

risk with respect to other workers at comparable exposure levels are still object of debate. Overall, the topic of workers at particular risk exposed to EMF is an open question and has to be managed case by case using a combination of information sources: directive itself, exposure assessment in the workplace, technical standards, findings of workers' health surveillance, information acquired by the general practitioner or specialists having in care the worker, data from the manufacturer of the devices (e.g. technical sheets or instruction manuals), scientific literature etc.

#### 1649d WHAT HEALTH SURVEILLANCE OF EMF EXPOSED WORKERS?

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10.1136/oemed-2018-ICOHabstracts.1205

In the European Union (EU), the Directive 2013/35/EU has introduced the legal obligation of an 'appropriate health surveillance' (HS) for workers exposed to electromagnetic fields (EMF). Until now no agreement exists on the criteria, and on the contents, of such an HS. The EU Directive specifically refers to the protection from the risks associated with known direct biophysical and indirect short-term effects caused by EMF, while does not address to the suggested long-term effects since scientific evidence of a causal relationship is considered not adequate. Accordingly, at least in EU Countries specific objectives of HS are:

- the prevention of established effect, such as the stimulation of muscles, nerves or sensory organs (including temporary annoyance or effects on cognition) and limb currents, or any thermal effects;
- the health and safety of workers 'at particular risk', e.g. workers with active implanted medical devices (cardiac pacemakers, ICD, insulin pumps, etc.) or pregnant workers; nevertheless a comprehensive definition of the conditions inducing a 'particular risk', and of the safe thresholds, are still lacking.

It should be noted here that the exposure limits introduced by the Directive 2013/35/UE do not necessarily provide an adequate protection of such workers, e.g. interference problems with pacemakers may occur at lower levels. HS is therefore mainly aimed to evidence the occurrence of clinical symptoms possibly related to EMF and the existence of conditions possibly inducing particular risk, while specific laboratory test are not required, except on individual clinical basis. As a conclusion, at present time no agreement exists on the health surveillance of EMF exposed workers, and knowledge on some aspects, e.g. the conditions inducing particular risk and the possible thresholds, are still insufficient, and do not give an adequate support to the occupational physician to face the problem.

#### 1650 MAGNETIC RESONANCE IMAGING (MRI) WORKERS: EMF EXPOSURE, OCCUPATIONAL RISK AND PREVENTION. AN UPDATE

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10.1136/oemed-2018-ICOHabstracts.1206

**Aim of special session** Magnetic Resonance Imaging (MRI) is an important technology both for diagnostic and research purposes. MRI operators are exposed to high levels of electromagnetic fields (EMF), mainly static magnetic fields and low-frequency time-varying magnetic fields (TvMF). Objective of this Special Session is an update of the results of research on the effects related to occupational EMF exposure in MRI operators, and on possible prevention.

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#### 1650a SUBJECTIVE SYMPTOMS IN MAGNETIC RESONANCE IMAGING OPERATORS: PRELIMINARY RESULTS OF AN ITALIAN STUDY

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10.1136/oemed-2018-ICOHabstracts.1207

**Introduction** Magnetic Resonance Imaging (MRI) operators are exposed to significant levels of electromagnetic fields (EMF). In these workers an elevated prevalence of various subjective symptoms has been reported. Even if most symptoms are non-specific, in some recent studies a group of 5 more specific symptoms, defined 'core symptoms', was proposed: vertigo, nausea, head ringing, magnetophosphenes and metallic taste. Our aim was to investigate the prevalence of subjective symptoms, including 'core symptoms', in Italian MRI operators, in order to evaluate the association with exposure.

**Methods** A sample of 152 MRI operators working in 6 different hospitals in Italy was collected. No measurements were available, so for each participant exposure was estimated based on scanner type (<1T, 1.5T –<3T and ≥3T respectively) and on the total number of MRI procedures followed. In all operators an *ad hoc* questionnaire including relevant sociodemographic and occupational data, and the occurrence of subjective symptoms based our previous experience, was collected. The influence of stress was also evaluated. The relation between occupational exposure and symptoms was studied using multivariate analysis.

**Result** The multivariate analysis shows a significant correlation between exposure level and the total number of investigated symptoms. The results were confirmed considering the specific subset of 'core symptoms' based on previous literature data. In the multivariate model, the weight of the other covariate factors was not significant. The overall results were substantially confirmed considering the effect of work stress.

**Discussion and conclusions** In the observed group of MRI operators the total number of subjective symptoms was associated with EMF exposure; the subset of 'core symptoms' also proved significantly dose-related with exposure. The symptoms

prevalence was not significantly influenced by work stress. The results support the association between subjective symptoms and EMF exposure in MRI operators. Another conclusion is that the appearance of the specific group of 'core symptoms' may be usefully investigated in health surveillance of MRI operators.

**1650b** PROTECTION OF MRI WORKERS AGAINST MAGNETIC FIELDS ACCORDING TO EU DIRECTIVE AND ICNIRP GUIDELINES

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10.1136/oemed-2018-ICOHabstracts.1208

**Introduction** Directive 2013/35/EU lays down minimum health and safety requirements regarding the exposure of workers to electromagnetic fields, including those present in Magnetic Resonance Imaging (MRI) facilities. For what concerns the Static Magnetic Field (SMF), the Directive follows a 'flexible approach' introduced by the 2009 ICNIRP guidelines, which is based on the distinction between sensory and health effects, thus allowing in some circumstances exposed workers to possibly experience unpleasant sensory effects. In addition, the Directive provides for the possibility of derogating from the health exposure limits, explicitly referring to the case of MRI. However, protection issues related to effects associated with movements of workers in the SMF are not completely addressed by EU limits. ICNIRP has published a guideline on this matter in 2014, but it has not yet been transposed into the Directive.

**Methods** Measurements were performed of low frequency switched gradient magnetic fields and of the magnetic flux density experienced as variable by workers moving in the SMF of 1.5 T, 3 T and 7 T MRI scanners. In the latter case, three different metrics were applied to process the collected data and compare them with the EU Directive Exposure Limit Values (ELVs) for SMF, the ICNIRP basic restrictions (BRs) aimed at preventing vertigo effects and the ICNIRP reference levels (RLs) intended to prevent stimulation effects.

**Results** Regarding movement in the SMF, reported values of the peak magnetic flux density, of its variation in 3 s and of the weighted-peak indices for stimulation effects show several cases of non-compliance with the corresponding ICNIRP BRs and RLs even when EU Directive ELVs are complied with. Results of exposure to low frequency magnetic fields are being processed.

Acknowledgments part of the work presented is funded by INAIL, Italian Workers' Compensation Authority.

**1650c** PREVENTION OF ELECTROMAGNETIC EXPOSURE OF WORKERS NEAR MRI SCANNERS – 25 YEARS OF EXPERIENCE IN POLAND

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10.1136/oemed-2018-ICOHabstracts.1209

**Introduction** Inside the diagnostic chamber of magnetic resonance imaging (MRI) scanners, every worker (medical personnel, cleaners, administrative, etc.) is affected by the strong static magnetic field (SMF) emitted continuously by superconducting magnets (24 hours per day).

**Methods** A retrospective study on the variety of parameters characterising the static and dynamic influence of SMF (B-field level and spatial distribution, spatial gradients (dB/dx), dynamic changes of exposure caused by body movements (dB/dt)) covered their analysis based on the results of our 25-year-long investigations into the context of the development of scanner design, work practice, requirements of occupational legislation and an understanding of the nature of health and safety hazards.

**Results** We found significant variability in the exposure pattern, and that exposure parameters may not be proportional to the magnet power, but may be highly dependent on the scanner design. It suggests the potential to reduce worker exposure by ergonomic and organisational interventions.

**Conclusion** Our extensive studies on workers' SMF exposure near MRI scanners has shown that the set of SMF action levels (0.5, 3, 50, 200, 400 mT; 1, 2, 8T) may sufficiently characterise various hazards caused by the static and dynamic influence of SMF on workers and various objects. The three-dimensional mapping of SMF distribution near MRI magnets, and its graphical representation in the diagnostic room, provides significant practical information for managers and workers in the MRI centre, leading to an understanding of how to develop the work practice in order to reduce daily exposure to SMF.

Research supported in Poland by the Ministry of Family, Labour and Social Policy – the National Programme 'Improvement of safety and working conditions' (project 1.G.12).

**1651** SOLAR UV: A RELEVANT OCCUPATIONAL RISK OVERLOOKED. EXPOSURE IN WORKERS, EFFECTS, PREVENTION

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10.1136/oemed-2018-ICOHabstracts.1210

**Aim of special session** The exposure to Solar UV Radiation is a significant risk factor in several occupational activities and the adverse health effects induced in exposed workers, mainly to the skin and to the eye, are relevant, frequent and well documented. Nevertheless, we have to admit that this important occupational risk is usually underestimated, if not ignored. On the contrary, the development of adequate preventive measures represents a priority in OHS. Objective of this Special Session is an update on the results on exposure evaluation, adverse effects and enforceable prevention strategies in exposed workers

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