# Effetti termici e non termici dell'esposizione a radiazioni solari

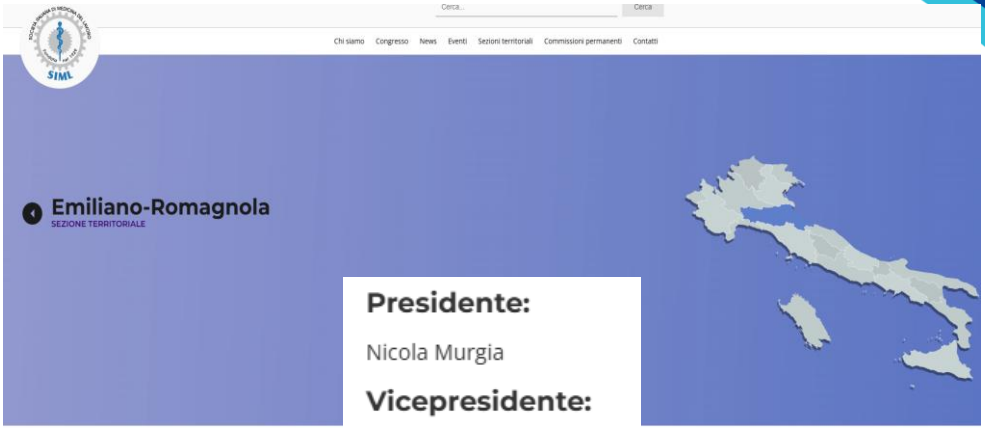

## Prof. Alberto Modenese

**Scuola di Specializzazione in Medicina del Lavoro**
**Università di Modena e Reggio Emilia**

**Società Italiana di Medicina del Lavoro (SIML)**
**Sezione Territoriale Emiliano-Romagnola**


**La prevenzione delle patologie da calore nei luoghi di lavoro: linee di indirizzo del Gruppo Tecnico Interregionale Salute e sicurezza sul lavoro**

**Bologna Fiera, 11 giugno 2025**




**Presidente:**

Nicola Murgia

**Vicepresidente:**

Alberto Modenese

**Consiglieri:**

Pietro Grazioli
Mattia Roberto Nocilla
Silvia Ranzieri **Segretario**

RegioneEmilia-Romagna

**Bologna Fiera, 10-11-12 giugno 2025**

AMBIENTE LA


***The main aim of the Scientific Committee on Radiation and Work of the ICOH is to stimulate an international exchange of experiences on research programmes, methodology and practice in the field of:***
***- exposure of workers to Ionizing Radiation (IR) and Non Ionizing Radiation (NIR), including Electromagnetic Fields (EMF) and Optical Radiation (OR)***
***- the prevention and health promotion of exposed workers.***

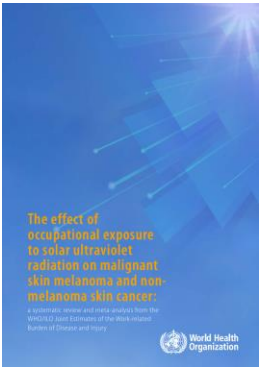
***The activities of the Scientific Committee on Radiation and Work are intended to provide a unique multidisciplinary and interdisciplinary network for sharing knowledge and advancements in the general field of occupational and environmental exposure of workers to IR and NIR, on adverse health effects, methodology and legislation, and any other topic of interest in the general field of protection and health promotion of IR and NIR exposed workers.***

**Chair**
Prof. Alberto MODENESE
University of Modena and Reggio Emilia
Department of Biomedical, Metabolic and Neural Sciences
Via Campi, 287 I-41100
Modena (MO)
ITALY
Phone: +39 059 205 5461
Email: alberto.modenese@unimore.it

**Past Chair 2018-2024**
Dr. Marc WITTLICH
Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA)
Head Of Division "Accident Prevention, Product Safety"
Alte Heerstr. 111
53757 - Sankt Augustin
GERMANY
Phone: +49 30 13001-3500
Email: marc.wittlich@dguv.de

**Secretary**
Mrs Claudine STREHL
Institute for Occupational Safety and Health (IFA)
German Social Accident Insurance (DGUV)
Alte Heerstraße 111 - 53757,
Sankt Augustin
Germany
Fax: 0049301300134 70
Email: claudine.strehl@dguv.de

**Past Chair 2012-2018**
Prof. Fabriziomaria GOBBA
University of Modena and Reggio Emilia
Department of Biomedical, Metabolic and Neural Sciences
Via Campi, 287 I-41100
Modena (MO)
ITALY
Phone: +39 059 205 5463
Email: fabriziomaria.gobba[@]unimore.it




https://www.grelf.unimore.it/

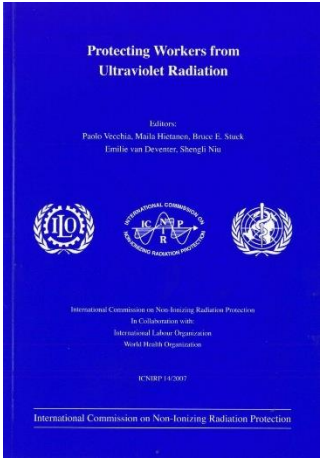
ICNIRP
INTERNATIONAL COMMISSION ON NON-IONIZING RADIATION PROTECTION



# ICNIRP GUIDELINES

## ON LIMITS OF EXPOSURE TO INCOHERENT VISIBLE AND INFRARED RADIATION

PUBLISHED IN: **HEALTH PHYSICS 105(1):74-96; 2013**




## WORKING GROUPS

**Composition**: Working Groups include Project Groups (PG) and Standing Committees (SC). They consist of members of the Commission and the SEG when additional expertise is needed. WG members are selected by the Commission members.

**Duties**: Working Groups are set up to assist ICNIRP in performing its projects as per its work plan. These entities are dedicated to fulfill a specific work plan task such as the preparation of the ICNIRP draft documents or the organization of a workshop. Upon completion of the task assigned, the WG is dissolved.

### Chronic UV Exposure
ICNIRP PG ON LONG-TERM EFFECTS OF CHRONIC UV EXPOSURE

**Task:** To review current evidence for long-term effects of chronic UV exposure and update guidance.

**Membership:** Nigel Cridland (Chair), Young Hwan Ahn, Ilko Ilev, Ken Karipidis, Alberto Modenese, Rachel Neale, Tsutomu Okuno, David Sliney

### LF Guidelines (≤10 MHz)
ICNIRP PG ON LOW FREQUENCY GUIDELINES (≤10 MHZ)

### Environment and EMFs
ICNIRP PG ON ENVIRONMENTAL EMF PROTECTION

### LF Dosimetry Review
ICNIRP PG ON LF DOSIMETRY REVIEW

### Sub-THz Gap
ICNIRP PG ON GAP BETWEEN RF GUIDELINES AND OPTICAL RADIATION GUIDELINES

### Radiation Protection System
ICNIRP PG ON RADIATION PROTECTION SYSTEM

### Communication
ICNIRP STANDING COMMITTEE ON COMMUNICATION

### Laser Guidelines
ICNIRP PG ON THE REVISION OF THE LASER GUIDELINES (2013)

### Laser Pointers
ICNIRP PG ON THE REVISION OF THE ICNIRP LASER POINTERS STATEMENT (2000)

## COMMISSION

**Composition**: The Commission membership consists of a Chairperson, Vice-Chairperson and up to 12 members. Commission members are independent experts in the scientific disciplines relevant to non-ionizing radiation protection such as biology, epidemiology, physics and engineering, bio-physics, and medicine. In carrying out their voluntary work for the Commission they do not represent either their countries of origin or their institutes. ICNIRP members are required to declare any personal interests in relation to their activities for ICNIRP. Members' declarations of personal interests are available below along the member's profile.

**Election**: Members are elected to the Commission from nominations received by current members, the Executive Council of the International Radiation Protection Association (IRPA), the IRPA Associate Societies, and by national and international public bodies for radiation protection following an open call for nominations published on the ICNIRP website. The election takes place every 4 years at the last ICNIRP Annual General Meeting before the end of a term of office.

**Duties**: The duties of the Commission include:

- Formulating and implementing ICNIRP policy in accordance with the Charter and resources available.
- Specifying, prioritizing and directing the ICNIRP work plan.
- Providing chairmanship and scientific expertise to the Working Groups and coordinating their activities according to the needs of ICNIRP.
- Reviewing and approving proposed ICNIRP publications.
- Fostering cooperation with other organizations in the field of non-ionizing radiation protection.

**Akimasa Hirata**
CHAIR

**Ken Karipidis**
VICE CHAIR

**Young Hwan Ahn**
MEMBER

**Nigel Cridland**
MEMBER

**Frank de Vocht**
MEMBER

**Anke Huss**
MEMBER

**Ilko Ilev**
MEMBER

**Jens Kuhne**
MEMBER

**Ilkka Laakso**
MEMBER

**Isabelle Lagroye**
MEMBER

**Alberto Modenese**
MEMBER

**Gunnhild Oftedal**
MEMBER

La Medicina del Lavoro

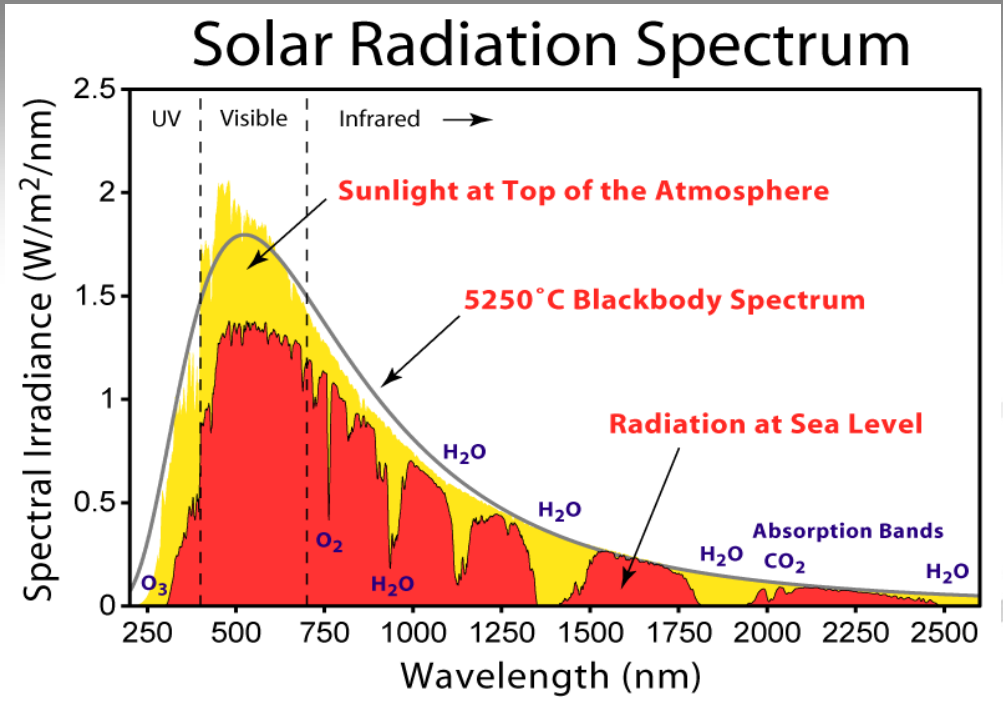
Med Lav 2010; 101, 6: 000-000

# Colpo di calore in ambito lavorativo: descrizione di un caso con esito fatale

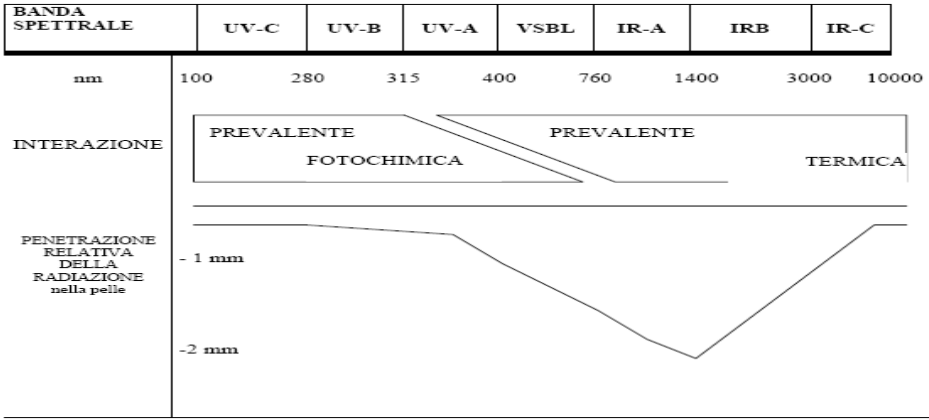
L. Roccatto, A. Modenese**, *****, V. Occhionero**, *****, A. Barbieri***, Donata Serra****, Elena Miani*****, F. Gobba**, *****

Azienda USL Modena, Dipartimento di Sanità Pubblica, Servizio Prevenzione e Sicurezza negli Ambienti di Lavoro - Area Nord
* Scuola di Specializzazione in Medicina del Lavoro, Università di Modena e Reggio Emilia
** Rianimazione, Dipartimento di Emergenza Urgenza, Università di Modena e Reggio Emilia
*** Azienda USL Modena, Dipartimento di Sanità Pubblica, Servizio Prevenzione e Sicurezza negli Ambienti di Lavoro - Area Centro
**** Specialista in Medicina Legale e delle Assicurazioni
***** Cattedra di Medicina del Lavoro, Università di Modena e Reggio Emilia

*«…Presentiamo il caso clinico di un lavoratore di 19 anni deceduto in seguito ad un colpo di calore. Il soggetto era addetto al taglio dell'erba con un decespugliatore e alla raccolta dei residui con un soffiatore. Dopo circa 7 ore di lavoro in una giornata soleggiata con temperatura massima di 33°C ed umidità massima del 61%, il soggetto era stato trovato a terra mentre stava vomitando. Immediatamente trasportato al vicino Pronto Soccorso, era giunto in ipertermia in stato comatoso; trasferito in Rianimazione, era deceduto dopo circa 36 ore a seguito della comparsa di instabilità cardio-circolatoria, gravi alterazioni della coagulazione e dell'equilibrio acido-base. …»*


Solar Radiation Spectrum
Spectral Irradiance (W/m²/nm)
2.5
2
1.5
1
0.5
0
UV
Visible
Infrared
Sunlight at Top of the Atmosphere
5250˚C Blackbody Spectrum
Radiation at Sea Level
H2O
H2O
O2
O3
H2O
Absorption Bands
H2O
CO2
H2O
250
500
750
1000
1250
1500
1750
2000
2250
2500
Wavelength (nm)

# Meccanismi di interazione




Meccanismi fotochimici: l'assorbimento dei fotoni da parte di specifiche molecole può dare luogo a rotture di legami chimici, formazione di nuovi legami e formazione di radicali liberi, specie chimiche altamente
reattive

Gli effetti di natura termica dipendono dall'incremento di temperatura prodotto dalla radiazione dalla sua durata nel tempo e dalla dimensione della superficie irradiata e dalla termosensibilità della struttura bersaglio

# PRINCIPALI FATTORI CHE INFLUENZANO IL RISCHIO DA ESPOSIZIONE A UVR

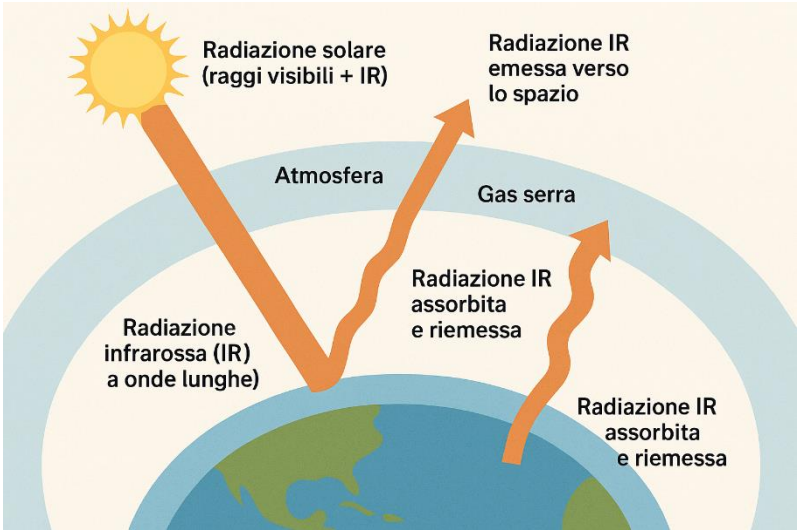
**Ambientali**

- *Livello di ozono nella stratosfera*
- *Latitudine*
- *Altitudine sul livello del mare*
- *Stagione del'anno / ora del giorno*
- *Presenza di nuvole*
- *Inquinamento atmosferico*
- *Riflettanza del suolo*

**Occupazionali**

**Individuali**

- *Genetici (fotosensibilità)*
- *presenza di patologie aggravanti*
- *Culturali (abbigliamento, uso di protezioni, etc)*


Radiazione solare
(raggi visibili + IR)
Radiazione IR
emessa verso
lo spazio
Atmosfera
Gas serra
Radiazione IR
assorbita
e riemessa
Radiazione
infrarossa (IR)
a onde lunghe)
Radiazione IR
assorbita
e riemessa

## Occupational exposure to solar UV radiation

**Outdoor Workers (OW):** working outdoor for more than 75% of their days (construction workers, farmers, fishermen, quarrymen, gardeners, lifeguards, others), mainly males (up to 90%), almost 15 millions in Europe *(EU-OSHA 2009)*; 1.6 billions in the World *(WHO & ILO , 2022)*
Highly exposed to UV, both short term – several times above Occupational Limits of 1-1.33 SED/day – and long-term (i.e. cumulative UV exposure).

Indoor workers receive 50-90% less UV compared to OW.


leisure exposures. Currently, one of the latest available definitions of workers at risk for SUVR exposure adverse skin effects, applied in Germany as criteria for the recognition of occupational skin cancers, is that of considering spending more than 1 h outdoor between 11 a.m. and 4 p.m. at risk on more than 50 days in the period from April to September in the northern hemisphere [5].

**Criteria for Occupational Health Prevention for Solar UVR Exposed Outdoor Workers-Prevalence, Affected Parties, and Occupational Disease**

*Marc Wittlich**

**The prevalence of occupational exposure to solar ultraviolet radiation: A systematic review and meta-analysis from the WHO/ILO Work-Related Burden of Disease and Injury Study**


Marília S. Paulo [a, b, 1]
Alberto Modenese [c, 1]
Balazs Adam [d]
Rami H. Al-Rifai [a]
Giulia Bravo [e]
Ralph Chou
Andreas Flouris [f]
Fabriziomaria Gobba [c]
Kasper Grandahl [g]
Frank Pega [h]
Cheryl E. Peters [i, j]
Thomas Tenkate [k]
Yuka Ujita [l]
Marc Wittlich [m]
Tom Loney [n, *]

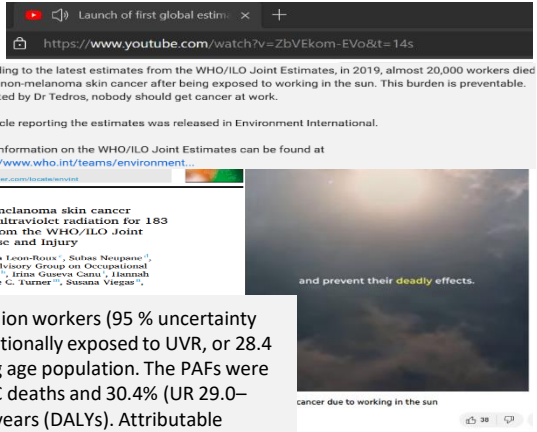


For melanoma: "Limited evidence" based on 14 studies: RR 1.16 (CI 95% 0.91–1.49), significant considering Lentigo Maligna Melanoma only= 1.45 (95% CI 1.08–1.94).
For NMSC: "Sufficient evidence", RR: 1.6 (95% CI 1.2–2.1)

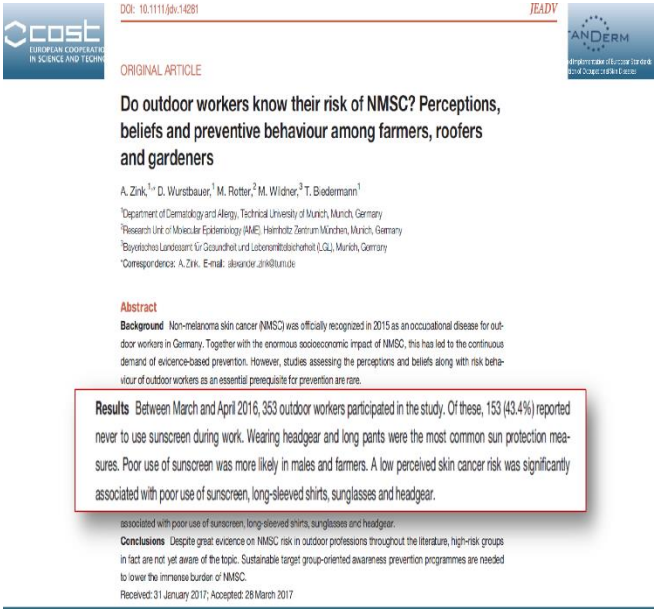
# How many OW and how many UV-inflicted skin cancers?

- World: ILO stats report on 229 millions of workers in construction, 1 billion of agricultural workers
- Europe: >15 milions

*(OSHA, 2009)*




Results: Globally in 2019, 1.6 billion workers (95 % uncertainty range [UR] 1.6 1.6) were occupationally exposed to UVR, or 28.4 % (UR 27.9–28.8) of the working age population. The PAFs were 29.0 % (UR 24.7–35.0) for NMSC deaths and 30.4% (UR 29.0–31.7) for disability adjusted life years (DALYs). Attributable NMSC burdens were 18,960 deaths (UR 18,180–19,740) and 0.5 million DALYs (UR 0.4–0.5). Men and older age groups carried larger burden. Over 2000–2019, attributable deaths and DALYs almost doubled.



DOI: 10.1111/jdv.14281 JEADV

ORIGINAL ARTICLE

# Do outdoor workers know their risk of NMSC? Perceptions, beliefs and preventive behaviour among farmers, roofers and gardeners

A. Zink,[1,*] D. Wurstbauer,[1] M. Rotter,[2] M. Widner,[3] T. Biedermann[1]

[1]Department of Dermatology and Allergy, Technical University of Munich, Munich, Germany
[2]Research Unit of Molecular Epidemiology (AME), Helmholtz Zentrum München, Munich, Germany
[3]Bayerisches Landesamt für Gesundheit und Lebensmittelsicherheit (LGL), Munich, Germany
*Correspondence: A. Zink. E-mail: alexander.zink@tum.de

**Abstract**

**Background** Non-melanoma skin cancer (NMSC) was officially recognized in 2015 as an occupational disease for outdoor workers in Germany. Together with the enormous socioeconomic impact of NMSC, this has led to the continuous demand of evidence-based prevention. However, studies assessing the perceptions and beliefs along with risk behaviour of outdoor workers as an essential prerequisite for prevention are rare.

**Results** Between March and April 2016, 353 outdoor workers participated in the study. Of these, 153 (43.4%) reported never to use sunscreen during work. Wearing headgear and long pants were the most common sun protection measures. Poor use of sunscreen was more likely in males and farmers. A low perceived skin cancer risk was significantly associated with poor use of sunscreen, long-sleeved shirts, sunglasses and headgear.

**Conclusions** Despite great evidence on NMSC risk in outdoor professions throughout the literature, high-risk groups in fact are not yet aware of the topic. Sustainable target group-oriented awareness prevention programmes are needed to lower the immense burden of NMSC.

Received: 31 January 2017; Accepted: 28 March 2017

RegioneEmilia-Romagna

**Bologna Fiera, 10-11-12 giugno 2025**

AMBIENTE LA

**Tabella 1. Elenco non esaustivo di studi condotti in gruppi di lavoratori che svolgono attività all'aperto riportanti livelli di esposizione a UV solari in varie attività lavorative in SED/giorno**

| | Studio (1° Autore, anno) | N° soggetti studiati, Mese/stagione e luogo | SED/giorno (media) |
|---|---|---|---|
| LAVORATORI EDILI | Boniol et al. 2015 | 126 lavoratori, Estate, Francia | 10.1 |
| | Gies et al. 2003 | 493 lavoratori all'aperto<br>Settembre-Novembre, Queensland (Nord Australia) | Piastrellisti 10<br>Riparatori di tetti 7.6<br>Giardinieri 3.1<br>Imbianchini 1.1<br>Ebanisti 0.3<br>Operai generici 5.9<br>Fabbri 5.6<br>Ispettori 2.5<br>Addetti alla preparazione e posa del calcestruzzo 4.7<br>Muratori 4.7<br>Sorveglianti 3.4<br>Carpentieri 5.3<br>Montatori 6<br>Idraulici 5.7<br>Altri lavoratori 4.9<br>Tutti i lavoratori 4.5 |
| | Hammond et al. 2009 | 77 OW: 39 costruttori e 19 operai stradali, Estate (Dicembre), Nuova Zelanda | Costruttori 5.25<br>Operai stradali 5.31 |
| | Milon et al. 2007 | 20 lavoratori edili, Svizzera, Luglio-Settembre, tre differenti altitudini: pianura (500–600 m); collina (1400–1500 m); alta montagna (2000–2500 m) | Lavoratori edili in:<br>11.9 pianura<br>21.4 collina<br>28.6 alta montagna |
| | Serrano et al. 2013 | 8 lavoratori, Valencia, Spagna | 6.11 |

| | | | |
|---|---|---|---|
| LAVORATORI AGRICOLI | Boniol et al. 2015 | 23 Giardinieri e 108 agricoltori, Estate, Francia | Giardinieri 12<br>Agricoltori 5 |
| | Hammond et al. 2009 | 77 OW, dei quali 16 orticoltori, Estate(Dicembre), Nuova Zelanda | 5.61 |
| | Siani et. 2011 | 31 viticoltori, Aprile, Luglio, Ottobre, Toscana, Italia | Aprile: Nuca = 14.5; Braccio = 10.3<br>Luglio: Nuca = 10.0; Braccio = 5.9<br>Ottobre: Nuca= 3.0; Braccio = 2.0 |
| | Schmalwieser et al. 2010 | 12 agricoltori, Aprile e Ottobre, Austria | 2.99 |
| | Serrano et al. 2009 | 4 giardinieri, Giugno-Luglio, Valencia, Spagna | 4.1 |

| | | | |
|---|---|---|---|
| LAVORATORI DI ALTRI SETTORI | Boniol et al. 2015 | 741 lavoratori di varie occupazioni (non tutti OW) | Lavoratori nel settore culturale, artistico, sociale 9.2<br>Lavoratori nel settore industriale 7.9<br>Lavoratori nel settore delle Telecomunicazioni 7.9<br>Trasportatori e corrieri 7.7<br>Impiegati d'ufficio 7.3<br>Commercianti e lavoratori nell'ambito dei servizi 6.9<br>Managers 6.3<br>Lavoratori nei servizi di difesa 6.2<br>Ingegneri, ricercatori 6.1<br>Lavoratori nell'ambito della salute e della cura della persona 6.0<br>Lavoratori nel settore dello sport e del tempo libero 5.9<br>Negozianti 5.4<br>Addetti alle pulizie 4.9<br>Ristoratori 4.6<br>Insegnanti 3.5<br>Assistenti d'infanzia 3.3 |
| | Gies et al. 2009 | 168 bagnini, Giugno-Luglio: (1) <35° N (Arizona, Texas); (2) >40° N (Nebraska, Oregon, USA) | Sud USA 3.3 (Texas)<br>3.2 (Arizona)<br>Nord USA 6.2 (Nebraska)<br>1.7 (Oregon)<br>Ovunque negli USA = 3.3 |
| | Serrano et al. 2009 | 5 bagnini, Estate(Giugno- Luglio), Valencia, Spagna | 11.4 |
| | Peters et al. 2016 | 78 lavoratori, Estate, Vancouver, Canada | 1.08 |
| | Cockell et al. 2001 | 30 scienziati, Estate(Luglio), Canada del Nord | 3.08 +/- 1.59 |
| | Cockell et al. 2002 | 8 scienziati, Inverno(Dicembre),Artide ed Antartide | 12 |

DOI: 10.1111/jdv.16303 JEADV

ORIGINAL ARTICLE

# Personal solar ultraviolet radiation dosimetry in an occupational setting across Europe

M. Wittlich,[1] S.M. John,[2] G.S. Tiplica,[3] C.M. Sălăvăstru,[4] A.I. Butacu,[3,*] A. Modenese,[5] V. Paolucci,[6] G. D'Hauw,[7] F. Gobba,[5] P. Sartorelli,[7] J. Macan,[8] J. Kovačić,[8] K. Grandahl,[9] H. Moldovan[10]

[1]Institute for Occupational Safety and Health of the German Social Accident Insurance, Sankt Augustin, Germany
[2]Department of Dermatology, Environmental Medicine and Health Theory, University of Osnabrück, Osnabrück, Germany
[3]2nd Department of Dermatology, Colentina Clinical Hospital, "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania
[4]Pediatric Dermatology Department, Colentina Clinical Hospital, "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania
[5]Occupational Medicine, Department of Biomedical, Metabolic and Neural Sciences, University of Modena & Reggio Emilia, Modena, Italy
[6]Department o
[7]Department o
Siena, Italy
[8]Occupational
[9]Department o
[10] Department
Romania
*Corresponde


RegioneEmilia-Romagna

**Bologna Fiera, 10-11-12 giugno 2025**

AMBIENTE LA

461 SED
± 37 SED

602 SED
± 74 SED

*2017*

504 SED
± 32 SED

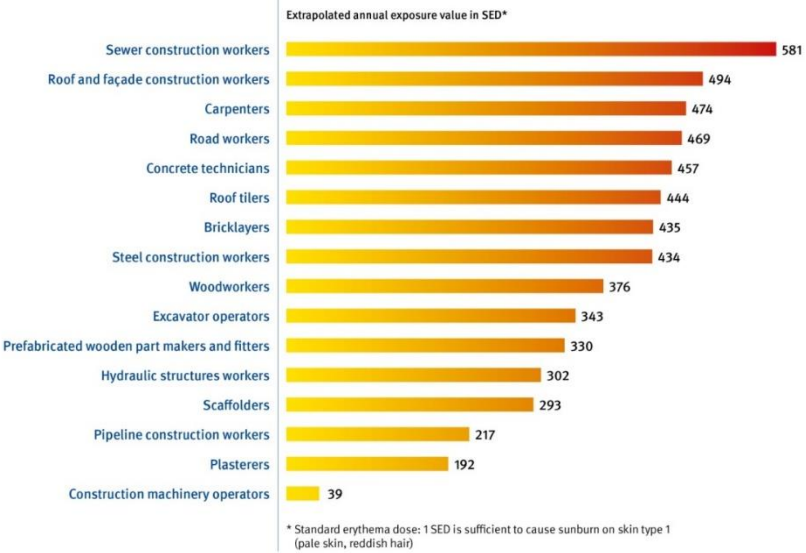
Bucharest
517 SED
± 17 SED

Tirgu-Mures
621 SED
± 35 SED

# Building trade

## UV radiation exposure

DGUV

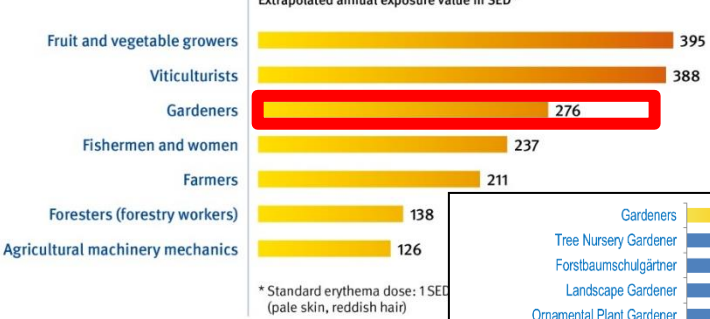


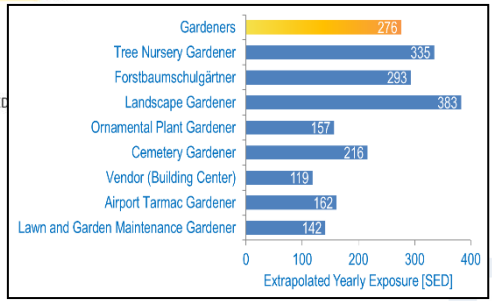

* Standard erythema dose: 1 SED is sufficient to cause sunburn on skin type 1 (pale skin, reddish hair)

Source: www.dguv.de

# Agriculture UV radiation exposure

DGUV SVLFG
Deutsche Gesetzliche Unfallversicherung und Sozialversicherung für Landwirtschaft, Forsten und Gartenbau



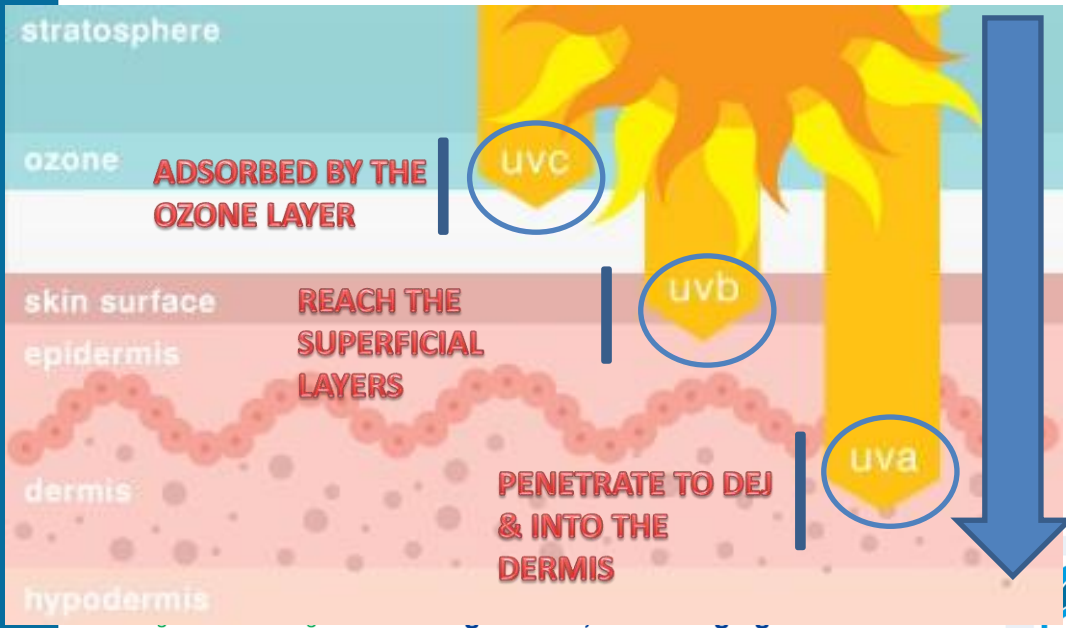
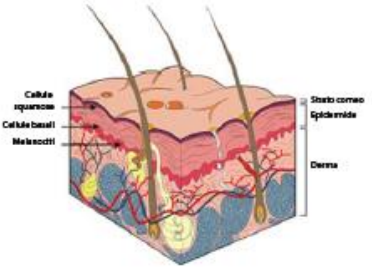
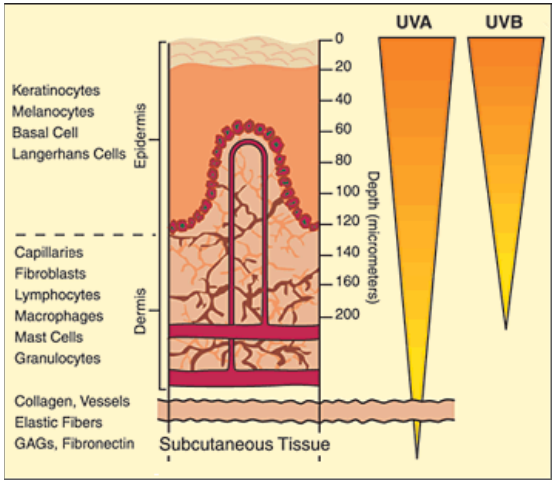

stratosphere
ozone
ADSORBED BY THE OZONE LAYER
uvc
skin surface
epidermis
REACH THE SUPERFICIAL LAYERS
uvb
dermis
PENETRATE TO DEJ & INTO THE DERMIS
uva
hypodermis

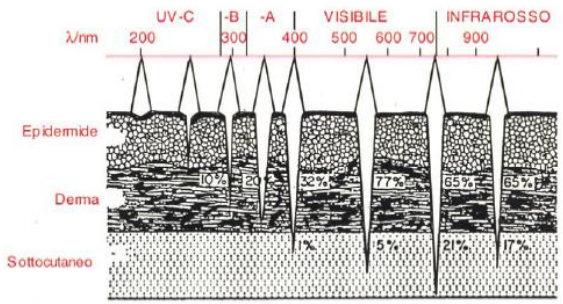
**Figura B.2.1. — La struttura della cute**



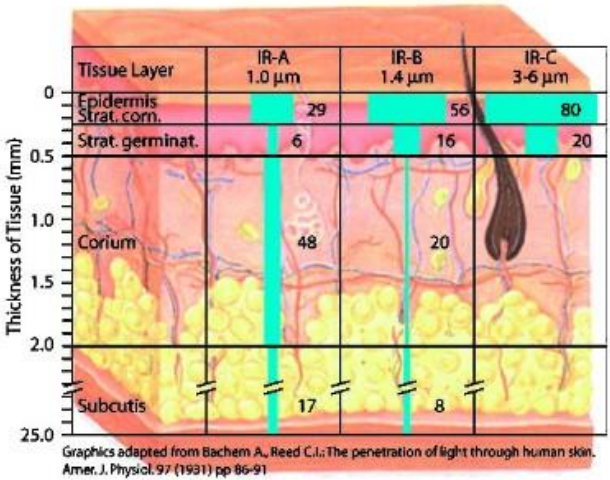

Lo strato esterno della cute, l'epidermide, contiene prevalentemente cheratinociti (cellule squamose) che sono prodotti nello strato basale e salgono in superficie per essere espulsi. Il derma è composto prevalentemente da fibre di collagene e contiene le terminazioni nervose, le ghiandole sudoripare, i follicoli piliferi e i vasi sanguigni.



## ASSORBIMENTO DELLA RADIAZIONE OTTICA NELLA CUTE



# EFFETTI CUTANEI DA IR



## EFFETTI CUTANEI ACUTI DA IR

- Eritema ed ustioni possono però essere determinate anche dall'esposizione a radiazioni IR, infatti la loro scarsa capacità di penetrazione della cute determina una rapida dissipazione della loro energia sotto forma di calore in questo organo.
-In questo caso il danno si manifesta immediatamente, e la sensazione dolorosa dovuta all'eccessivo riscaldamento permette di solito di accorgersi del pericolo, diversamente da quanto avviene per gli UV, e di sottrarsi all'esposizione, a meno che il soggetto non abbia perso conoscenza.
- Clinicamente il quadro e l'evoluzione sono simili a quelli delle patologie da calore, con vasodilatazione, eritema, bruciore, e eventuale comparsa di flittene; per esposizioni ripetute il quadro può evolvere in un'iperpigmentazione cutanea e infiammazione cronica (*eritema ab igne*).

# Effetti cutanei cronici - radiazione IR

Condizione di ipertermia cutanea superficiale associata ad alterazioni teleangectasiche dei vasi sanguigni e aree di iperpigmentazione (”*eritema ab igne*”). Nel tempo queste alterazioni possono determinare un importante ispessimento del tessuto cutaneo, esitando in una vera e propria cheratosi termica

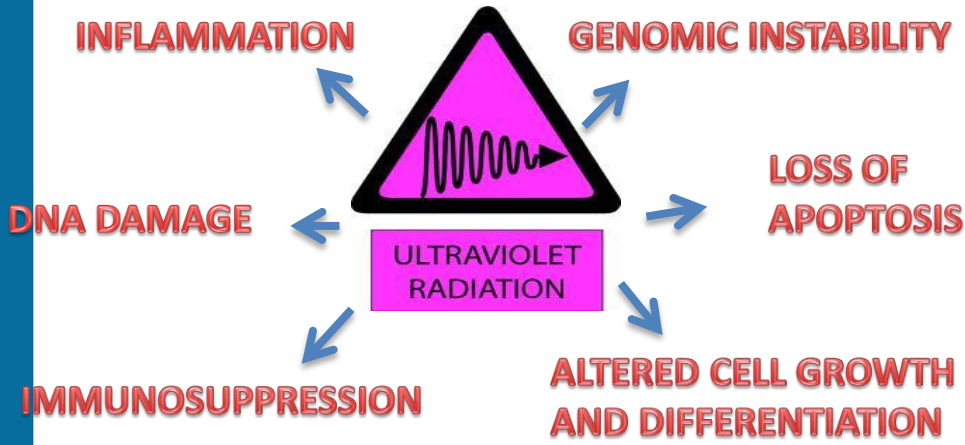
## *Principali sostanze in grado di indurre reazioni di fotosensibilizzazione per azione locale (da ICNIRP, 2004, modificata)*

| Agente | Tipo di reazione | λ efficaci (nm) |
|---|---|---|
| Sulfonamidi e composti correlati | Fototossica e fotoallergica | 290 - 320 |
| Composti salicilanilidici (disinfettanti) in saponi e deodoranti | Fototossica e fotoallergica | 290 - 400 |
| Fenotiazine | Fototossica e fotoallergica | 320 - visibile |
| Coloranti | Iperpigmentazione fototossica | Visibile |
| Catrame e derivati (composti fenolici) | Fototossica | 340 - 430 |
| Oli essenziali (profumi) | Iperpigmentazione fototossica | 290 - 380 |
| Composti furocumarinici (psoraleni) | Iperpigmentazione fototossica | 290 - 380 |
| Solfuro di cadmio (tatuaggi) | Fototossica | 380 – 445 |

# Principali sostanze in grado di indurre reazioni di fotosensibilizzazione per assorbimento sistemico

| Agente | Tipo di reazione | λ efficaci (nm) | Incidenza delle reazioni |
|---|---|---|---|
| Amiodarone | Fototossica | 300 – 400 | Alta |
| Diuretici tiazidici | Fotoallergica | 300 – 400 | Media |
| Clorpromazina, fenotiazine | Fototossica e fotoallergica | 320 – 400 | Media |
| Acido nalidixico | Fototossica | 320 – 360 | Alta |
| Antinfiammatori non steroidei | Fototossica e fotoallergica | 310 – 340 | Bassa |
| Protriptilina | Fototossica | 290 – 320 | Alta |
| Psoraleni | Fototossica | 320 – 380 | Alta |
| Sulfonamidi (batteriostatici, antidiabetici) | Fotoallergica | 315 – 400 | Bassa |

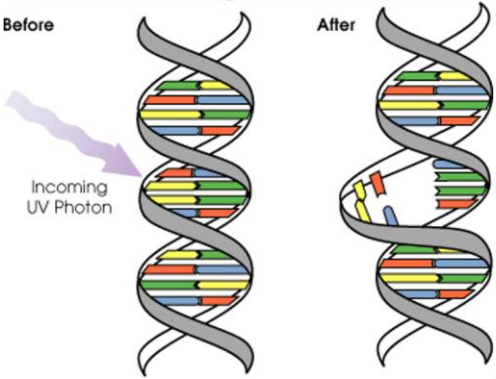
# Excessive UV exposure induces multiple cascades of altered molecular signaling causing:



# DNA DAMAGE

**UVB → DIRECT** MUTAGENIC EFFECT

**UVA → INDIRECT** MUTAGENIC EFFECT:



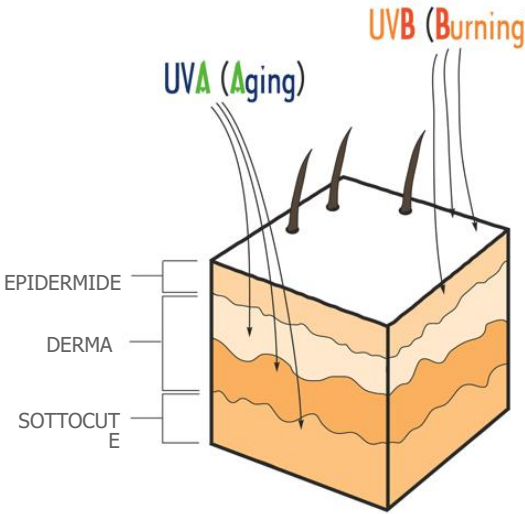

**REACTIVE OXIGEN SPECIES** (ROS)

- STRAND BREAKS
- ABASIC SITES
- BASE MODIFICATIONS
- OXIDATIVE DAMAGE TO LIPIDS, PROTEINS AND NUCLEIC ACIDS

UVA SIGNATURE:

- 8-hydroxiguanine abducts
- T→G mutations

# UVA e UVB




Radiazione Solare 95% UVA e 5% UVB.

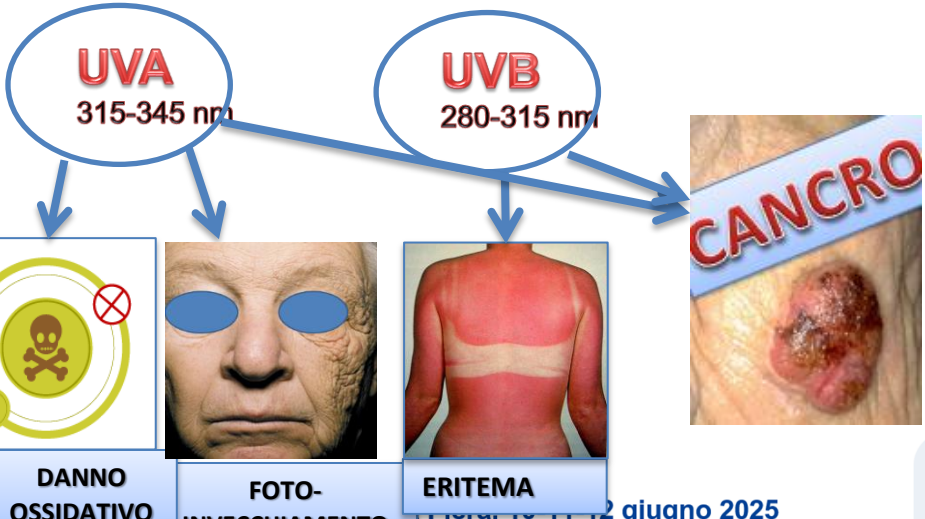
UVA causa abbronzatura, fotoinvecchiamento e tumori della pelle

UVB causa ustioni solari e tumori della pelle.

Le lampade abbronznti emettono circa 12 volte il livello di UVA che c'è nella Radiazione Solare.

I tumori della pelle hanno origine dalle cellule dell'epidermide.

# RADIAZIONE UV



# Effetti cutanei dell'esposizione a UV

| Effects on the skin | | |
|---|---|---|
| ***Acute*** | | |
| Sunburn | Sunburn | Sunburn |
| Photodermatoses | Photodermatoses | |
| ***Chronic*** | | |
| Cutaneous malignant melanoma | Cutaneous malignant melanoma | Cutaneous malignant melanoma |
| Cancer of the lip | | |
| Basal cell carcinoma of the skin | Basal cell carcinoma of the skin | Basal cell carcinoma of the skin |
| Squamous cell carcinoma of the skin | Squamous cell carcinoma of the skin | Squamous cell carcinoma of the skin |
| Chronic sun damage<br>- photoageing<br>- solar keratoses | Photoageing/solar keratoses | Photoageing/solar keratoses |

Da OMS 2010

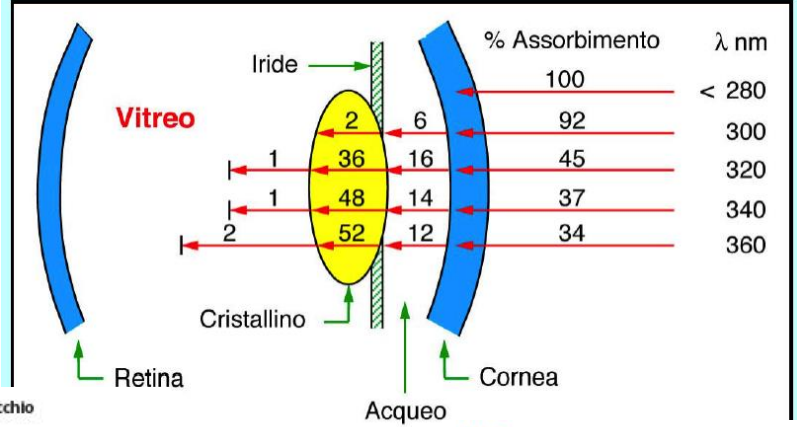
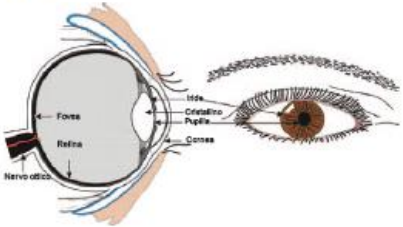
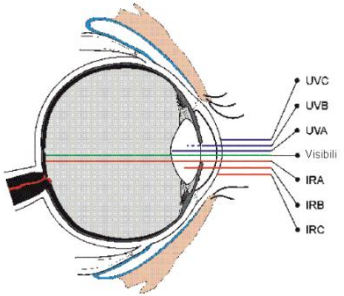



**Figura B.1.1. — Struttura dell'occhio**




La luce che penetra nell'occhio passa attraverso la cornea, l'umor acqueo, quindi attraverso un'apertura variabile (pupilla) e attraverso il cristallino e l'umor vitreo per essere messa a fuoco sulla retina. Il nervo ottico trasporta i segnali dai fotoricettori della retina fino al cervello.

**Figura B.1.2. — Penetrazione di diverse lunghezze d'onda attraverso l'occhio**



The ocular media partially transmit and refract UVR. The refraction may concentrate directly incident radiation to a higher irradiance. Therefore, ocular effects of the Sun are primarily located in the lower nasal part of the outer eye (Figure 5).

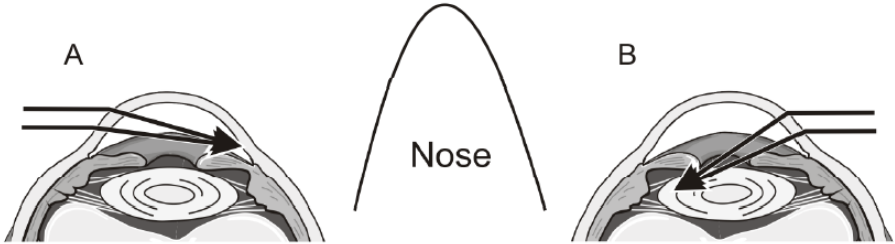



**Figure 5.** Concentration of UVR in the eye by refraction (the Coroneo Effect) into the corneal limbus (A) and nasal area of the lens (B)

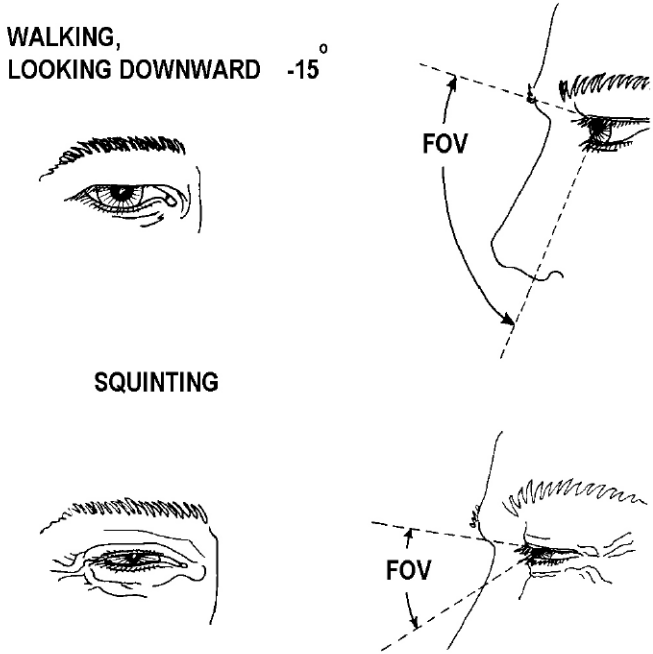



**Figure 7.** Exposure of the eye is greatly limited outdoors because of squinting and shielding of overhead UVR by the brow ridge (after Sliney 1995)

# EFFETTI OCULARI DELL'ESPOSIZIONE A RADIAZIONE OTTICA

| Lunghezza d'onda (nm) | | Occhi |
|---|---|---|
| 100-280 | UVC | Fotocheratite<br>Fotocongiuntivite |
| 280-315 | UVB | Fotocheratite<br>Fotocongiuntivite<br>Cataratta |
| 315-400 | UVA | Fotocheratite<br>Fotocongiuntivite<br>Cataratta<br>Danno fotoretinico |
| 380-780 | Visibile | Danno fotoretinico<br>(rischio da luce blu)<br>Ustione della retina |
| 780-1 400 | IRA | Cataratta<br>Ustione della retina |
| 1 400-3 000 | IRB | Cataratta |
| 3 000-$10^6$ | IRC | Ustione della cornea |

**Figura B.1.2. — Penetrazione di diverse lunghezze d'onda attraverso l'occhio**

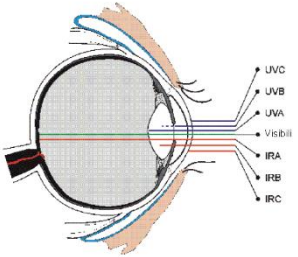


**Table 2.1** Candidate, and selected, health outcomes to be assessed for the burden of disease related to ultraviolet radiation

| Outcomes associated with UVR | Strong evidence of causality | Included in the Burden of Disease study |
|---|---|---|
| Effects on the eyes | | |
| Acute | | |
| Acute photokeratitis and conjunctivitis | Acute photokeratitis and conjunctivitis | |
| Acute solar retinopathy | Acute solar retinopathy | |
| Chronic | | |
| Climatic droplet keratopathy | | |
| Pterygium | Pterygium | Pterygium |
| Pinguecula | | |
| Squamous cell carcinoma of the cornea | Squamous cell carcinoma of the cornea | Squamous cell carcinoma of the cornea |
| Squamous cell carcinoma of the conjunctiva | Squamous cell carcinoma of the conjunctiva | Squamous cell carcinoma of the conjunctiva |
| Cataract | Cortical cataract | Cortical cataract |
| Ocular melanoma | | |
| Macular degeneration | | |

Da OMS 2010

**Table 2** Population attributable fraction for health outcomes caused by UVR exposure

| Health outcome | Upper PAF estimate | Lower PAF estimate |
|---|---|---|
| Cutaneous malignant melanoma | 0.9 | 0.5 |
| Squamous cell carcinoma of the skin[a] | 0.7 | 0.5 |
| Basal cell carcinoma of the skin | 0.9 | 0.5 |
| Photoageing/solar keratoses | 1.0 | 1.0 |
| Sunburn | 1.0 | 1.0 |
| Cortical cataract | 0.25 | 0.25 |
| Pterygium | 0.74 | 0.42 |
| Squamous cell carcinoma of the cornea and conjunctiva | 0.7 | 0.5 |
| Reactivation of herpes labialis | 0.5 | 0.25 |

[a] The PAF provided here is for light-skinned populations; based on limited epidemiological data, the PAF assumed for intermediately pigmented populations is one fifth of this (i.e. 0.10–0.14), and for deeply pigmented populations, one fifth of that (i.e. 0.02–0.03).

Da OMS 2010

International Journal of
*Environmental Research and Public Health*

MDPI

*Review*

# Occupational Exposure to Solar Radiation at Different Latitudes and Pterygium: A Systematic Review of the Last 10 Years of Scientific Literature

**Alberto Modenese *** and **Fabriziomaria Gobba**

Department of Biomedical, Metabolical and Neurosciences, University of Modena & Re
41124 Modena, Italy; f.gobba@unimore.it
* Correspondence: albertomodenese1@gmail.com; Tel.: +39-059-205-5463

Received: 8 November 2017; Accepted: 23 December 2017; Published: 26 December 201

**Abstract:** Pterygium is a chronic eye disease: among its recognized risk facto
exposure to ultraviolet (UV) radiation. The Sun is the main source of UV ex
the World Health Organization, the Population Attributable Fraction of pte
radiation (SR) is 42–74%. Outdoor work can deeply influence the eye exposure
despite this, pterygium is currently not adequately considered as a possible
in this working category, at least in Europe. For this reason, we performed a
the scientific literature published in the last ten years (2008–2017) considering the role of outdoor work as a risk factor for pterygium, in order to give new support for the prevention of this UV related disease in workers. We identified 29 relevant papers. Our results show that pterygium prevalence highly increased with latitude and mean annual UV index, and outdoor work is one of the most relevant risk factors, as well as age and male sex, both in high risk and in moderate risk World areas considering the environmental UV levels. Accordingly, pterygium occurring in outdoor workers should be considered an occupational disease. Moreover, our findings clearly support the need of further research on more effective prevention of the occupational risk related to long-term solar radiation exposure of the eye.

**Keywords:** pterygium; solar ultraviolet radiation; occupational eye exposure; outdoor work; worker health prevention

Int Ophthalmol (2014) 34:383–400
DOI 10.1007/s10792-013-9791-x

REVIEW

Ultraviolet light and ocular diseases

Jason C. S. Yam · Alvin K. H. Kwok

# CARCINOMI SUAMOCELLULARI DI CORNEA E CONGIUNTIVA

## Ocular surface squamous neoplasia

OSSN is a term for precancerous and cancerous epithelial lesions of the conjunctiva and cornea [37]. It includes dysplasia and carcinoma in situ and SCC. It can also be called corneal (or conjunctival) intraepithelial neoplasia [37].

Exposure to solar UVR has been identified in many studies as a major etiologic factor in the development of OSSN, although human papilloma virus and human immunodeficiency virus also play a role [37].

Int Ophthalmol (2014) 34:383–400
DOI 10.1007/s10792-013-9791-x

REVIEW

# Ultraviolet light and ocular diseases

Jason C. S. Yam · Alvin K. H. Kwok

# MELANOMA OCULARE

**Table 4** Summary of results from case control studies evaluating UV exposure as risk factors in uveal melanoma [92–100]

| Reference | Region | No. of cases | Findings in relation to UV exposure |
|---|---|---|---|
| Gallagher et al. 1985 [92] | Canada | 87 | Sunlight exposure was not found to be as significant risk factor for ocular melanoma |
| Tucker et al. 1985 [93] | United States | 444 | Sunbathing: OR = 1.5; 95 % CI 0.9–2.3 |
| | | | Use of sunlamps: OR = 2.1; 95 % CI 0.3–17.9 |
| | | | No eye protection in sun: OR = 1.4; 95 % CI 0.9–2.3 |
| | | | Gardening: OR 1.6; 95 % CI 1.01–2.4 |
| Seddon et al. 1990 [94] | New England | 197 | Outdoor work was not found to be a significant risk factor for ocular melanoma |
| Holly et al. 1990 [95] | United States | 407 | Exposure to UV light: OR = 3.7, $p = 0.003$ |
| | | | Tendency to sunburn: OR = 1.8, $p < 0.001$ |
| | | | Light-colored eye: OR = 2.5, $p < 0.001$ |
| | | | Welding burn: OR = 7.2, $p < 0.001$ |
| Holly et al. 1996 [96] | United States | 221 | Exposure to artificial UV light: OR = 3.0; 95 % CI 1.2–7.8 |
| | | | Welding exposure: OR = 2.2; 95 % CI 1.3–3.5 |
| Pane and Hurst 2000 [97] | Queensland, Australia | 125 | Cumulative lifetime ocular UVB exposure was not found to be a risk factor for ocular melanoma |
| Guenel et al. 2001 [98] | France | 50 | Occupational exposure to solar UV light: OR = 0.9, 95 % CI 0.4–2.3 |
| | | | Exposure to artificial UV light: OR = 5.5; 95 % CI 1.8–17.2 |
| | | | Welders: OR = 7.3; 95 % CI 2.6–20.1 |
| Vadjic et al. 2002 [99] | Australia | 290 | Outdoors activity: OR = 1.8; 95 % CI 1.1–2.8 |
| Lutz et al. 2005 [100] | Nine European countries | 292 | Occupational exposure to sunlight was not associated with increased risk of ocular melanoma |

Acta Ophthalmologica

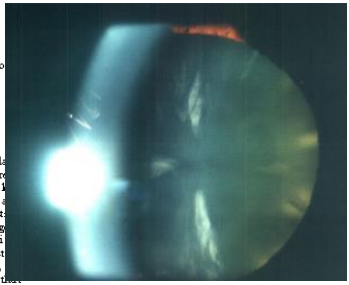
Acta Ophthalmologica 2018

Review Article

# Cataract frequency and subtypes involved in workers assessed for their solar radiation exposure: a systematic review

Alberto Modenese and Fabriziomaria Gobba

Chair of Occupational Medicine, Department of Biomedical, Metabolic and Neural Sciences, University of Modena & Reggio Emilia, Modena, Italy



**ABSTRACT.**

Cataract is currently the primary cause of blindness worldwide, and one of its main risk factors is solar ultraviolet radiation exposure. According to the localization of lens opacities, three main subtypes of cataract are recognized: nuclear, cortical and posterior subcapsular cataract. One of the main determinants of individual long-term solar radiation exposure is outdoor work. We systematically reviewed scientific literature from the last 20 years to update the recent development of research on the risk of cataract in outdoor workers and on the specific subtypes involved, also investigating the methods applied to evaluate the occupational risk. A total of 15 studies were included in the review, of which 12 showed a positive association. The studies confirm the relationship of long-term occupational solar radiation exposure with cortical cataract and give new support for nuclear cataract, although no substantial new data were available to support a relation with the posterior subcapsular subtype. In most of the studies, the exposure assessment was not adequate to support a representative evaluation of the ocular risk; however, outdoor work is clearly a relevant risk factor for cataract. Further research providing a better evaluation of the relation between solar radiation exposure levels and lens damage in workers is needed and aimed to establish adequate occupational exposure limits and better preventive measures, studying also their effectiveness.

Key words: cortical cataract nuclear cataract occupational exposure posterior subcapsular cataract solar radiation ultraviolet radiation

Acta Ophthalmol.



doi: 10.1111/aos.13734

2016). The lens nucleus is particula susceptible to UV-A-induced str able to determine changes in the fluorescence, increased yellowing loss of pyridine nucleotides (Line et al. 2014), by modulating g expression and apoptotic stimuli the lens epithelial cells (Andley et 2000, 2004). Considering UV-B, animal models, it has been showed th *in vivo* exposure to subthreshold dose of UV-B can induce apoptosis in the lens epithelial cells and not in the lens fibre cells (Galichanin 2017).

The two main mechanisms for the induction of cataracts by ocular UV light exposure are oxidative stress and its resultant inflammation (Varma et al. 2011; Øsnes-Ringen et al. 2013) and phototoxidation that may involve photosensitizers (Roberts 2011). These may be endogenous, as metabolites of inert tryptophan enzymatically modified with age (Balasubramanian 2000) or UV absorbing advanced glycation end products (Ortwerth et al. 1997), or exogenous photosensitizers, for example phototoxic drugs (Roberts 2002). All of these mechanisms produce reactive oxygen species (singlet oxygen and/

# EFFETTI ACUTI SULL'OCCHIO

## FOTOCHERATITI E FOTOCONGIUNTIVITI ACUTE

- Fotocheratite: infiammazione della cornea
- Fotocongiuntivite: infiammazione della congiuntiva.
- I sintomi, che variano dalla leggera irritazione, alla sensibilità alla luce e lacrimazione fino al dolore acuto
- Si manifestano dopo un lasso di tempo compreso tra 30 minuti e un giorno, a seconda dell'intensità dell'esposizione, e regrediscono in genere nel giro di qualche giorno.

# MECCANISMO TERMICO

•Fortemente dipendente dalle modalità di conduzione del calore attraverso il tessuto irradiato**.**

•Richiede un'esposizione molto intensa in brevi periodi (alcuni secondi o meno) per determinare la fotocoagulazione del tessuto

•Non risponde al principio di reciprocità.

•Normalmente occorrono temperature di almeno 45 ° C per produrre un'ustione termica.

•Temperature più elevate determinano un danno termico per esposizioni brevi, e.g. circa 59 ° C per 10 s o 72 ° C per 1 ms

*(Priebe; Welch 1978, Allen; Polhamus 1989, Schulmeister; Jean 2011)*

# EFFETTI TERMICI OCULARI DELLA RADIAZIONE OTTICA

•**ACUTI:**

- **USTIONI CORNEALI (IRC-IRB)**
- **DANNO TERMICO RETINICO (IRA)**

• **CRONICI**

- **CATARATTA TERMICA (IRC-IRB-IRA)**

# Cataratta da radiazione infrarossa

Acta Ophthalmol (Copenh). 1984 Dec;62(6):976-92.

## Infrared radiation and cataract II. Epidemiologic investigation of glass workers.

Lydahl E, Philipson B.

Abstract

An epidemiologic investigation on the prevalence of **cataract** in **glass workers** is presented. The study includes 209 **workers** over 50 years of age exposed to infrared (IR) radiation in the Swedish manual **glass** industry for 20 years or more, and 298 non-IR-exposed controls. The examination includes an evaluation of the individual IR-exposure and an ophthalmological examination with special reference to the lens. In IR-exposed **workers** 70 years of age and older there is a statistically significant increase of aphakia and of all types of **cataract** cuneiform and nuclear, compared to the controls of the same age group. In the s the risk for an IR-exposed ... **cataract** to 0.7 ( as high for non-exposed controls (95% confidence interval 1.4-4.4). The ... operated for **cataract** is 12 times as high (95% confidence interval 2.6-53). ... the occupational IR-exposure of the **glass workers** accelerates the developmen ... changes in the lens. All **workers** with a high exposure to IR radiation should be ... adequate eye p...

Lav Um. 1972 Nov;24(6):185-202.

## [Occupational risks in the glass and crystal industry].

[Article in Italian]

Sartorelli E, Franzinelli A, Bellamio-Sartorelli C.

AIHAJ. 2000 Jan-Feb;61(1):5-10.

## Infrared radiation exposure in traditional glass factories.

Sisto R, Pinto I, Stacchini N, Giuliani F.

ISPESL, Dip. Igiene del Lavoro, Monte Porzio Catone, Italy.

Abstract

This article reports on a general method of evaluating exposure to **infrared** radiation (IR-A, IR-B, IR-C) from high temperature (T > 1000 degrees C) black body sources, simply by performing measurements with a luxometric and/or near IR detector. The method, which may be applied to any black body source, uses the universality of the Planck formula for the black body spectrum, which allows estimation of the radiated power in any wavelength range by measuring the power radiated in another range. This capability may be very useful when the range of interest is one in which radiometers are expensive and difficult to calibrate, as for the IR-B and IR-C ranges, because a more commonly available luxometer can be used instead. The results of measurements and ... traditional Italian glass ... reported and compared with the threshold limit value given by the American Conference of Governmental Industrial Hygienists. Intense exposures in the IR-B and IR-C ranges has been found for some workers, exceeding the limit by a large factor. This exposure must be reduced, as it has been shown by epidemiologic studies that there is indeed a correlation between cataractogenesis and work with fused glass and metals.

# Conclusioni

- Il rischio da esposizione a radiazioni ottiche naturali solari non equivale al rischio da calore, ma la popolazione lavorativa esposta è la stessa.
- Nell'ottica di prevenzione, valutazione del rischio e sorveglianza sanitaria, va quindi considerato che i lavoratori outdoor esposti al rischio da temperature elevate sono anche potenzialmente a maggior rischio di effetti avversi a lungo termine da esposizione ad UV, quali i tumori cutanei.
- Una parte della radiazione ottica, i.e. luce visibile «calda» e infrarosso, interagisce comunque con i tessuti biologici con meccanismi di tipo termico, e possono dare effetti di tipo acuto, sostanzialmente solo a livello oculare in presenza di importanti riflessioni o focalizzazioni forzate.