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**БЪЛГАРСКО СПИСАНИЕ ЗА ОБЩЕСТВЕНО ЗДРАВЕ
ОФИЦИАЛНО ИЗДАНИЕ НА НАЦИОНАЛНИЯ ЦЕНТЪР ПО ОПАЗВАНЕ НА ОБЩЕСТВЕНОТО ЗДРАВЕ**

ЦЕЛ И ОБХВАТ

"Българско списание за обществено здраве" е многопрофилно списание, което включва публикации в областта на здравната политика и практика, здравния мениджмънт и икономика, епидемиология на неинфекциозните и заразните болести, здраве на населението (жените,децата), промоция на здравето и профилактика на болестите, околна среда и здраве, трудова медицина, храни и хранене, кризисни ситуации и обществено здраве, психично здраве. Списанието дава форум за дискусия по актуални проблеми на общественото здраве в България, Европа, САЩ и др. страни. В специални приложения се публикуват материали, посветени на актуални теми, проучвания, резюмета и доклади от международни и национални научни форуми и кръгли маси. Списанието има за цел да популяризира и насърчава изследвания, добри практики, политики, управление и образование в областта на общественото здраве. Излиза в 4 книжки годишно на български и английски език, публикувани на интернет страницата на Националния център по общественото здраве анализи (http://ncpha.government.bg)

АДРЕС НА РЕДАКЦИЯТА:

Проф. д-р Петко Салчев, дм - Главен редактор
"Българско списание за обществено здраве"
Национален център по обществено здраве и анализи
Бул. "Акад. Иван Гешов" 15, София 1431, България
e-mail: t.karanesheva@ncpha.government.bg

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Prof. Petko Salchev, MD, PhD - Editor-in-Chief
Bulgarian Journal of Public Health
National Center of Public Health and analyses
15 Acad.Ivan Geshov Blvd ,1431 Sofia, Bulgaria
e-mail: t.karanesheva@ncpha.government.bg

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БИОЛОГИЧНО ДЕЙСТВИЕ НА ЕЛЕКТРОМАГНИТНИТЕ ПОЛЕТА

КРАТКО ОПИСАНИЕ НА НАУЧНИТЕ РЕЗУЛТАТИ ОТ 8-ТА МЕЖДУНАРОДНА РАБОТНА СРЕЩА, 21–26 СЕПТЕМВРИ 2014 Г., ВАРНА, БЪЛГАРИЯ

Традиционната за Средиземноморските страни Международна работна среща по биологични ефекти на електромагнитните полета (ЕМП) събра учени от 27 държави, повечето страни-членки на Европейския съюз, а също и от други страни, като Армения, Египет, Индия, Иран, Малайзия, Перу, Русия, САЩ, Турция, Япония.

Научните съобщения бяха фокусирани основно върху качеството на научните изследвания, здравето на работещите и населението и съвременното законодателство в Европа в областта на нейонизиращите лъчения.

***Организираните сесии по:** „Качество на научните изследвания“, „Измерване, оценка, моделиране и дозиметрия на електромагнитните полета“, „Биофизика и биология при електромагнитни взаимодействия“, „Медицински приложения на електромагнитните полета и УВ лъчение“, „Комуникация на риска и политика за постигане на принципа на превантивност“, „Здраве и безопасност при работа“, „Обществено здраве“, „Законодателство в Европа по нейонизиращи лъчения“, дадоха възможност за представяне на нови научни резултати и дискусии по теми, които са силно „чувствителни“ в последните години по отношение на противоречията в науката.*

Някои от основните научни постижения, представени на този форум и публикувани в настоящото списание, са:

***В областта на качеството на научните изследвания:** Научният комитет на Европейската комисия SCENIHR (Scientific Committee on Emerging and Newly Identified Health Risks) дискутира приемането и публикуването на „Ръководство за научни изследвания в областта на електромагнетизма“, което включва минималните изисквания за дизайн на научното изследване, с цел намаляване на противоречията в научните резултати и по-високи критерии за оценка на доказателствата за биологичен и вреден ефект от въздействието на нейонизиращите лъчения върху човека. Специално внимание е отделено на потенциалните ефекти върху нервната система - невро-поведенческите нарушения; риска от възникване на неоплазми под електромагнитно въздействие; по-дълбокото разбиране на биофизичните механизми на взаимодействие на полетата с живите организми, особено за доказване на ефекти от епидемиологични проучвания; комбинираното действие на нейонизиращите лъчения с други фактори на средата; въздействието на милиметровия диапазон на електромагнитните полета.*

***В областта на комуникацията на риска:** Анализът на резултатите в различните страни показва намаляване на страховете сред населението, което се дължи основно на прилагането на качествени програми за комуникация на риска на национално ниво. Дискусията беше свързана основно с усъвършенстване на тези програми, тъй като те са разработени на основата на „максималния риск“ и поради това не са достатъчно балансирани с реалните условия.*

***„Измервания, оценка, моделиране, дозиметрия“:** В тази област са представени нови компютърни методи за моделиране, усъвършенствани и с много по-висока точност за оценка на експозицията. Предложени са нови модели, основани на хомогенни характеристики на човешка глава с метални очила, модели на човек, използващ „smart” устройства, както и модели за анализ на въздействието на излъчването от мобилни телефони в реално време. Новости са представени в областта на измерванията в работната среда с устройства, прилагащи ЯМР технологии.*

„Новото законодателство в Европа“: *Транспонирането на Директива 2013/35/ЕК за работещи в условия на ЕМП трябва да завърши на 1.07.2016 г. в страните-членки. Обсъдена бе готовността на всяка една от държавите за въвеждането на новите гранични стойности, както и на политиката за защита на работещите. Дискусия беше проведена и върху защитата на работещите с изкуствени източници на оптични лъчения, както и на населението, използващо солариуми. Доказателствата говорят за силно завишен риск от кожна меланома, свързана с облъчването с УВ лъчение.*

В областта на „биофизиката и биологията на електромагнитните взаимодействия“ *бяха обсъдени основни механизми на биологични ефекти от облъчване с различни честотни обхвати на лъчението. Най-сериозните резултати тук бяха свързани с възможните „нетермични ефекти“, които доскоро бяха неглижирани при разработването на гранични стойности за експозиция. Дискутирани бяха новите подходи за прилагане на научна методология при изследвания с доброволци.*

„Приложенията на нейонизиращите лъчения в медицината“ *обедини учените към общ подход при прилагане на различните нейонизиращи лъчения – електромагнитни полета, магнитни импулси, ЯМР, оптични, лазерни лъчения, при оценката на положителния ефект от въздействието им върху пациентите, както и при защитата на медицинския персонал, прилагащ тези технологии.*

„Здравето и безопасността при работа в условия на нейонизиращи лъчения“ *се изследва с нови методи за оценка на кумулативния ефект, при оценката на различни допълнителни фактори на средата, както и на неблагоприятни навици на работещите върху здравното им състояние. Рисковите контингенти остават тези, работещи в металургията, военното дело, комуникациите, физиотерапията, ЯМР.*

Ефектите на въздействие на ЕМП върху населението (обществено здраве) *се изследват със сериозни епидемиологични подходи при лица, прилагащи устройства за изкуствен тен, живеещи в сгради с трансформатори, в условия на голяма гъстота на базови станции за мобилна комуникация и на други телекомуникационни източници. Най-сериозните проблеми са свързани с лицата, обявяващи себе си за „свръхчувствителни към ЕМП“, което е заболяване, включено в много страни като нозологична единица, но не свързано с въздействието на лъчения. Дискутирано беше ниското ниво на прилаганата измервателна апаратура за целите на общественото здраве в много страни, което създава несигурност при оценка на резултатите от изследванията.*

В заключение, представените публикации в списанието са сериозна новост в областта на електромагнитобиологията, особено за последните години. Те представят съвременното ниво на тази наука в Европа и в света. Присъствието и участието в научните дискусии на големи международни организации, на световно известни учени от цял свят, спомогна за сериозно повишаване на научното ниво на традиционните работни срещи на Средиземноморските страни.

За осъществяването на тази работна среща, както и публикуването на най-престижните научни резултати, спомогна Проект БГ 07. Програма „Инициативи за обществено здраве“, с финансовата помощ на Норвежкия финансов механизъм 2009-2014 и на Европейския финансов механизъм 2009-2014 г. по тема: „Усъвършенстване на контрола и на информационните системи в превенцията на риска в здравеопазването“.

Доц. М. Израел, д.м.,
Председател на орг.комитет на
8-ма международна работна среща
„Биологични ефекти на ЕМП“ и
Ръководител на Проект БГ 07, ПДПС 01

BIOLOGICAL EFFECT OF BIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS

BRIEF DESCRIPTION OF THE SCIENTIFIC RESULTS OF THE 8TH INTERNATIONAL WORKSHOP - 21 TO 26 SEPTEMBER 2014, VARNA, BULGARIA

Short overview:

The 8th International Workshop on Biological effects of Electromagnetic Fields completed. The main challenge of this Workshop was to gather scientists from 27 countries, most of them from Europe, and also from Armenia, Egypt, India, Iran, Japan, Malaysia, Peru, Russia, Turkey, USA.

Since this meeting was focused on few directions, mainly "quality of science" and "occupational/public health and new European legislation", it achieved very high quality of presentations in comparison with many other meetings in this field before.

The organization of round tables on "European legislation in the field of EMF and optical radiation", "risk communication programmes and policy", "new projects in the field of non-ionizing radiation" were new approach giving the possibility for discussion and possible future research and decisions.

Several sessions: *"Quality of science", "Measurement, exposure, modeling, dosimetry", "Human exposure standards", "Biophysics and biology", "Medical applications of EMF and UV", "Occupational health and safety", "Public health", covered wide spectrum of the contemporary research studies in the field of non-ionizing radiation focused on human health, and also the main scientific interests of all participants.*

Exposure and risk assessment of UV radiation in different occupations was discussed together with similar topics concerning other frequency ranges as a part of non-ionizing radiation health and safety.

The youth session, and the competition between the students for the "young scientists' award" gave a special spirit of the Workshop.

Some of the main outcomes from the different sessions are as follows:

Quality of science: *Risk communication and management*

Council Recommendations invites the Commission to encourage research, to promote consensus on guidelines and to keep the matter under review. The EU policy is based on best available scientific knowledge, and the SCENIHR looks for gaps in knowledge. It gives particular attention on potential adverse effect on nervous system, including neurobehavioral disorders and on the risk of neoplastic diseases, understanding biophysical mechanisms of biological effects and epidemiological findings, the potential effect of co-exposure to other factors in the environment, adverse effects of THz range. The new idea is to develop a set of prioritized research recommendations updating previous efforts in this area (in particular by the SCENIHR and the WHO). These recommendations should include methodological guidance on the experimental design and minimum requirements to ensure data quality and usability for risk assessment.

Public concern on EMF exposures decreases in most of the countries in the world. This phenomenon is a result of implementation of risk communication programmes as some countries presented (Japan, Bulgaria and others).

Meanwhile, risk communication programmes needs to be improved because it is based only on pick out worst case results, and it is imbalanced.

Measurement, exposure, modeling, dosimetry

New approaches in the field of measurements and exposure assessment in the near field zone were presented, also for evaluation of the SAR values in the close proximity to the source.

Modelling of human exposure in the low and RF *ranges were proposed for improving the uncertainty in exposure assessment and dosimetry. New models, as surface-based model of the human body, numerical model of human homogeneous head with metallic glasses, models for evaluation of the exposure from smart meters and for real-time signal analyses by mobile phones' exposure were presented.*

Several papers concerning methods for assessment of SAR values from mobile phones, smart meters presented original methods for evaluation.

One of the main focuses in this session was the improvement of the calibration methods, far vs. near field assessment of the exposure, the influence of the human body on the uncertainty of measurements.

Power frequency magnetic field was discussed concerning details in exposure assessment.

Human exposure standards

The main topic of the presentations, also of the discussion on the round table was the EU Directive 2013/35/EU that is in a stage of transposition in national legislation of the Member states. Most of the countries are not prepared for this transposition, and they wait for the Practical Guide that should be prepared by the European Commission.

The discussion covered also the methods for compliance with this Directive, also the way for harmonization in the field of EMF human exposure between European countries and others, as Russia, Latin America.

Similar situation exists concerning the Directive 2006/25/EC for optical radiation: the Practical Guide is not transposed in national legislation in some countries (including Bulgaria) that complicates the practical implementation of the measures.

Special questionnaire for determining of various measures used in international guidelines and EU Directive 2013/35/EU was discussed and disseminated amongst the participants. Results are in processing, and general conclusions will be available in the near future.

Biophysics and biology

First, in this session, the hypersensitivity phenomena were discussed. The question was: if these phenomena exist or this is other type of sensitivity that people associate with EMF exposure. Cell hydration was one of the discussed markers for studying weak biological effects, and contrariwise was the dosimetric considerations for observing the reason of every RF biological effect.

In addition, big variety of laboratory studies of the interaction of static and pulsed magnetic fields, ELF, intermediate frequencies, RF, millimeter waves, were presented. Some experimental studies could be addressed to low level of exposure (low dose), and others to non-thermal effects.

There were presentations concerning dielectric properties of tissues, also possible cancer development due to EMF exposure. Water characteristics under EMF exposure were in discussion, as well.

Of course, the permanent discussions on Ca2+ efflux, growth parameters of cells, the possible effects from weak exposure of pulsed fields were considered.

Several studies of EMF exposure to humans (volunteers) of mobile phones were presented.

It was very important that non-ionizing and ionizing radiation were discussed for biological and adverse effects or for synergism. The risk assessment and the risk policy concerning non-ionizing radiation exposure should follow the used policy in the field of ionizing radiation.

Medical applications EMF and UV

New methods for applying low frequency magnetic fields, direct currents, ultrasound, magnetic nanoparticles were presented at this session.

One important outcome is that speaking about health effects, both adverse and beneficial effects on health should be considered. Medical applications of the whole frequency range of EMF, also of the optical radiation (UV) have to be studied. The wide spread of devices with sources of non-ionizing radiation moves the medical diagnosis and treatment to new challenges. In other case, medical personnel (in MRI, physiotherapy) and patients are exposed to non-ionizing radiation that could be harmful for their health.

Occupational health and safety

Results show high risk for workers exposed to ELF in energetics, for workers with RF exposure in military application of radars and other radio equipment, for radiographers in medical diagnosis with MRI equipment, for medical staff in physiotherapy, for workers exposed to magnetic fields in industry. New methods for evaluation of cumulative solar radiation in outdoor workers, also new aspects of ELF safety were discussed.

Combination of EMF and co-factors, as smoking habit, shift work was investigated.

Public health

There were several aspects of non-ionizing radiation exposure to general population concerning the use *of sunbeds for tanning, power lines, transformer stations, digital TV and LTE base stations. Results of measurements in the vicinity of the cited sources, also in metro stations were presented. Some results were focused on exposure to children concerning possible adverse effect on their health and childhood leukaemia.*

Legislation concerning the use of solaria was discussed, and the opinions were that stringent requirements should be applied.

Some of the general challenges were connected with new methodology in laboratory, human and epidemiological studies, investigations in the whole frequency range, including optical (mainly UV) radiation, intermediate frequencies, millimeter waves, ionizing radiation, as well. Other achievement is the study of combination of factors, including EMF, as smoking habit, ionizing radiation, a shift work.

As a chair of the organizing committee, I want to express my gratitude to all guests for their participation, and for their excellent presentations, and especially to those that were so busy to attend the meeting for the whole time, as the representatives of the European Commission (SCENIHR) – Giulio Gallo, Theodoros Samaras, Donata Meroni, WHO – Emilie van Deventer (attending online).

I, also, want to thank to our partners: ICOH (Scientific Committee Radiation and Work), especially to Fabriciomaria Gobba, to the European Commission, to the Director of the National Centre of Public Health and Analyses, the Dean of the Faculty of Public Health and the Rector of the Medical University of Pleven, and of the Medical University of Varna.

Special thanks are for the support from the BG 07: Programme "Public Health Initiatives" with the financial contribution of the Norwegian Financial Mechanism 2009-2014 and EEA Financial Mechanism 2009-2014: "Improving control and information systems in risk prevention and healthcare".

I express my personal gratitude to all members of the Committee: prof. P.Kostarakis, prof. M.Markov, prof. Ch.Sammut, prof. T.Kalkan, to the International Advisory Committee, helping in arranging the programme, and giving advices in the process of organization of the meeting.

It is very important for me to express my special gratitude to the Bulgarian organizers of the meeting, mainly to V. Zaryabova, T. Shalamanova, also to M. Ivanova, V. Topalova, Chr. Petkova, P. Ivanova, R. Petrova, M. Dimitrova, A. Kostova, L. Israel, V. Staneva. All they worked hard for the real organization of the meeting and for the comfort of the participants.

Finally, as you understood, the next meeting will be held in Armenia. We wish to prof. Sinerik Ayrapetyan to continue the process of gathering scientists all over the world, and to follow the traditions of these meeting created by prof. Panos Kostarakis and improved by the next chairs, and to organize a meeting with high level of research quality in the field of non-ionizing radiation.

Thank you!

Michel Israel,
Chair of the 8th IWBEEMF,
Varna, Bulgaria

8th International Workshop on Biological Effects of Electromagnetic Fields

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RISK COMMUNICATION ACTIVITIES ON EMF IN JAPAN

Chiyoji Ohkubo
Japan EMF Information Center

ABSTRACT

Possible health effects of exposure electromagnetic fields (EMFs) are one of the public concerns in the environmental issues. In 2007, the Japanese Ministry of Economy, Trade and Industry (METI) formed a Working Group on Electric Power Facility and EMF Policy. The Working Group recommended that a neutral and permanent EMF information center should be established to promote risk communication and facilitate peoples' understanding based on scientific evidences. In response to this recommendation, the Japan EMF Information Center (JEIC) was settled in July 2008. Activities of the JEIC and other organizations will be described at the meeting.

Key words: *Risk communication; Risk perception; EMF*

Electromagnetic fields (EMFs) are unavoidably produced wherever electricity is used, and are thus inherent in modern societies. Throughout the world, peoples in general public concern about exposure to EMFs emitted from such sources as power lines, domestic electric appliances, mobile telecommunication devices and their base stations could lead to adverse health consequences, especially in children and pregnant female. As a result, the construction of new power lines and mobile telephone base stations has met with considerable opposition not only in Japan but in many countries. Lack of knowledge about health consequences of EMF exposure may not be the sole reason for social opposition to innovations. Ignorance of differences in risk perception that are not adequately reflected in risk communications of EMFs among scientists, governments, industry and the general public, is also to be accused.

The scientific evidence on EMFs and their potential health effects has been reviewed many times, mostly by the World Health Organization (WHO). In 2007, the World Health Organization (WHO) issued the Environmental Health Criteria monograph 238 and Fact Sheet 322 on extremely low frequency (ELF) EMFs for supporting the needs of the health ministries of Member States of the WHO International EMF Project and one of its aims is to help the relevant national authorities develop their risk commination strategies.

Public perception of EMF risks in Japan is very high. It was shown in a survey conducted in 2003 that perceived risk of EMFs is higher than that of smoking. The Ministry of Economy, Trade and Industry (METI) formed a Working Group on Electric Power Facility and EMF Policy in June 2007. The Working Group compiled their report in which their recommendations to the METI were incorporated.

To address issues related to possible long-term exposure effects of ELF-EMF, the Working Group recommended that a neutral and permanent EMF information center should be established to promote risk communication and facilitate peoples' understanding based on scientific evidences. In response to this recommendation, the Japan EMF Information Centre (JEIC) was established in July 2008. The JEIC is funded by the Japan Electrical Safety & Environment Technology Laboratories (JET) that was established in 1963 as an authorized testing body, designated by the Government of Japan under the Electrical Appliance and Material Control Law. The Administration Audit Committee was founded in order to ensure and monitor the neutrality and transparency of JEIC operations.

The JEIC institutional system is determined to develop itself into a world-class risk communication center with expertise in EMFs. Challenge is to provide an accurate translation of scientific information and terminology for the media, policy-makers and the general public. JEIC's philosophy and purpose are to provide easy-to-understand scientific information on EMFs and its possible health effects and minimize the gap of risk perception among stakeholders and promote risk communication from a fair perspective.

JEIC's work to achieve its purposes includes

(1) creating an EMF information database including EMF research,

(2) communication with mass media,

A NEW METHOD FOR THE EVALUATION OF CUMULATIVE SOLAR RADIATION EXPOSURE IN OUTDOOR WORKERS

Modenese Alberto[1], Bisegna Fabio[2], Borra Massimo[3], Grandi Carlo[4], Gugliermetti Franco[2], Militello Andrea[3], Gobba Fabriziomaria[1]

[1] Chair of Occupational Medicine, University of Modena and Reggio Emilia
[2] Department of Astronautic, Electric and Energetic Engineering, University of Rome "Sapienza"
[3] INAIL – Research Sector, Department of Occupational Hygiene, Monte Porzio Catone (Roma)
[4] INAIL – Research Sector, Department of Occupational Medicine, Monte Porzio Catone (Roma)

ABSTRACT

So far, few studies on occupational risk related to Solar Radiation (SR) in outdoor workers have attempted to retrace a detailed history of individual exposure. We propose a new method for the evaluation of the SR cumulative exposure both during work and leisure time, integrating subjective and objective exposure data. The former are collected with a questionnaire, which investigates in detail work and leisure activities during life. The latter are available through internet databases for many geographical regions and provide an estimate of the SR on the Earth's surface in specific areas and periods. These data will be integrated in a mathematical model, in order to obtain an esteem of the individual total amount of SR the subjects have been exposed to during their life. This personal exposure index can be used to evaluate specific correlations with the biological effects and to weigh the role of the personal and environmental factors that can increase or reduce SR exposure.

Key words: *Solar Radiation, ultraviolet radiation, cumulative eye exposure, cumulative skin exposure, occupational medicine.*

1. INTRODUCTION

The health risk related to an excessive exposure to solar radiation (SR) is well known [1]. The Sun represents the main exposure source for all the frequency bands of optical radiation, that is the part of the electromagnetic spectrum ranging between 100 nm and 1 mm, including infrared (IR), ultraviolet (UV) and visible radiation. The UV radiation (UVR) is further divided into UV-A (wavelength 380-315 nm), UV-B (315-280 nm) and UV-C (280 - 100 nm), while the infrared into IR-A (1400-780 nm), IR -B (3000 - 1400 nm) and IR-C (1 mm - 3000 nm) [2]. The SR that reaches the Earth's surface has a spectral composition which is significantly different from that emitted by the Sun. This is due primarily to an atmospheric absorption of UVR by various gaseous components, in particular the ozone, which blocks all wavelengths of less than 290 nm , and so all the UV-C and a significant part of the UV- B. Due to the filtering effect performed by the atmosphere, the SR on the Earth's surface is composed largely of frequencies within the IR and the visible radiation which constitute respectively the 45 % and about the 50% of the SR, and only for the 5% of UVR. Although it covers only a minimal part of the spectrum reaching the Earth's surface , the UVR represents the major risk for human health, because it is able to induce the most severe biological effects [3].

Thus, SR may be responsible for acute and chronic adverse effects particularly to the skin and the eyes. It has to be noted that both UV radiation and SR have been classified by IARC as human carcinogens, group I [1, 4].

According to recent studies, outdoor workers have a relevant exposure to SR and it is estimated that about 14.5 million workers in Europe are exposed to SR for at least 75 % of their working time. The exposure levels largely exceed the limit of 30 Joule / m2, effective radiant exposure (Heff) referred to a daily exposure of 8 hours, for artificial UV(European Directive 2006/25/EC) [5-8].

The highest exposure to UVR have been registered among farmers, construction and maritime workers [8-17]. For example, regarding construction workers, recent studies have showed that they are exposed to SR with a Standard Erythemal Dose (SED) of 9.9 in Australia [9]; they have a daily dose ranging from 11.9 to 28.6 SED depending on the altitude in Switzerland [10] and they are exposed to 6.11 SED in Spain [11].

For farmers, high exposure to UVR have been reported in New Zeland [12], Australia [13], Austria [14], and also in Italy, where it has been collected a measure of 1870 Joule / m2 in April [15].

In all these studies the researchers measured an acute exposure to SR in a single day or few days with personal dosimeters.

On the contrary, very few studies have attempted to retrace the history of a chronic exposure to SR in groups of outdoor workers. Rosenthal et al presented a model of ocular and facial skin exposure to UVB that combines interview histories of work and leisure activities, eyeglass wearing and hat use with field and laboratory measurements of UV radiant exposure in a group of American watermen [18]. In Australia, McCarty et al. developed a simplified model for quantifying lifetime ocular UV-B exposure considering the ambient UV-B levels, the duration of outdoor exposure, the proportion of ambient UV-B that reaches the eye and the use of ocular protection [19].

These kind of methods are important because many individual and environmental factors can modify SR exposure and therefore influence the dose of SR that determines the pathological effects. To date there is no adequate knowledge on the interaction among these factors and the occurrence of adverse effects (especially the chronic ones).

The quality and quantity of SR that reaches the Earth's surface vary depending on the time of the day, the day of the year, and geographical location (altitude and latitude). Also the composition of the atmosphere, the presence of pollutants and the meteorological conditions (clouds, rain, snow, etc) may influence the amount of UVR that reaches the ground: they can absorb, refract or diffuse UV rays. Finally, the type of surface can increase or reduce SR exposure, for example fresh snow reflects up to 90% of UV rays [3].

In addition, there are also several individual factors that can influence SR exposure:

- occupational activity: outdoor work is a recognized risk factor for many cutaneous and ocular diseases related to UVR exposure;
- key individual protecting behaviours: regular use of covering clothes, sunglasses and hat, sunscreen protections and the interruption of exposure during the central hours of the day: these factors may be important to reduce SR exposure, both during working and leisure activities [3], [7];
- individual characteristics. People with fair photo-types, such as Fitzpatrick's photo-types I and II, are more sensitive to the UV damage [20].

As previously mentioned, sunlight exposure may cause several acute and chronic effects, mainly ocular and cutaneous, but also immunological and various others. According to a recent WHO review, acute ocular effects with a strong evidence of causality are photokeratitis, photoconjunctivitis and solar retinopathy; chronic diseases are pterygium, cortical cataract and epithelial cancers of the cornea and conjunctiva [1]. Several studies have reported high rates of pterygium and cataract in groups of outdoor workers [21-23].

Regarding the skin, acute effects with strong evidence of causality are sunburns and photodermatoses; chronic effects are photoageing and solar keratoses, and skin cancers: Basal Cell Carcinoma (BCC), Squamous Cell Carcinoma (SCC) and Malignant Melanoma (MM) [1, 24-25].

Several studies have investigated the association between occupational exposure to SR and the occurrence of skin cancers. In a recent German study, outdoor workers showed a relative risk (RR) for BCC of 2.9 (95% Confidence Interval – CI 2.2-3.9) and 2.5 (95 % CI 1.4-4.7) for SCC [26]. In the multicenter European study HELIOS, the construction sector showed an Odds Ratio (OR) for epithelial skin cancers of 1.10 (95 % CI 0.93-1.31) and the agriculture and fisheries sectors showed an OR of 1.18 (95% CI 0.96-1.45) [27].

The only immune effect due to SR exposure with a strong evidence of causality in the WHO's review is the reactivation of latent herpes labialis infections [1].

Finally, it has to be noted that SR exposure may also induce positive effects for human health: sunlight has got a key role in the metabolism of vitamin D and therefore in the prevention of diseases such as rickets, osteomalacia and osteoporosis [1].

In future epidemiological studies, a more accurate methodology for assessing occupational and environmental exposure to SR should be useful, in order to allow a better comparison between exposure levels and early biological skin and eye effects, and to study the role of the protective factors in the onset of these diseases.

2. METHODS

We are developing a tool for the evaluation of the cumulative lifetime exposure to SR both during working and leisure time, that integrates subjective and objective data.

a. Subjective data.

Subjective data are collected with an interviewer-administrated questionnaire that assesses exposure modes during work and leisure activities (tab. 1). The questionnaire is composed by three sections, dedicated respectively to work activities, leisure activities and vacation periods. The items of the questionnaire have been elaborated by a team of occupational physicians and experts in optical radiation and industrial hygiene. To answer the questions of each section, the respondent has to consider only the months of the year between March and October (except for vacations on the snow), when the exposure to SR is more intense. At the beginning of each section, the interviewer has to define the period of life, in number of years, the section refers to. In each section, the 12 items investigate the type of outdoor activity, the total time people spend outside during the activity and main personal habits that may influence SR exposure. The habits are investigated with a 5 point Likert-type frequency scale, which ranges from 0, meaning “never adopted this habit during the activity” to 5 “always adopted this habit during the activity”.

The administrator has to fill out a new copy of a section – henceforth “tab” – if one of the following changes in exposure habits is detected:

- job change (i.e. farmer, construction worker, quarryman, fisherman, forester, seaman, etc);
- workplace change, when there is a significant change in the SR exposure (different UV index);
- work tasks change (for the same job, we can have different tasks with different position adopted during work, different number of hours in the sunlight and different protective equipment);
- residence change, when there is a significant change in the SR exposure (different UV index);
- for leisure activities, change in the number of days per week the activity is done by the respondent (normally 2 days per week for working people);
- leisure activity change (i.e. a new outdoor activity, such as a new hobby or outdoor sport);
- protective habits change (i.e. the respondent states that he has started to use sunglasses, hat, sunscreen protections, etc.);
- presence of reflecting surfaces, such as water, snow, metals, etc.;
- vacation place change, when there is a significant change in the SR exposure (different UV index);
- change in the number of days of vacation per year.

To evaluate the feasibility of the questionnaire, a pilot administration was performed by one of the authors (A.M.) in a sample of patients undergoing to a skin examination in an Italian dermatologic center and in a group of volunteers working in the same Italian region. A first administration was performed between 01/16/2014 and 01/30/2014. Based on the evaluation of the preliminary results and on the comments collected, some modifications in the number and in the formulation of the items have been performed, to avoid the redundancy of the information collected and to improve the compliance.

Then, a new administration was carried out between 02/18/2014 and 02/25/2014 , in a different group of subjects. In order to assess the internal consistency of the questionnaire, test reliability was evaluated using the Cronbach-Alpha [28].

At the end of each administration, the patient was asked to rate the comprehensibility and the utility of the three sections on a 5 point Likert scale and to write down suggestions and items not fully understandable, if any.

Table 1. *Main points assessed in the questionnaire to evaluate solar radiation exposure*

	Working time exposure	***Leisure time exposure***	***Working time exposure***
1	Type of outdoor job	Place of residence (latitude)	Place of vacation (latitude)
2	Job place	Place of residence (altitude)	Place of vacation (altitude)
3	Time spent outdoor		
4	Lunch time and place	Practice of outdoor sports	Frequency of sunburns
5	Prevalent postures	Exposure to sunbeds	Use of suntan lotion
6	Time in the shade		
7	Time near reflecting surfaces		
8	Time wearing hat		
9	Time wearing sunglasses		
10	Time wearing spectacles		
11	Time wearing protective clothes		
12	Time with sunscreen protections		

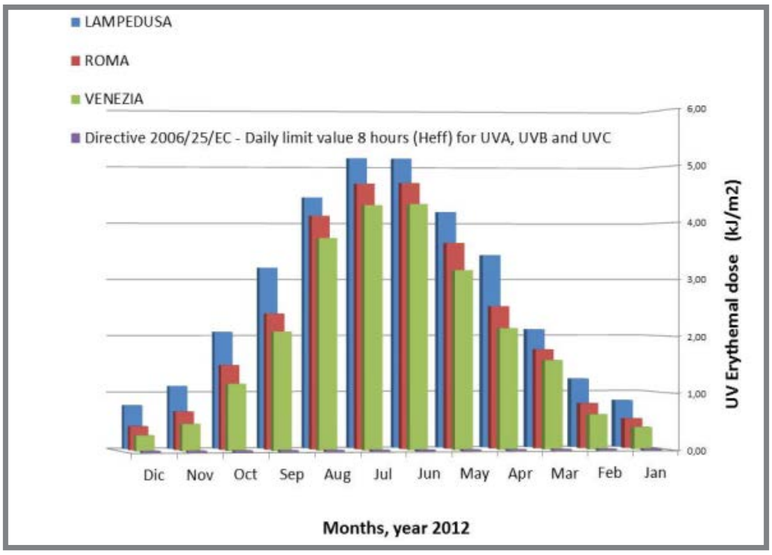
b. Objective data.

The second part of the method includes the collecting of objective data, and in particular climate data of the areas indicated in the questionnaire in the period of interest.

These data are available through internet databases for many geographical regions and they provide an estimate of the SR to the Earth's surface. As an example the Tropospheric Emission Monitoring Internet Service (TEMIS) spreads data collected by the satellites of the European Space Agency (ESA) [29]. The first data available is the clear sky UV index, that is the effective UV irradiance (1 unit equals 25 mW / m2) reaching the Earth's surface. It is based on the CIE action spectrum for the susceptibility of the caucasian skin to sunburn (erithema) and it is valid for cloud-free conditions at local solar noon. Clear sky UV index in this database is available since November 1978. Another more specific data available from TEMIS is the UV dose, that is an integration of the erythemal UV index, as derived from satellite observations, from sunrise to sunset, with a time step of 10 minutes. The integration takes the cloud cover into account, and thus leads to an estimate of the daily erythemal UV dose. UV dose in this database is available since 1995.

In figure 1 there is an example of the average daily erythemal dose registered during the year 2012 in three different regions in Italy, representing the typical exposure respectively of Southern, Central and Northern Italy: Lampedusa, 35°30' N, Rome, 41°53' N, and Venice, 45°26'N (fig. 1). The data reveal a much higher daily UV dose at the Earth's surface compared to the limits set in the European Directive 2006/25/EC in all of these three places. The chart shows also that the weight of UV doses during November, December, January and February is negligible compared to the March-October period, supporting the choice of not considering November-February in the questionnaire

Figure 1. *Comparison of the average daily erythemal dose among three Italian regions during the year 2012*



To validate the method taking into consideration environmental and individual factors (posture, etc.), we have done some "on field" measures of personal SR exposure. The results are useful to calculate the reduction- or multiplication-coefficients of the SR exposure that reaches specific parts of the body depending on the posture and on the personal habits adopted.

Two experts in optical radiation and industrial hygiene have collected several measures of effective radiant exposure (Heff) in a group of 6 fishermen working on 3 boats in different places in Italy. The measures has been taken with polysulfon and electronic dosimeters positioned on the back, on the arm, on the chest and on the cap's peak of the fishermen and also on the boat and on the wharf to measure the environmental exposure.

Therefore, the data collected have been elaborated to determine the ratios of exposure in various parts of the human body during the execution of the fishermen tasks.

3. RESULTS AND DISCUSSION

a. Subjective data.

Here we present the results of the second administration of the questionnaire.

The questionnaire has been administered to 14 subjects. The administration of the questionnaire has taken 25-40 minutes. The respondents are 11 men and 3 women aged between 40 and 79 (mean 55,6).We administered a total of 14 tabs for the outdoor work section, with a value of Cronbach's Alpha equals to 0.36.

Then we proceeded to identify the items that affected the value of Alpha . These items were "working near reflecting surfaces", "working with sunglasses" and "use of sunscreen". Regarding sunglasses and sunscreen, the possible reason that explicates the low Alpha score is the lack of these protective behaviors in this group of outdoor workers: 78% of the sample never uses sunscreen and 64% never wears sunglasses. Regarding the reflective surfaces, the poor internal consistency with respect to the other parts of this section may depend by the fact that reflection phenomena can certainly increase the eye / skin exposure, but their absence, during work time, does not indicate necessarily a lower exposure. Recalculating Cronbach's Alpha, not considering these 3 items, the score rises to 0.6, which is an acceptable value. Workers, mostly farmers and construction workers, spend outside an average 5h 50' per day between 9 am and 5 pm and 2h15' between 11 am and 3 pm. More than the 40% of the outdoor workers regularly use protecting clothes (pants and sweater), but they only sometimes use hat.

For the section that investigates leisure activities, we have administered a total of 19 tabs with a Cronbach's Alpha of 0.63, demonstrating good internal consistency. The respondents declare that they spend outdoor an average time of 4h 50' between 9 am and 5 pm and 1h 45' between 11 am and 3 pm, during the weekend between March and October. The practice of an outdoor sport is reported by 6 respondents with an average of 9h 20' of sport per week. Only 1 subject declares he regularly uses tanning beds for many years. Over 25% of the sample affirm to perform leisure activities often/always close to reflecting surfaces. Regarding the protective habits, 21% and 37 % of the subjects report that they always wear, respectively, hat and sunglasses; only 16 % usually wears protective clothes. Sunscreens are often used by the 10% of the sample.

For the section investigating the vacation periods, we have administered a total of 25 tabs with a Cronbach's Alpha of 0.48. After the deletion of 1 item regarding the use of suntan oils, which are never used by 77% of the subjects, the Cronbach's Alpha rises to 0.62. The respondents declare they spend outdoor on average 6h 50' per day between 9 and 17, and 1 h 50 ' between 11 and 15 during the vacation period. They are close to reflecting surfaces (mostly sea water, almost never snow) for 3h 15' on average. Over 35% of the subjects declare they often/always experience sunburns during holidays. The 48% of the sample always uses sunglasses; the 47% never wears hat and the 59% never uses sunscreens. 5 subjects rated the comprehensibility and the utility of the questionnaire proposed. All of them gave to all the sections a high score both in comprehensibility and in utility. The outdoor work section received an average rating of 4.8 in comprehensibility and 4.6 in utility. The leisure time section has been rated 4.6 both in comprehensibility and in utility. Finally, the vacation section has been rated 4.4 in comprehensibility and 4.6 in utility. No one wrote down suggestions or indicated problems in the formulation of the items.

Summarizing the results of the questionnaire, we can affirm that the highest sun exposure, in terms of hour spent outside during a single day, can be found during the vacation periods; but if we consider the central hours of the day, when the solar radiation is more intense, the longest outdoor periods are referred during work activities. If we consider that work activities are performed all the year, and the vacation activities only few weeks, we can assume that, for outdoor jobs, work exposure is more relevant both than vacation and weekend exposure. Thus, it is very important to encourage the adoption of protective habits, especially during work activities.

b. Objective data

The results of the on-field measures of effective radiant exposure in a small group of fishermen are showed in table 2.

Table 2. *Average relative UV dose in kJ / m2 - effective radiant energy (heff) - for four different parts of the human body in 6 fishermen (one working day, sunny weather)*

	Back	*Cap's peak*	*External arm*	*Chest*
First boat	0.44 - 0.68	0.75 - 0.90	/	0.28
Second boat	0.15 - 0.34	0.4	/	/
Third boat	0.04 - 0.17	/	0.05 - 0.12	0.15

The highest exposure to solar UVR have been measured for the nose, ear and upper shoulder of the fishermen with a dosimeter placed on the cap's peak of the men. This information is important both to understand which are the parts of the body with a higher exposure and to evaluate the protective role of wearing hat in reducing SR exposure. Working posture is a major factor influencing back and chest exposure: if the worker bends down he shades his chest while at the same time he increases the exposure on the back. Finally, the dosimeter placed on the external arm, due to the "Coroneo's effect", represents the exposure of the external part of the face and of the eye and it is important to evaluate the UVR dose coming from the side (oblique light) [30].

These measures seems to be appropriate to characterize the relationships between working postures, protective equipment and reflecting / refracting phenomena and the exposure of different parts of the body. These measures should be carried out for different outdoor jobs, to finally elaborate specific coefficients for the factors modulating SR exposure.

This approach will allow us to integrate subjective data from the questionnaire with objective climate data, to obtain an exposure index that esteems the cumulative SR exposure of a specific tissue (1).

$$E_{(h)\,tissue} = \sum x_i \cdot y_i \cdot e_i \cdot E_a \cdot m_a \cdot n_a \qquad (1)$$

The equation (1) is an estimate of the average annual effective UV dose to a specific tissue (Eh) and it takes into account: the fraction of time (xi) the tissue i is actually exposed to SR; the average exposure ratio (yi) of the effective irradiance measured on the tissue i compared with the effective irradiance measured on the horizontal plane; the monthly coefficient (ei) multiplied by the average annual effective radiant exposure on a horizontal plane for the specific locality (Ea) to obtain the average monthly effective radiant exposure on a horizontal plane; the attenuation coefficient (ma) which takes into account the use of protective equipment (hats, sunglasses, sunscreen, etc); the attenuation coefficient (na) which takes into account the presence of environmental factors that moderate the exposure (canopies, awnings, vegetation, etc.).

The final index enable to esteem the total lifelong individual exposure to SR of the subjects, and could be a useful tool to be applied in future epidemiological studies on the effects of SR, and their prevention.

4. CONCLUSION

The proposed instrument is aimed to provide a detailed estimate of lifetime exposure to SR in groups of outdoor workers, taking into account individual factors such as the use of sunglasses and protective clothing, prevalent postures during work, etc. These data, integrated with long term climate data, enable the calculation of a semi-quantitative assessment of the cumulative dose of SR to the ocular surface and to various skin areas.

This method is innovative since at present a few studies in the scientific literature have attempted to retrace a detailed history of SR exposure, and it should also overcome studies based on short term instrumental measurement of radiant energy.

In conclusion, the methodology proposed here, applied in epidemiological studies, should allow a better comparison between exposure levels and early biological skin and eye effects, and a deeper study of the role of protective factors in the onset of these diseases.

REFERENCES

1. World Health Organization (WHO), Environmental burden of diseases series n° 17. Solar Ultraviolet radiation; Geneva, 2010.
2. International Standards Organization, Commission Internationale d'Eclairage; Erythema reference action spectrum and Standard Erythema Dose, ISO 17166:1999(E)/CIE S 007-1998
3. International Commission on Non-Ionizing Radiation Protection. ICNIRP statement. Protection of workers against ultraviolet radiation. Health Phys 2010; 99(1):66-87.
4. International Agency for Research on Cancer (IARC), Radiation Volume 100 D. A review of human carcinogens, Lyon, France, 2012
5. Directive 2006/25/EC of the European Parliament and of the Council of 5 April 2006 on the minimum health and safety requirements regarding the exposure of workers to risks arising from physical agents (artificial optical radiation) (19th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC).
6. International Commission on Non-Ionizing Radiation Protection. Guidelines on limits of exposure to ultraviolet radiation of wavelengths between 180 nm and 400 nm (incoherent optical radiation). Health Phys. 2004 Aug;87(2):171-86.
7. European Commission. Non-binding guide to good practice for implementing Directive 2006/25/EC 'Artificial Optical Radiation'. Unione Europea, 2011; ISBN 978-92-79-16046-2.
8. Agenzia europea per la sicurezza e la salute sul lavoro. Outlook 1 Rischi nuovi ed emergenti in materia di sicurezza e salute sul lavoro. Lussemburgo, Ufficio delle pubblicazioni ufficiali delle Comunità europee, 2009
9. Gies P, Wright J. Measured Solar Ultraviolet Radiation Exposures of Outdoor Workers in Queensland in the Building and Construction Industry. Photochem Photobiol, 2003,78(4):342–348
10. Milon A, Sottas PE, Bulliard JL, Vernez D. Effective exposure to solar UV in building workers: influence of local and individual factors. J Expo Sci Environ Epidemiol. 2007;17(1):58-68
11. Serrano MA, Cañada J, Moreno JC. Solar UV exposure in construction workers in Valencia, Spain. J Expo Sci Environ Epidemiol. 2012 Jun 27. doi: 10.1038/jes.2012.58.
12. Hammond V, Reeder AI, Gray A.. Patterns of real-time occupational ultraviolet radiation exposure among a sample of outdoor workers in New Zealand. Public Health, 2009;123:182-187.
13. Airey DK, Wong JC, Fleming RA, Meldrum LR. . An estimate of the total UV-B exposure for outdoor workers during a south-east Queensland summer. Health Phys. 1997;72(4):544–549
14. Schmalwieser AW, Cabaj A, Schauberger G, Rohn H, Maier B, Maier H. Facial Solar UV Exposure of Austrian Farmers During Occupation. Photochem Photobiol,2010;86:1404–1413
15. Siani AM, Casale GR, Sisto R, Colosimo A, Lang CA, Kimlin MG. Occupational Exposures to Solar Ultraviolet Radiation of Vineyard Workers in Tuscany (Italy). Photochem Photobiol, 2011;87:925-934
16. Serrano MA, Cañada J, Moreno JC; Solar Radiation Group. Erythemal Ultraviolet Exposure in Two Groups of Outdoor Workers in Valencia, Spain. Photochem Photobiol, 2009;85:1468–1473.
17. Gies P, Glanz K, O'Riordan D, Elliott T, Nehl E. Measured occupational solar UVR exposures of liguards in pool settings. Am J Ind Med, 2009; 52(8):645-653
18. Rosenthal FS, West SK, Munoz B, Emmett EA, Strickland PT, Taylor HR. Ocular and facial skin exposure to ultraviolet radiation in sunlight: a personal exposure model with application to a worker population. Health Phys. 1991 Jul;61(1):77-86.
19. McCarty CA, Lee SE, Livingston PM, Bissinella M, Taylor HR. Ocular exposure to UV-B in sunlight: the Melbourne visual impairment project model. Bull World Health Organ. 1996;74(4):353-60.
20. Fitzpatrick TB. Soleil et peau. J Med Esthet, 1975;2:33–34.
21. Maharshak I, Avisar R. Bilateral primary pterygia: an occupational disease? Arch Environ Occup Health. 2009 Summer;64(2):137-40.
22. McCarty CA, Taylor HR. A review of the epidemiologic evidence linking ultraviolet radiation and cataracts. Dev Ophthalmol. 2002;35:21-31.
23. Pascolini D, Mariotti SPM. Global estimates of visual impairment: 2010. British Journal Ophthalmology Online First published December 1, 2011.
24. Lucas R, McMichael T, Smith W, Armstrong B. Solar ultraviolet radiation: global burden of disease from solar ultraviolet radiation. 2006, Geneva: World Health Organization. ISBN 9789241594400.
25. Ferlay J, Shin HR, Bray F, Forman D, Mathers C, Parkin DM. GLOBOCAN 2008 v1.2, Cancer Incidence and Mortality Worldwide: IARC CancerBase No. 10. Lyon, France: International Agency for Research on Cancer 2010. http://globocan.iarc.fr
26. Radespiel-Tröger M Meyer M, Pfahlberg A, Lausen B, Uter W, Gefeller O. Outdoor work and skin cancer incidence: a registry-based study in Bavaria. Int Arch Occup Environ Health (2009);82:357–363.
27. Suarez B López-Abente G, Martínez C, Navarro C, Tormo MJ, Rosso S, Schraub S, Gafà L, Sancho-Garnier H, Wechsler J, Zanetti R.. Occupation and skin cancer: the results of the HELIOS-I multicenter case-control study. BMC Public Health 2007;7:180.
28. Cronbach, L. J. Coefficient Alpha and the Internal Structure of Tests. Psychometrika 1951; 16:297-334.
29. http://www.temis.nl/
30. Coroneo MT, Müller-Stolzenburg NW, HoA. Peripheral light focusing by the anterior eye and the ophthalmohelioses. Ophthalmic Surg 1991;22:705-11.

Address for correspondence:
Alberto Modenese,
University of Modena and Reggio Emilia, Modena, Italy,
e-mail: albertomodenese1@gmail.com