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Methodology of Standards Development for EMF RF in Russia and by International Commissions: Distinctions in Approaches

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15.1 Introduction

A standard is a general term that incorporates both regulations and guidelines and can be defined as a set of specifications or rules to promote the safety of an individual or the population. The ultimate goal of electromagnetic field (EMF) standards is to protect human health. Exposure limits are intended to protect against adverse health effects of EMF exposure across the entire frequency range and modulation. Naturally, it is an axiom that appropriate standards evaluating harmful factors in the environment must be developed and that the scientific community must understand this as a necessity.

The Russian standard for base stations has already been in existence for more than 30 years and is more rigid than the maximum level recommended by the International Commission of Non-Ionizing Radiation Protection (ICNIRP). This distinction has been discussed at scientific meetings for many years—unfortunately, without result.

The second EMF source of mobile communication—the mobile phone—has no sufficient substantiation on exposure limits. The irradiation of a brain is not limited and is not supervised. The children using mobile phones are especially at high risk.

15.2 Methodology for the Risk Assessment of RF EMF for the Population: History of Development of Standardization in the USSR (and Later in Russia)

About 60 years ago, in 1958, the maximum permissible levels (MPLs) of radiofrequency EMF (EMF RF) for professionals had been regulated at the state level for the first time in the USSR and in the world. These standards were based on the results of clinical research of professionals and on the results of experimental studies with animals.

With the development of the tele-radio networks in the USSR, there was a need to ensure the safety of the population in conditions when relatively powerful sources of RF EMF were placed at the border or within the boundaries of a residential building. This task was entrusted to the Kiev Research Institute of General and Communal Hygiene Ministry of Health of Ukraine.

The first RF EMF standard for the population, SanPiN 848-70, was approved by the Ministry of Health of the USSR in 1970 and was considered for the population exposure limit of 1 μW/cm^2 in the microwave band of 300 MHz to 300 GHz. In 1978, the USSR Ministry of Health approved the next SanPiN No. 1823-78. In this document, MPL for the population in the frequency range of 300 MHz to 300 GHz was set as 5 μW/cm^2.

The methodological bases for the development of MPLs were "guidelines on the assessment of the biological effect of low-intensity microwave radiation for hygienic

at ambient conditions" (Ministry of Health of USSR, Kiev, 1981) and "methodological approaches to the study of the effect of low levels of microwave energy on human health in terms of residential areas" (USSR, Ministry of Health, 1981).

Scientific development of hygienic standards was coordinated by Federal Commission on Scientific Problems of Environment of the USSR Academy of Medical Sciences. The main co-developers were the Kiev Institute of Communal Hygiene and the Institute of Biophysics, USSR Ministry of Health. Among the leaders who studied the problem of research on the biological effects of EMF RF and the development of normative documents were academics Shandala and Ilyin and professors Savin, Palzev, Dumanskiy, Kholodov, Akoev, Shihodyrov, and Y. Grigoriev.

Standardization strategy in the USSR and Russia is discussed in detail in a series of publications: Grigoriev (1998), Grigoriev et al. (2002, 2003a, 2004), and Grigoriev and Grigoriev (2013, 2016).

Currently, three questions remain relevant for standardization:

1. Are there nonthermal biological effects of low levels of RF EMF?
2. Is it possible that the irradiation of the population with RF EMF throughout human life leads to increased adverse biological effects?
3. Is there a "threshold" level of exposure to RF EMF, and if so how do we define it?

15.2.1 Nonthermal Biological Effects

A number of Russian scientists in the 1960s–1970s have pointed to the possibility of informational or the nonthermal action of EMF RF (Presman, 1968; Ivanov-Muromsky, 1977). Numerous animal experiments have shown that clear bioeffects appear under the influence of very low RF EMF with nonthermal intensity (Frey et al., 1975; Kholodov, 1975, 1996; Adey, 1980; Chizhenkova, 1988, 2000, 2004; Lukyanova et al., 1996, 2010; Grigoriev, 1998, 2015; Lukyanova, 1999, 2015; Belyaev and Grigoriev, 2007; Belyaev, 2015). Specific possible mechanisms of thermal effects are considered (Barnes and Greenebaum, 2016).

More than 100 articles have been published on monitoring volunteers who used mobile phones. In most cases, the different functional responses of the body's systems under the influence of nonthermal EMF levels from mobile phone use have been published (Reiser et al., 1995; Dec et al., 1997; Thuroczy et al., 1999; Krause, 2002; Huber et al., 2003; Croft et al., 2008).

In our laboratory, we tested 10 volunteers aged 23–47 years. Exposure of volunteer's brain to EMF from mobile phones (MNT standards GSM-450, GSM-900, and GSM-1800) was done for a period of 5, 10, and 20 min (Grigoriev et al., 1999). There were changes in EEG brain—increasing power of the alpha—rhythm in the spectrum of the EEG, an increase in the number of spindle variations in the alpha- and beta-bands (Lukyanova et al., 1996; Lukyanova, 2002, 2015). The changes persisted for 2 h after the end of irradiation.

Another study of 29 volunteers (25–40 years) exposed to EMF nonthermal intensity (up to 200 μW/cm^2) has shown the dependence of the changes in cognitive function based on the typological features of EEG (Lukyanova et al., 2010).

The role of the modulation of the carrier frequency in the formation of biological effects of RF EMF at low intensity confirms our view about the presence of nonthermal mechanism of interaction of EMF with biological tissue (Blackman, 1984; Grigoriev, 1996, 2004; Belyev and Grigoriev, 2007; Grigoriev and Grigoriev, 2013, 2016).

These results together with numerous studies conducted by scientists from many countries provide direct evidence that RF EMF intensity of up to 10 mW/cm^2 may have a nonthermal mechanism of action.

The problem of a possible nonthermal mechanism of action of EMF RF with low-intensity EMF has been one of the reasons for the WHO program on harmonization of the existing international standards, which unfortunately turned to be unsuccessful. One of the main reasons is that engineering committees continue to affirm that biological effects are not possible without heat development. Let us point that the biological systems are nonlinear thermodynamic systems with a number of targets within single organs or tissues. As it was shown, even a simple conformational change in the protein or a change in the ion binding is capable of initiating signal transduction modifications (Markov, 2006).

15.3 Cumulative Effect in Terms of EMF RF Repeated or Extended Long-Term Exposure

Solving this problem requires a large number of experimental and epidemiological studies. Radiobiological studies of cumulative effects occurring after repeated or chronic effects of RF EMF in terms of accumulation of negative effects and their recovery rate, the residual lesions, identification of effective compensatory processes, and the estimation of the optimal time intervals for use of a mobile phone have not been performed.

It took about 20 years of active use of mobile phones to confidently say that the accumulation process is present; we now have understood the necessity of monitoring the health of the population exposed to this new environmental factor.

In 2003, at the International Conference in Budapest "Mobile Communications and the Brain," Hardell and Mild (2003) reported the results of multiple years of epidemiological research (1997–2000). The 1617 patients aged 20–80 years were divided into 5 groups with a difference of 10 years. An increased risk of brain tumors was observed in the age group of 20–29 years, whereas for other age categories such dependence was not found. Further analysis of these data showed that persons in the age group of 20–29 years began using cell phones in their childhood. These results indicate that people who started using mobile phones from childhood and adolescence may be at increased risk than those who started using mobile phones at a later age, which directly indicates a cumulative effect.

There is evidence that RF EMF can cause development of tumors in the brain of mobile phone users after a 10–12 year "waiting period" (Hardell and Calberg, 2009). The term "heavy users" that appeared in some publications linked the unfavorable bioeffects of the prolonged mobile phone use to accumulative processes of adverse biological effects.

It has been shown that after a single exposure to low-intensity RF EMF, certain changes in the brain EEG occur (Lukyanova, 1999, 2015). During the first hours after exposure, there is a restoration of bioelectrical activity of the brain, which indicates

the insinuation of compensatory processes. Naturally, in these conditions, a repeated exposure might weaken compensatory processes and lead to development of the process of accumulation (Lukyanov et al., 2015). A number of factors such as the reactivity of the organism, the increasing of the user's age, and factors of environment may influence the compensation processes.

The decision of IARC (2011), in which RF EMF is classified as a possible carcinogen by the radiation group 2B, is another confirmation of the presence of the cumulative effect of the repeated impacts of low-intensity EMF RF.

Thus, the accumulation of adverse biological effects in the conditions of repeated or long-term chronic exposure is one of the most important criteria for risk assessment of the impact of mobile phone EMF RF on the population to develop appropriate standards.

15.3.1 Threshold Levels

The threshold level is the lowest level of exposure of the physical factor (EMF RF), below which the risk to public health does not exist, is introduced in analogy with the principles of ionizing radiation.

Given the complexity of this problem, we propose to determine the threshold level as a criterion for the body's response to RF EMF exposure, but on the condition that this response should not be pathological. This reaction may be compensatory/adaptive and should exist within the physiological range. In this case, the threshold level is "conditional action level." This term emphasizes that the EMF, acting with a certain intensity and mode of irradiation on the biological object, causes certain reactions in the body, but these reactions should not be pathological. The MPL, i.e., already the so-called inactive level, is set using the "safety factor." That is, the value of the current level will be reduced by the value of the safety factor.

Summing up on this issue, it can be concluded that the Russian standards for the population had previously been installed on the basis of the threshold value that has been set on the basis of compensatory/adaptive response within the physiological norm, not on the basis of pathological effects.

In 1984, the first practical result of the scientific program of the USSR was the development of the interim sanitary norms and rules to protect the public from exposure to EMFs generated by radio facilities (VSN No. 2963-84). The MPL for the population was established at 10 μW/cm^2 for the frequency range of 300 MHz to 30 GHz.

It should be noted that despite the "temporary" status adopted in the 1984 document, its basic rules of MAL 10 μW/cm^2 also apply to the present time for risk assessment, especially for base stations. The next standard approved by the Ministry of Health in 1996 fully retained the MPL for the population, bearing in mind the base station, as 10 μW/cm^2 for the frequency range of 300 MHz to 300 GHz.

We emphasize that the studies of the biological effect of RF EMF and their evaluation in the USSR were carried out in accordance with the Ministry of Health recommendations, "Methodological approaches to the study of the effect of low levels of microwave energy on the health of human beings in populated areas" and "Guidelines on the assessment of the biological effect of low-intensity microwave radiation for hygienic at ambient conditions." Results of acute, protracted, and

chronic experiments with laboratory animals were used, as well as observations of humans in a real production environment. Studies were conducted on volunteers under simulated situations.

It is important that individual fragments of these comprehensive studies were analyzed, synthesized, and presented in more than 100 master's and doctoral theses, which had previously passed very thorough testing of the control in the Higher Attestation Commission of the USSR.

15.4 Development of Standards for Cellular Communications in Russia

First of all, let us consider the physical features of each of the two RF EMF sources of mobile communication, which are currently the main sources of environmental pollution and pose a real threat to the entire population.

15.4.1 Base Stations

EMF RFs are creating a constant electromagnetic background in the environment. The exposure is at a low and nonthermal level in the presence of various frequencies and round-the-clock exposure of the population during all stages of life. There is an exposure of all groups of the population, including children, patients and radiosensitive people. This chronic exposure of the population raises the issue of probable danger and negatively perceived growth of electromagnetic pollution by base stations of environment.

Critical targets: nervous system, immune system, and brain.

15.4.2 Mobile Phones

For mobile phone users, EMF RF exposure affects various groups of the population, including children 3 years of age. It is an open source of radiation, without protection, is easy to approach, and cannot be controlled. Expanding opportunities for communication and information is perceived by the population as a factor of increased comfort and is consequently superfluous, without restrictions.

15.4.2.1 Exposure

Daily fractional exposures are repeated throughout life. Generally, the total mobile phone usage is estimated to be 30–40 min a day. Most of the population uses mobile communications without any restrictions 2–4 h a day. It is necessary to note that this daily EMF exposure of the brain occurs for the first time in the history of civilization.

Critical target: brain and its function.

Thus, these data suggest that sources of EMF RF are quite different for the risk assessment and require an individual approach to the development of standards and exposure limits.

In 1994, development of standards for mobile phone users started for the first time in Russia. Based on the hygienic standard GN 2.1.8/2.2.4.019-94, the temporary permissible levels (TPLs) of mobile phones are 100 μW/cm² for EMF 450, 900, and 1800 Hz, with the limitation that mobile phones cannot be used for more than 40 min a day.

Then, based on SanPiN 2.1.8/2.2.4.1383-03 (hygienic requirements for the placement and operation of radio transmitting facilities) and SanPiN 2.1.8/2.2.4.1190-03 (hygienic requirements to placement and exploitation of the mobile communication) introduced in 2003, MPL for users of mobile phones remains 100 μW/cm².

When determining the limit values for base stations, the RNCNIRP decided to leave the limit value for the general public of 10 μW/cm² unchanged, as it was set in 1984. This value was well justified by previous research, and so there was no need for changing it (Vinogradov and Dumanskiy, 1974, 1975; Shandala and Vinogradov, 1982; Shandala et al., 1983, 1985; Vinogradov and Naumenko, 1986; Vinogradov et al., 1999).

It is important to note that the MPL of 10 μW/cm² for the population has remained intact for more than 30 years. Previously, the standard was used only in Russia and the countries formerly in coalition with the Soviet Union. Now, MPLs of 10 μW/cm² or less are used as RF legal exposure limits or nonbinding recommendations for national, regional, urban, or sensitive areas for at least 20 countries worldwide (Figure 15.1).

The adoption of the standard in 2003 for the mobile phone in terms of formalizing requirements for methods of measuring the near field and for the establishment of a threshold for the evaluation of RF EMF exposure on brain function as a critical organ was not optimal. Paltsev and Rubtsova carried out comprehensive studies on establishing hygienic standards for the users of mobile phones (experiments with 110 rats, GSM 900 and 1800 MHz for 1 h/day for 40 days at 0.5 and 2 mW/cm²) (Rubsova and Paltsev, 2006). In addition, the authors conducted a study on 25 volunteers and found no significant changes in the nervous and cardiovascular systems after a single 30-min exposure to EMF of different mobile phones (Suvorov et al., 2002).

They reported that data about the changes in the immune status of animals after exposure to 500 μW/cm² were in agreement with earlier studies, indicating that the effects of RF EMF with power density 500 μW/cm² cause immune changes that can be regarded as pathological (Vinogradov and Dumanskiy, 1974, 1975; Shandala and Vinogradov, 1982; Shandala et al., 1983, 1985; Vinogradov and Naumenko, 1986; Vinogradov et al., 1999).

There was a proposal to use a safety factor of 5 and set to the cell phone MPL at 100 μW/cm² (Russian Standard, 2003—SanPiN 2.1.8/2.2.4.1190-03). It should be emphasized that SanPiN 2.1.8/2.2.4.1190-03, for the first time, introduced the recommendation to limit cell phone use for persons younger than 18 years as well as pregnant women.

The following results of our research were used as the base for the development of the Russian standard for mobile phones (model studies on isolated hearts of frogs, experiment with imprinting, physiological studies of children). The studies conducted in our laboratory have shown that the nonthermal RF EMF effects can be significant. Experiments on isolated frog hearts were conducted by Afrikanova and Grigoriev (2005). The low intensity frequency modulation was changed over time with constant frequency, preset from 1 to 100 Hz. Irradiation was carried out at 9.3 GHz. Dimensions of the frog hearts were comparable with the wavelength of the radiation. RF EMF exposure was carried out under conditions of maximum absorption of energy.

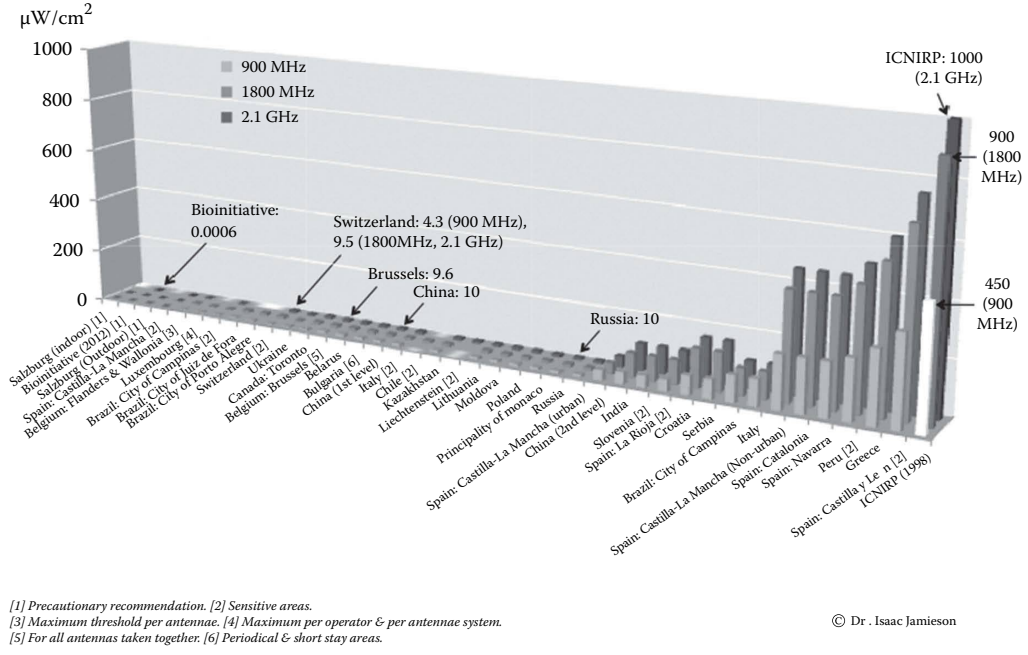

FIGURE 15.1 RF EMF legal exposure limits and nonbinding recommendations in different countries of the world. (Adapted from Jamieson, I., Changing perspectives—Improving lives. European Economic and Social Committee, Brussels, Belgium, November 4, 2014.)

The modulated signal was characterized by EMI modulation frequency ranging from 1 to 100 Hz. The pulse shape was rectangular ($S = 0.016\,mW/cm^2$). The study was conducted during exposure and after the impact of electromagnetic irradiation for 24 h. A total of 180 frog hearts were used.

A heart rate was estimated during each 30 min within 6 h from the moment of preparation of the isolated heart samples, during exposure, and also within the day after an irradiation. Simultaneously, a control "sham exposure" was run. It is important for assessing the response to irradiation that hearts in Ringer's solution can beat for 2 days. Besides, the morphological criterion of a state of excited heart tissues was studied (after a vital staining). Intact uncolored hearts on 24 h of observations showed slowing the rate of the heart on the average of 7%; the cardiac standstill was not present (Figure 15.2). The presence of the heart in stain solution during half-hour has resulted in the modification of its function. The number of the heart contractions was decreased by 30%, and 14% of hearts ceased contraction (Figure 15.2). The reaction of hearts irradiated in a continuous mode (the CW) was low and did not differ from reaction of the "colored hearts."

There was a sharp decrease in the heart rate and an increase in the number of hearts that stopped beating when the exposure was in modulated mode (Figure 15.2). The greatest effect was obtained at a frequency drift of modulation in a band of 6–10 Hz and time of exposure of 5 min. Under these conditions of exposure, slowing of the heart rate and stopping of the hearts in 85% of samples were observed. These effects were not reversible. Thus, in all, the series of the modulation frequency ranging from 1 to 100 Hz has a great influence on the function of the heart than in CW mode.

For the assessment of a role of the modulation, the procedure detailed in the general physiology of imprinting was used (Grigoriev, 1996; Grigoriev and Stepanov, 1998,

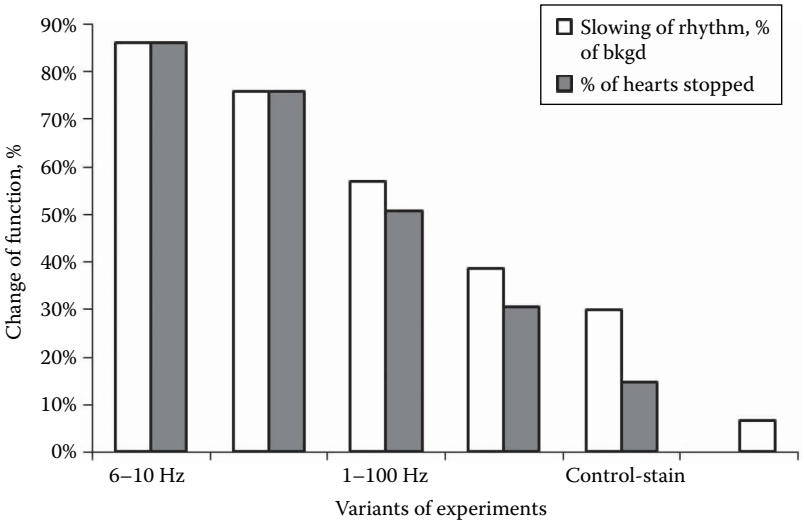

FIGURE 15.2 Change of the cardiac rhythm and cardiac standstill. The continuous regime (CW) and regime of the various modulations from 1 to 100 Hz.

2000). Imprinting is an original aspect of memorizing: The organism at birth fixes in the memory what it has seen for the first time.

One hundred and twenty-nine embryos of chickens were irradiated on day 16 of an incubation to EMF 9.3 GHz for 5 min (S = 40 μW/cm^2), with a quantization of 10 and 40 Hz, meander, pulse duration of 2.5 ms. Besides, there was a series with a continuous irradiation (CW) and "sham" exposure.

The imprinting suppression (up to 50%) was found in newborn chicken only for the series of EMF exposure at 10 and 40 Hz (Table 15.1). In case of CW exposure (S = 40 μW/cm^2) and in control group, the imprinting disturbance was not found.

In one experiment, we studied the possibility of fixing specific modulation mode EMF by brain (Grigoriev, 1996). The imprinting model was used in this experiment, and the signal of the EMF quantization was used as imprint stimulant. Irradiation of chickens was performed on the 16th day of incubation in a non-echo chamber: EMF at 9.3 GHz with the quantization of 1, 2, 3, 7, 9, or 10 Hz (S = 0.04 mW/cm^2, duration of each irradiation was 5 min).

The possibility for the development of temporal communications in 15-days old embryos was earlier shown through an electric current and sound (Hunt, 1949). Taking into account these results, we assumed that the electromagnetic modulation waveform can be fixed by the brain, and thus gain the value of an imprint signal.

The experiment protocol was as follows: on the 16th day of incubation, embryos were irradiated with EMF with modulations of 1, 2, 3, 7, 9, and 10 Hz. After the birth of chickens, the next stage was the imprinting period (24 h after birth), and in this period, no chorionic irritator was applied to the chickens. After 48 h, strobe lights with the same frequency were shown to a chicken as imprint stimulant, from which the embryo was subjected to an electromagnetic irradiation for Day 16 of incubation. The difference between alleged light stimulant and differentiation stimulant was equal to 8 Hz. The experiments were conducted on 127 chicken embryos. A possibility of imprinting is shown in Figure 15.3. The analysis of the obtained data has allowed the author to make a deduction that the embryo brain at Day 16 of incubation can fix electromagnetic stimulant with modulation of 9 or 10 Hz and can store this information for a particular time after birth.

The analysis of 28 biological experiments conducted in the laboratories in the Soviet Union and then in Russia with use of modulated RF EMF (Grigoriev, 1996, 1999a, 2001, 2004b) leads to the following conclusions:

TABLE 15.1 Imprinting in Chickens after an EMF Irradiation of Embryos for Continuous and Modulated Regimens

Series No.	Series Name	PFD, μW/cm^2	Exposure Time	Number of Embryos	Number of Chickens with Imprinting
1	Control—sham exposure	—	—	83	81 (97%)
2	Continuous exposure	40	5	27	23 (89%)
3	10 or 40 Hz modulated exposure	40	5	19	9 (50%)

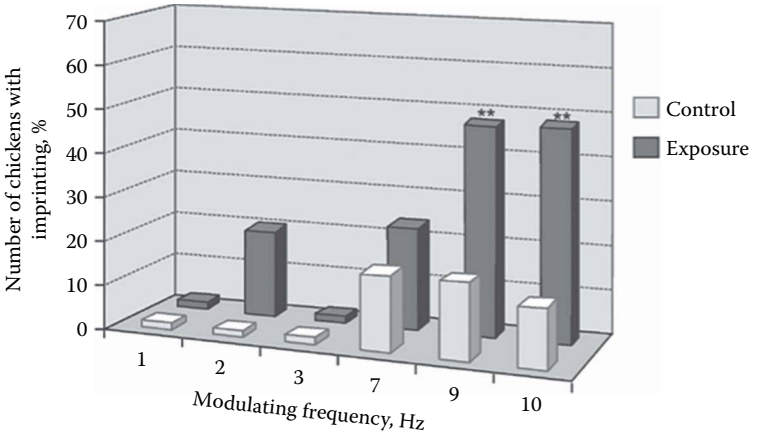

FIGURE 15.3 The number of chickens that recorded the brain electromagnetic signal (fixed imprinting).

- The exposure of biosystems to EMF with composite regimens of modulation leads to the development of bioeffects, both physiological and unfavorable, which are distinct from bioeffects induced by nonmodulated (CW) EMF.
- The acute exposure to modulated low-intensity EMF at nonthermal levels can result in the development of pathological effects.
- There is a dependence of development of a reciprocal biological response on the intensity and directness of the concrete regimen of EMF modulation; this dependence was found at all levels of biological systems—*in vitro*, *in situ,* and *in vivo*.
- As a rule, modulated EMF has invoked more expressed bioeffects than CW.
- The effects of EMF RF modulation are better pronounced at lower levels of intensity.

At the same time, we have our own experience of long-term monitoring of children who are mobile phone users. In 2006, we began long-term psychophysiological studies of primary school children who are mobile phone users and reported our results in 2014 (Grigoriev and Khorseva, 2014). It should be noted that apart from the main group in which children use mobile phones, a control group of children who did not have mobile phones and did not use was formed. The study was performed at the Lyceum in Chimki city.

Complex diagnostics of neurodynamic characteristics of children included psychophysiological indicators, assessment of neuropsychological status, and level of language development, as well as analysis of anamnesis and biographical data.

The following functional changes (preliminary results) were obtained in the first 6 years of observation:

- Fatigue (39.7%)
- Reduced ability to work in school and at home (50.7%)
- Decrease in the stability of voluntary attention (production—14.3%, accuracy—19.4%)

- Weakening of semantic memory (decrease of accuracy—19.4%, increasing time on the job—30.1%, changing the speed audiometer reaction—55.5%)
- Violation of phonemic perception (all children users). Similar results on phonemic perception of abuse were observed in India, but for the adult users of mobile phones (Panda et al., 2007, 2010, 2011).

In a recent study, Calvente et al. (2016), investigating the cognitive and behavioral function in 10-year-old children mobile phone users, concluded that "the impact of EMF RF low levels in the environment can have a negative impact on cognitive and/or behavioral development of children."

Thus, the preliminary results of the observations show that MP EMF may have a negative impact on the mental and physical health of children. The above effects reflected on the negative success of a child at school. The observed increase in the number of phonemic perception disorders increased the likelihood of errors in speech and writing and also reduced the effectiveness of the speech therapist. Despite the fact that in most cases, the change was within the age norm, stable values were below the normal limits.

The following factors allow us to conclude that the potential risk to the health of children who use mobile phones is very high:

- Absorption of electromagnetic energy by the head of a child is much higher than in the head of adults (children's brain tissue has a higher conductivity, the size of the child's head is smaller, and the skull bone of the child is thin).
- The distance from the antenna to the brain is short, because the child's ear shell is very soft and has almost no layer of the cartilage.
- The child's body is more sensitive to EMFs than adults.
- The child's brain is more vulnerable to the effects of EMF.
- The brains of children have a greater propensity to accumulation of adverse reactions in the context of repeated exposures to EMF.
- EMF RF may have an adverse effect on cognitive functions.
- Today's children use mobile phones at an early age and will continue to use them during their lifespan, and so the duration of the exposure of children to electromagnetic radiation will be substantially larger than that of modern adult users.

According to the members of the Russian National Committee of Non-Ionizing Radiation Protection (RNCNIRP, 2008), some possible disorders that might originate in children who use mobile phones include weakened memory, decline of attention, reduction of mental and cognitive abilities, irritability, sleep disturbance, tendency to stress reactions, and increased epileptic readiness.

It is also possible to expect the development of the adverse effects in older age as the result of the accumulation of adverse effects both in cells and in various functional systems of the body: brain tumors, tumors of the auditory and vestibular nerves (at age 25–30 years), Alzheimer's disease, "dementia," depressive syndrome, and other manifestations of degeneration of the nervous structures of the brain (at age 50–60 years).

Children users of mobile phones are not able to know that their brains are subjected to EMF, risking their health. This is a significant factor in moral ethics for parents.

Also important is that the risk of EMF RF exposure is not less than the risk for children's health from tobacco or alcohol.

Considering the above, we believe that children should be assigned to the high-risk group, and in fact considering a full range of circumstances, they can be equated to the "professionals." As a result, there is a need to develop specific standards for children age. Justification of these conclusions will be found in our monographs published in 2014 and 2015: Grigoriev and Khorseva (2014) and Grigoriev and Grigoriev (2013, 2016).

Our proposal for the development of specific standards for children may have additional justification. Indeed, in Russia, the only country that approved SanPin in 2003, it was recommended to restrict the use of mobile phones in children below 18 years. However, this document is still accessible only to professionals working in this field. The population does not have information about the existence of such recommendations, and children, with the permission of parents, use mobile communication and spend a maximum amount of time on cell phones, without supervision. In fact, there are two independent processes: on one hand, there is a formal recommendation on limiting the use of mobile phones by children and adolescents, and on the other hand, they use WiFi without control, even with the support of their parents, exceeding all reasonable limits on the use of mobile communications. The existence of a separate corresponding normative instrument for children will allow to draw attention of the public and government authorities to the problem and effectively implement preventive measures.

15.5 Principles for Development of International Standards/Recommendations

Currently, international standards are developed by ICNIRP, IEEE, CENELEC, and other international and national commissions. Their methodology uses only the results of experimental animal studies obtained under the conditions of acute effects and thermal-level EMF RF (Bernhard, 1999).

Any standard safety margin depends on the predetermined threshold. Outside Russia, the threshold level is determined on the basis of "stable pathological reactions" in the conditions of acute exposure to RF EMF heat level (WHO Handbook, 2002).

Taking into account the methodology of this standardization—*risk assessment of RF EMF on the basis of thermal effects in acute single exposure and determining the threshold criterion of stable pathological response*—a series of regulations was published, ICNIRP Guidelines (1998), IEEE S95.1-2005, and CENELEC EN 50166-2.2000.

In the WHO publication "Establishing a dialogue on risks from electromagnetic fields" (2002), it is stated that "Exposure limits are based on effects related to short-term acute exposure rather than long-term exposure, because the available scientific information on the long-term low level effects of exposure to EMF fields is considered to be insufficient to establish quantitative limits."

Moreover, in this edition, WHO considers it possible that the indicative or threshold level of exposure shall be established on the basis of data on early adverse biological effects of acute exposure to EMF, but it needs to set a high safety factor of 50 for

preventing adverse effects on human health caused by local or general increase in body temperature. It must be remembered that in this case, it is a one-time acute exposure, but in real life, EMF exposure will be permanent and lifelong. In this case, we can expect the development of other adverse effects that are not associated with the heating of the entire body or individual organs. It is necessary to note that Western standards are based on the settlement data.

Thus, in our opinion, the WHO has controversial and perhaps erroneous ideas about the principles of hygienic regulation. The author regrets that these principles have been used in the ICNIRP and IEEE guidelines.

Unfortunately, the development of international standards has ignored the view of many scientists about the possibility of nonthermal mechanism of the implementation of the biological action of low levels of EMF (Presman, 1968; Frey et al., 1975; Kholodov, 1975, 1996; Ivanov-Muramsky, 1977). Furthermore, it was not taken into account that at low levels of exposure to RF EMF, a significant role in shaping the biological effects can have a major effect (Grigoriev, 1996, 1999b, 2001, 2004, 2006; Adey, 2002; Markov, 2006; Belyaev and Grigoriev, 2007; Belyaev, 2015).

Our long experience with ionizing and non-ionizing radiations led us to formulate the following postulate: "The development of hygiene standards for the population should take into account the actual conditions of EMF RF exposure of the population—local or total exposure, acute single exposure or chronic, constant, or repeated exposure; the functional importance of 'critical organ' or 'critical body systems'; and effect on all population groups or only on certain limited groups of the population" (Grigoriev, 1997, 2008a).

Taking into account this postulate, we can make a clear conclusion that the Western standards do not meet the basic hygienic requirements. We make this conclusion based on the evaluation of the modern electromagnetic situation in the habitat of the population. In reality, the population has never met with high (thermal) RF EMF levels, especially in the context of an acute exposure. The current population is subjected to round-the-clock chronic exposure to RF EMF throughout the life span, and intermittent irradiation of the brain occurs. In all these cases, the impact is observed at nonthermal RF EMF levels. In addition, Western regulations do not take into account events that occurred for the first time during the life of our civilization. *Children who use mobile phones voluntarily irradiate their brains. This EMF RF exposure of the brain occurs every day, and the fractional exposure is projected for many years.*

We criticized the Western standards because they do not correspond to the actual conditions of RF EMF exposure on the population (report in 2003 at an international seminar in China, Grigoriev et al., 2003b). The criticism of these standards was continued in 2008 at an international conference in London on "EMF and Health—a global assessment" (Grigoriev, 2008). However, until now, we do not have enough clarification from ICNIRP as to how their standards and guidelines can be used in relation to very different conditions of RF EMF exposure on the population.

We further wish to note that there is no scientific background to extrapolate international standards to the real conditions of the habitat of the population. Completely absent are studies and papers on the methodology of transition to a rationing of acute exposure levels of thermal EMF RF to chronic long-term effects of low levels of radiation.

As a result of the existence of different methodologies, rationing RF EMF led to large differences in the recommended MPL for the people who are directly related to the risk assessment of the EMF of base stations; while MPL (Ministry of Health) established in Russia is 10 μW/cm^2, ICNIRP level is 100 times higher (1000 μW/cm^2).

This analysis of the methodology of RF EMF regulation abroad allows us to conclude that the current so-called International Recommendations/Guidelines (ICNIRP, 1998) and the IEEE Standards (S95.1-2005), CENELEC (EN 50166-2.2000) do not correspond to existing conditions of RF EMF exposure on the population and cannot guarantee the safety of the public health.

Interestingly, this view was confirmed by the European Parliament in 2009 (in Paragraph 22 of the EMF resolution):

> 22. Notes that the limits on exposure to electromagnetic fields which have been set for the general public are obsolete, since they have not been adjusted in the wake of Council Recommendation 1999/519/EC of 12 July 1999 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 30 GHz), obviously take no account of developments in information and communication technologies, of the recommendations issued by the European Environment Agency or of the stricter emission standards adopted, for example, by Belgium, Italy and Austria, and do not address the issue of vulnerable groups, such as pregnant women, newborn babies and children. (The European Parliament approved the EMF resolution, April 12, 2009. The votes by the MEPs were: 559 yes, 22 against and 8 abstentions)

15.6 Children and the Possible Standardization of EMF RF

We believe that it is necessary within the framework of the development problems of the methodology of EMF RF standards to specifically consider additional criteria for risk assessment related to the exposure of children to RF EMF who became active users of mobile phones.

Western experts working on new standards, completely ignoring the problem of childhood cell phone use do not take into account the WHO opinion on the higher sensitivity of children to environmental factors in the International standards: "children are different from adults."

Children have a unique vulnerability. As they grow and develop, there are "windows of susceptibility": periods when their organs and systems may be particularly sensitive to the effect of certain environmental threats (WHO, 2003).

Previously, we paid attention to this problem (Grigoriev, 2004a, 2005, 2007, 2008, 2012, 2013; Belyev and Grigoriev, 2007; Fragopoulou et al., 2010; Markov and Grigoriev, 2013, 2015). The Russian National Committee on Non-Ionizing Radiation Protection adopted six resolutions on the need to protect children from the EMF of mobile phones (2001, 2004, 2008, 2009, 2011, 2012). Some of these decisions have been translated into English, and at our request, the WHO Secretariat has sent the decision to the members of the WHO "International EMF Project" advisory committee.

In Russian SanPiN 2.1.8/2.2.4.1190-03, Item 6.9 (2003) recommended to limit the possibility of the use of mobile phones by children.

Finally, in 2014–2016, several books and several articles were published confirming the need to address this problem (Grigoriev and Khorseva, 2014; Gandhi, 2015; Markov and Grigoriev, 2015; Grigoriev and Grigoriev, 2016). In 2012, American Academy of Pediatrics appealed to the Federal Communication Commission (FCC) of USA and urgently requested the revision of the methodological approach and standards to protect the health of children from mobile phone EMF (Kucinich, 2012).

15.7 The Real Picture of Today

The electromagnetic burden on the population is growing daily. At the same time, over the last 20 years, debates are still continuing on the following topic: Is the health of the population at risk because of increasing pollution due to RF EMF from the base stations and mobile phones?

The brains of almost all people on earth are exposed to EMF radiation. However, practically, there are no restrictions for the use of mobile communications. Having the advantages and convenience of mobile communication, the population is ignoring the information about the possible risks to their health. This threat affects everybody, including children aged 3–4 years. Pregnant women do not protect their fetuses from exposure to EMF.

The scientific community is watching this picture and is waiting for the results of this uncontrolled global experiment (Markov and Grigoriev, 2013). We saw similar hazards during the Victorian period in Britain (wallpaper with mercury and toys with lead).

15.8 What to Do?

In 2013, we were invited to Brussels for the EMF Workshop on Risk Communication of the European Commission for Health and Consumer Protection (DG SANCO) to present our viewpoint on the possible risk of mobile phone EMF to public health. The main theme of our report was that there are four postulates that show the risk to public health from mobile communication (Grigoriev, 2013). It is necessary to convince the population and to create an environment of reasonable restrictions on the use of this communication.

The first postulate: "EMF—harmful type of radiation." Mobile communication uses RF EMF. This type of electromagnetic radiation is considered harmful. Exceeding the permissible levels can cause disease; therefore, it requires hygienic control. *This is the absolute truth.*

The second postulate: "The brain and EMF." The mobile phone is an open source of EMF, and there is no protection for valuable human organs. EMFs affect the brain during mobile phone use. Nerve structures inside the internal ear (the vestibular and the auditory apparatus) are located directly under the beam of EMF. *This is the absolute truth.*

The third postulate: "Children and EMF." For the first time, in history the child's brain is subjected to RF EMF. There are no results of the study of chronic local RF EMF exposure on the brain. Children are more vulnerable to external environmental factors. This opinion was expressed by WHO (2003) and in the Parma Declaration (WHO European Region, 2010). *This is the absolute truth*.

Fourth postulate: "The lack of adequate recommendations/standards." There is no agreement on the methodology for determining the EMF RF remote control and for the development of international standards, and there are no results from 20 years of debate on this issue. *This is a real fact*.

15.9 My Suggestion

I have extensive experience in research on issues related to "ionizing radiation and health" (over 60 years) and "non-ionizing radiation and health" (about 40 years).

I believe that the time has come to provide the public with full information on the possible dangers of mobile communication for their health. The abovementioned four postulates allow the public to comprehend the likely risks to their health from uncontrolled use of mobile communication. Given the global situation, which occurred due to the use of mobile communications for the past 25 years, I believe that at this stage, only the people themselves can take more effective measures to limit the effects of RF EMF on their own health.

As a temporary measure of limiting exposure to EMF on the population, it is necessary to introduce the concept of "*voluntary risk*"; that is, the mobile phone use should be a product of self-selection on the background of the official public information about possible health hazards.

I appeal to colleagues: Do not sin against the truth!

15.10 Conclusion

Of course, new sources of electromagnetic radiation are creating additional problems in the development of standards. Public health protection issues in connection with the use of mobile communications have become completely different. The use of mobile phones has led to the local long-term RF EMF exposure to the brain. The normative level is not considered a permanent RF EMF exposure on the brain of the user. Existing regulations do not address to the real hazard RF EMF exposure. Given these circumstances, standards cannot currently guarantee the well-being of adults and children.

Children mobile phone users were included in the group of high risk. In this regard, there is a need to develop more appropriate stringent standards to ensure absolute security for growing children. Existing standards should take into consideration the vulnerable group of people hypersensitive to RF EMF.

Given that the current regulations are outdated, it is necessary to carry out complex research into possible biological effects on conditions of chronic exposure to low-intensity EMF RF, bearing in mind, above all, long-term exposure on the brain at all levels of development.

As a temporary measure of limiting exposure to EMF on the population, it is necessary to introduce the concept of "voluntary risk"; that is, mobile telephony should be a product of self-selection on the background of the official public information about possible health hazards.

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