central nervous system (thalamus), acts on the hearing and vision in patients with EHS [47,66,67];

13) the production heat shock proteins, changes in the synthesis of 143 brain proteins (in cerebellum, hippocampus and frontal lobes) as the expression of oxidative stress, in patients with EHS the blood levels of HSP27 and HSP70 increase, and oxygen and nitric free radicals are formed intra - and extracellularly [56,66,68,69];

14) generalized stress reaction manifested by changes in function the autonomic nervous system in patients with EHS. Heart rate (HR), heart rate variability (HRV) and the electrical activity of the heart rises [70–72];

15) significant changes and reduced activity in the cerebral cortex measured by transcranial magnetic stimulation during exposure to electromagnetic fields, caused

cognitive and neurological changes and disorders of attention and memory in people with EHS [73-76];

16) changes in the right temporal lobe and in the angular gyrus of the right temporal lobe measured by magnetic resonance method in patients with EHS [76];

17) changes in the quality of sleep and its character measured by polysomnography [63,76-78];

18) subjective symptoms of nervous system distress as headaches, nausea, fatigue, feeling of total burnout, pressure and tinnitus, cardiac symptoms, shortness of breath, difficulty with memory concentration, sleeplessness or sleep disorders, stress and depression in people with EHS during exposure to electromagnetic radiation [71,79-93].

### Conclusions

While analyzing the presented results of research on the influence of electromagnetic field in the microwave range on the humans in the world, it seems, that now in Poland the phenomenon of electromagnetic hypersensitivity in humans was not noticed.

In countries with high social status such as Sweden, Finland, Switzerland, Austria, Germany, France, England, the United States, Canada, but also other countries, even Montenegro, Croatia, Russia, Iran and Taiwan this problem has been studied for over 20 years. However, in Poland and the so-called countries of Eastern Bloc in the 60s and 70s extensive researches were carried out on the influence of electromagnetic field on living organisms, mainly on people working professionally with microwave frequency (military research). Austria is the only country with legal regulation rules of the diagnosis and treatment of EMF-related health problems. Studying the non-thermal effects of EMF, differences in the sensitivity of the individuals to the electromagnetic field, range 1:100 was observed. Pathomechanism of symptoms was assigned to elevated blood level of histamine in subjects.

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