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Non-Ionising Radiation Protection in Australia

Non-Ionising Radiation Protection in Australia

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Acknowledgement of Country

ARPANSA respectfully acknowledges Australia’s Aboriginal and Torres Strait Islander communities and their rich culture and pays respect to their Elders past and present. We acknowledge Aboriginal and Torres Strait Islander peoples as Australia’s first peoples and as the Traditional Owners and custodians of the land and water on which we rely.

We recognise and value the ongoing contribution of Aboriginal and Torres Strait Islander peoples and communities to Australian life and how this enriches us. We embrace the spirit of reconciliation, working towards the equality of outcomes and ensuring an equal voice.

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Summary

Non-ionising radiation (NIR) is generally defined as electromagnetic radiation (of a wavelength greater than 100 nanometres) that does not have enough energy to cause ionisation. Some international radiation protection authorities, including authorities in some Australian states include sound as part of their NIR definition. There are different types of NIR, with varying biological mechanisms including: static fields, extremely low frequency (ELF) and radiofrequency (RF) electromagnetic fields, and optical radiation in the infrared, visible and ultraviolet (UV) spectrums. Mechanical energy includes infrasound and ultrasound.

The highest public exposure to NIR is from solar UV where overexposure is always possible and common if appropriate personal protection measures are not taken. Overexposure to UV can cause sunburn, skin damage and skin cancer. Exposure to the public from other NIR sources is generally extremely low and no established health effects are expected. NIR overexposures are possible in occupational settings and are common in outdoor workers from solar UV exposure. Other NIR overexposures to workers can occur in various occupational settings including the heating and welding of materials, telecommunications, electricity distribution and the military.

There are international and national standards and guidelines to limit public and occupational exposure to NIR. For occupational NIR exposure a range of mitigations, including engineering controls, personal protective equipment and training are available to minimise overexposure events. NIR devices also have interventional applications including the medical and cosmetic use of optical sources such as lasers, electromagnetic sources and highly focussed ultrasound. In the clinical setting NIR diagnostic and therapeutic medical devices are regulated and self-regulatory bodies provide guidance on protection of the patient.

NIR is regulated differently across all Australian jurisdictions. Specifically, for different types of NIR:

- The Commonwealth and state and territory Cancer Councils, in partnership with ARPANSA, promote sun protection for the Australian public through advice and education around exposure and health outcomes. ARPANSA provides real time environmental UV monitoring services for the public at 11 sites across major population centres. The Cancer Councils also provide advocacy programs for cancer prevention and treatment, one of which resulted in a national legislation banning commercial solariums in Australia by 2016.
- Protection against solar UV for outdoor workers is well promoted throughout Australia. Worksafe Australia and Cancer Council Australia provide advice on protection of workers, however, there does not appear to be clear regulations in place to mandate these protective measures. Rather, protection from solar UV is integrated into individual workplace health and safety policy. Only two jurisdictions have specific regulatory oversight of artificial sources in occupational settings.
- Lasers used for industrial, research and entertainment applications are regulated in four jurisdictions within Australia. These regulations differ depending on the specific use of the laser and the laser classification. Protection for members of the public is restricted specifically to the use of commercially available handheld laser pointers. This protection is by way of limitation in power output from these devices. Currently all states and territories incorporate lasers of accessible power limit greater than 1 mW within their prohibited weapons legislation. At the national level, laser pointers above this power output are prohibited for importation into Australia.

- Regulation of NIR used for cosmetic purposes differs significantly within Australia. Existing regulations are focussed only on optical devices, primarily lasers with only one jurisdiction regulating the use of intense pulsed light devices. There is no regulatory oversight of any other NIR modality used for cosmetic purposes. ARPANSA has published national advice for light based cosmetic treatments for clients and service providers.
- Regulation of RF exposure is thorough in the area of communications where public exposure occurs, however, only the Commonwealth regulates RF emitting devices at workplaces. This oversight is limited by the specificity of the regulations where the focus is on devices rather than exposure. In this case, there is a clear limitation in being able to address other sources of RF exposure and a risk of regulations becoming outdated based on the technology focus of the oversight. All other jurisdictions (apart from Western Australia) have no specific regulations regarding RF exposure in the workplace.
- There are generally no specific regulations within Australia (apart from Western Australia) regarding exposure to static and ELF fields for the public or workers. In the clinical setting magnetic resonance imaging (MRI) is a medical device regulated by the Therapeutics Good Administration (TGA). There are self-regulatory bodies that provide guidance on the use of MRI with a focus on patient, volunteer and worker protection from overexposure to static, ELF and RF fields.
- Although there are limits on environmental airborne ultrasound, there are no specific regulations regarding the use of ultrasound in the workplace. In the clinical setting diagnostic ultrasound imaging is a medical device regulated by the TGA. There are self-regulatory bodies that provide guidance on the use of medical ultrasound with a focus on protection of the foetus.
- There have been some guidance documents on infrasound exposure but there are no clear regulations on limits.
- While there are generally no specific occupational NIR exposure regulations in most states or territories, NIR could be treated as a general occupational hazard and protected through Work Health and Safety regulations.

Non-ionising radiation protection in Australia

		 Ultraviolet radiation	 Lasers	 Cosmetics (all NIR)	 Radiofrequency	 Static/ELF fields	 Ultrasound	 Infrasound
Exposure	Frequency/wavelength	100–400 nm	Various optical ranges	Modality dependent	100 kHz – 300 GHz	0–100 kHz	Greater than 20 kHz	Less than 20 Hz
	Established health effects	Skin cancer, cataracts, erythema, wrinkling and skin damage, Welder's Flash	Partial or total blindness, burns	Burns, scarring, hyper/hypopigmentation, edema, erythema	Thermal stress, burns, electric shock	Electric shock, nausea, vertigo, phosphene induction (perception of seeing lights)	Bruising, burns, hearing damage, pain, vertigo, tinnitus	Hearing damage
	International guidance	ICNIRP (2004)	IEC (2004, 2014)	None	ICNIRP (1998)	ICNIRP (2009) ICNIRP (2010)	IRPA (1984)	None
	Australian Government standards	ARPANSA (2006)	AS/NZS 4173:2018 AS/NZS IEC 60825.1:2014 AS/NZS IEC 60825.14:2011	AS/NZS 4173:2018 AS/NZS IEC 60825.1:2014 AS/NZS IEC 60825.14:2011	ARPANSA (2002)	No general standard	No general standard	None
	Typical exposure scenarios	Sunbathing, solaria or tanning beds	Laser pointers, entertainment, research and surgical lasers	Laser or intense pulsed light (IPL) hair removal, skin rejuvenation, body sculpting	Mobile phones, Wi-fi, TV and radio, RF welding	Magnetic Resonance Imaging (MRI) scan, power lines	Ultrasound diagnostic imaging	Wind turbines
Regulation/protection	 Public	<ul style="list-style-type: none"> No specific regulations governing solar UV exposure for members of the public Since 2016 commercial solaria are banned nationally in Australia through legislation ARPANSA and the state and territory Cancer Councils promote sun smart behaviour through providing information and advice 	<ul style="list-style-type: none"> Members of the public prohibited from possessing handheld laser pointers with an accessible emission limit exceeding 1 milliwatt. The prohibition applies in every state and territory in Australia under prohibited weapons legislation and also applies to their import into Australia 	<ul style="list-style-type: none"> No specific regulations in place for home use devices (e.g. commercially available IPLs) Licensing of treatment providers in the Tasmania, Queensland and Western Australia ARPANSA published advice for consumers and treatment providers underdoing optical treatments in 2019 Australian Standards apply to cosmetic use of lasers and ILSs 	<ul style="list-style-type: none"> The Australian Communications and Media Authority (ACMA) applies ARPANSA's standard for public exposure from telecommunications sources 	<ul style="list-style-type: none"> No specific national regulations or guidelines regarding exposure to static and ELF fields. ARPANSA promotes application of the ICNIRP guidelines In Western Australia, interim guidelines by the National Health and Medical Research Council from 1989 apply to protection of the public 	<ul style="list-style-type: none"> No regulations or guidelines for public exposure to ultrasound 	<ul style="list-style-type: none"> No regulations or guidelines for public exposure to infrasound
	 Workers	<ul style="list-style-type: none"> The Commonwealth regulates use of artificial sources of UV radiation by Commonwealth entities Western Australia require the registration of UV transilluminator equipment Other jurisdictions provide protection of workers from artificial UV sources through Work Health and Safety regulation Cancer Councils and ARPANSA promote sun safety measures and behaviour for outdoor workers through the provision of advice and advocacy programs 	<ul style="list-style-type: none"> Currently four jurisdictions licence the occupational use of lasers in Australia (Commonwealth, Tasmania, Western Australia and Queensland) The Commonwealth, Tasmania and Western Australia regulate the use of both Class 3B and Class 4 laser products for research, industrial and entertainment purposes Queensland regulates Class 4 lasers only Safety is regulated through Work Health and Safety regulations 	<ul style="list-style-type: none"> Cosmetic lasers licenced in Tasmania, Western Australia and Queensland IPL devices are only licenced in Tasmania Licensing requires protection of clinicians and technicians by adherence to Australian safety and manufacturing standards as well as laser safety training ARPANSA published advice for cosmetic treatment providers using optical devices in 2019 that contains references to relevant occupational Australian standards 	<ul style="list-style-type: none"> The Commonwealth regulates a limited number of RF emitting devices (e.g. RF welders, industrial microwaves) used by Commonwealth entities Comcare applies ARPANSA's standard for Defence Force personnel exposed to radar and communications devices Western Australia applies ARPANSA's standard In other jurisdictions, protection is governed by Work Health and Safety regulations 	<ul style="list-style-type: none"> No specific national regulations or guidelines regarding exposure to static and ELF fields. ARPANSA promotes application of the ICNIRP guidelines In Western Australia, interim guidelines by the National Health and Medical Research Council (NHMRC) from 1989 apply to protection of workers 	<ul style="list-style-type: none"> No regulations or guidelines for occupational exposure to ultrasound 	<ul style="list-style-type: none"> No regulations or guidelines for occupational exposure to infrasound
	 Patients	<ul style="list-style-type: none"> Medical devices emitting UV radiation (e.g. phototherapy devices) are approved by the Therapeutic Goods Administration (TGA) 	<ul style="list-style-type: none"> The TGA approves laser devices used for medical purposes (e.g. lasers for photodynamic therapy, laser eye correction lasers) Australian Standards apply to medical use of lasers 	<ul style="list-style-type: none"> Not applicable 	<ul style="list-style-type: none"> Devices that emit RF used for medical diagnostics and treatment are subject to TGA approval (e.g. diathermy, MRI) ACMA regulates the emissions from transmitting medical devices. (e.g. those that use bluetooth and Wi-fi signals) 	<ul style="list-style-type: none"> There are no specific regulations for static field exposures, however, devices require TGA approval (e.g. MRI) 	<ul style="list-style-type: none"> No specific regulations for the use of ultrasound in diagnostic or other medical procedures International guidance on the safe use of ultrasound in medicine by the World Federation for Ultrasound in Medicine and Biology adopted by the Australasian Society for Ultrasound in Medicine (2019) Medical ultrasound devices require TGA approval 	<ul style="list-style-type: none"> No medical standards, regulations or guidelines for patient exposure to infrasound

1. Purpose

Australia is a country with a complex multi-government system and consists of the Commonwealth, 6 states and 2 territories. Under the Australian constitution all 9 jurisdictions have power to legislate with each jurisdiction maintaining Acts that protect people from the harmful effect of radiation. The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), the commonwealth radiation protection body, promotes uniformity of radiation protection and nuclear safety policy and practices across all Australian jurisdictions. The promotion of national uniformity in radiation protection includes both ionising and non-ionising radiation (NIR) however the focus is often on the regulation of ionising radiation. The purpose of this document is to identify the regulation of NIR across all the Australian jurisdictions.

2. Scope

This document outlines the definitions and regulations of NIR across all Australian jurisdictions. A summary of NIR risks and international/Australian guidelines and standards is also presented. The presentation of NIR regulation in Australia in this document is based on a desktop review with limited consultation with national and state regulatory bodies; there could, therefore, be NIR regulations in Australia that are not listed in this document. A comprehensive review of NIR regulation in Australia would require extensive consultation with all the regulatory bodies. Consequently, this report focusses on the major standards and guidelines that are applied across common industrial, commercial and medical activities within Australia. Equipment and scenario specific standards and guidelines are not necessarily included unless they cover a widespread use or common potential exposure (e.g. laser product equipment classification and requirements). Also, the report does not consider protection of the environment.

3. Definitions of NIR

NIR is generally defined as electromagnetic radiation that does not have enough energy to cause ionisation. This means that NIR cannot remove an electron from an atom or molecule leaving it with an electrical charge (Wood and Karipidis, 2017). Tables 1 and 2 show how different organisations internationally and how different jurisdictions within Australia define NIR, respectively. A major difference is that organisations such as ICNIRP and some Australian states (New South Wales and Queensland) include low and high frequency sound as part of their NIR definition

Table 1: International definitions of NIR

Organisation/ publication	Reference	Definition
The International Commission of Non-ionizing Radiation Protection (ICNIRP)	ICNIRP website	<p>Electromagnetic radiation that does not carry enough photon energy to ionise atoms or molecules and includes mechanical waves in the low and high frequency range (infrasound and ultrasound).</p> <p>ICNIRP uses subcategories of NIR, that group frequencies or wavelength bands together, and treats these groupings separately in terms of protection, mainly because the frequencies or wavelengths of the NIR in each grouping have different actions on the tissues.</p>
World Health Organisation (WHO)	WHO website	Radiation in the part of the electromagnetic spectrum where there is insufficient energy to cause ionisation. It includes electric and magnetic fields, radio waves, microwaves, infrared, ultraviolet, and visible radiation.
Wood and Karipidis	Wood AW and Karipidis K, editors. Non-ionizing Radiation Protection: Summary of Research and Policy Options. John Wiley & Sons; 2017 May 8.	Radiation that does not cause atoms and molecules to be ionised, that is, electrons are not removed from the atom or molecule leaving it with an electrical charge. NIR is regarded primarily as electromagnetic radiation whose wavelength is longer than 100 nanometres (nm) (Wood and Karipidis, 2017).

Table 2: Australian jurisdictions' definitions of NIR

Jurisdiction	Act	Definition
Commonwealth	Australian Radiation Protection and Nuclear Safety Act 1998	Non-ionising radiation means electromagnetic radiation of a wavelength greater than 100 nanometres.
Australian Capital territory	Radiation Protection Act 2006	Radiation is non-ionising if it is electromagnetic radiation of a wavelength greater than 100 nanometres.
New South Wales	Radiation Control Act 1990 No. 13	Non-ionising radiation means: <ul style="list-style-type: none"> (a) electromagnetic radiation of a wavelength greater than 100 nanometres or (b) non-varying electric or magnetic fields or (c) sonic, infrasonic or ultrasonic waves that are prescribed as non-ionising radiation for the purposes of this definition.
Northern Territory	Radiation Protection Act 2004	Non-ionising radiation is electromagnetic radiation of a wavelength greater than 100 nanometres.
Queensland	Radiation Safety Act 1999	<ul style="list-style-type: none"> (a) electromagnetic radiation of a wavelength greater than 100 nanometres or (b) sonic radiation.
South Australia	Radiation Protection and Control Act 1982	Non-ionising radiation means electromagnetic radiation of a wavelength greater than 100 nanometres.
Tasmania	Radiation Protection Act 2005	Non-ionising radiation is electromagnetic radiation of a wavelength equal to or greater than 100 nanometres.
Victoria	Radiation Act 2005 No. 62 of 2005	Non-ionising radiation means electromagnetic radiation of a wavelength of greater than 100 nanometres.
Western Australia	Radiation Safety (General) Regulations 1983	Non-ionising radiation means radiation other than ionising radiation.

4. Types of NIR

NIR covers the electromagnetic spectrum across the frequencies 0 Hz to 3 PHz (3×10^{15} Hz). This frequency range is divided into broad categories of NIR characterised by their physical properties and effects on biological tissue. These categories include; static fields, extremely low frequency (ELF) and radiofrequency (RF) electromagnetic fields, and optical radiation in the infrared (IR), visible and ultraviolet (UV) spectrums. Mechanical energy includes ultrasound, defined as acoustic waves greater than 20 KHz, and infrasound, defined by frequencies below 20 Hz (HPA, 2010). Exposure to NIR results in varying biological and health effects depending on the type of radiation and level of exposure. Consequently, international and national radiation protection bodies have developed standards and guidelines to limit exposure to NIR. Table 3 describes the types of NIR, known biological and health effects and associated international and Australian guidelines/standards.

Table 3: Types of NIR

Frequency ¹	Biological mechanism	Health effect	International Guidance	Australian Government standards
Static (0 Hz)	Electrostimulation	Electric shock	ICNIRP (2009)	None
	Surface electric charge	Nausea, vertigo		
ELF (1 Hz – 100 kHz)	Electrostimulation	Electric shock	ICNIRP (2010)	No general standard
	Surface electric charge	Phosphene induction (perception of seeing lights)		
RF (100 kHz – 300 GHz)	Electrostimulation	Electric shock	ICNIRP (1998)	ARPANSA (2002)
	Thermal	Thermal stress, burns		
IR (1 mm – 780 nm)	Thermal	Thermal Stress	ICNIRP (2013) IEC (2004, 2014)	AS/NZS 4173:2018, AS/NZS IEC 60825.1:2014, AS/NZS IEC 60825.14:2011
	Photo coagulation	Burns, glassblower's cataracts		

(Table 3 continued over page)

Table 3 (continued)

Frequency ¹	Biological mechanism	Health effect	International Guidance	Australian Government standards
Visible (780 – 400 nm)	Circadian rhythm disruption	Sleep disruption	ICNIRP (2013), IEC (2004, 2014)	AS/NZS 4173:2018, AS/NZS IEC 60825.1:2014, AS/NZS IEC 60825.14:2011
	Photochemical	Temporary or permanent vision damage or blindness		
	Photo thermal	Thermal stress		
UV (400 - 100 nm)	Photochemical	Erythema (sunburn), skin wrinkling and damage, cataracts, welder’s flash, skin cancer	ICNIRP (2004)	ARPANSA (2006)
Ultrasound (US) (greater than 20 kHz)	Thermal	Burns	IRPA (1984)	No general standards
	Mechanical	Edema (bruising), hearing damage or loss, pain, vertigo, tinnitus		
Infrasound (IS) (less than 20 Hz)	Mechanical	Hearing damage or loss	None	None

¹ Optical radiation which includes IR, visible and UV radiation is described using wavelength rather than frequency as per common terminology.

5. Typical NIR exposure

Exposure to NIR is ubiquitous in everyday life. There are natural sources of NIR including the Earth’s magnetic field, lightning storms and the sun. Artificial NIR exposures in the environment include ELF electric and magnetic fields from power supply and distribution infrastructure, RF fields from telecommunications and other radio transmissions, optical radiation from artificial lighting sources and ultrasound and infrasound from industrial sources.

5.1 Public

Public exposure to NIR occurs as part of everyday life in modern society. Table 4 shows some typical NIR exposures to the public that have been ranked according to the level of exposure in relation to exposure guidelines (highest to lowest). The highest public exposure to NIR is from solar UV where overexposure is always possible and common if appropriate personal protection measures are not taken (Cancer Council Australia, 2019). Overexposure to the public from UV can also occur through the use of personal tanning beds. Exposure to the public from ELF and RF sources is generally extremely low.

Table 4: Typical scenarios of NIR exposure to the public

Scenario	NIR source	Exposure level/dose	Likelihood of overexposure ^{1,2}
Sunbathing	UV	Up to 12.5 Standard Erythematol Dose (SED)/h (based on an extreme UV index of 14 where each UV index unit corresponds to 0.9 SEDs/h, (Hill et al, 2004))	Certain
Solaria or tanning bed	UV	Effective Irradiance – 300-900 mW/m ² or approx. 12 – 36 SED/h (Gies et al. 2011)	Certain
Using a laser pointer	Visible	Radiant power – up to 112 mW, which can be a Class 3B laser (Wheatley, 2013)	Possible
Using a device with visual display (tablet, smartphone, computer)	RF	SAR (from smart devices) - below 2 W/kg e.g. Apple iPad Pro 12.9 - 0.99 W/Kg (devicespecifications.com, 2019)	Not possible
	Visible	Radiance – 0.05-0.31 W/m ² .sr (O’Hagan et al, 2016)	Not possible
Using a mobile phone handset	RF	SAR – below 2 W/kg e.g. Apple iPhone 7 Plus = 1.34 W/kg, Samsung Galaxy Neo Active Neo = 0.928 W/kg (devicespecifications.com, 2019)	Not possible
Environmental exposure to RF from transmitters (base-stations, small cells, smart meters)	RF	Power density - 100 µW/m ² – 2 mW/m ² (Henderson et al, 2014)	Not possible
Living near power distribution infrastructure (power lines, substation, transformers)	ELF	Magnetic field strength – up to 3.5 uT (Urban et al, 2014) Electric field strength - up to 1000 V/m (Urban et al, 2014)	Not possible
Nail curing	UV	Irradiance - 115 W/m ² (Diffey, 2012) SED/h - 1.58 SED/h	Not possible
Wi-fi	RF	Power density - 1.1 mW/m ² (Karipidis et al, 2017)	Not possible
RF airport scanners	RF	Power Density - 0.00001 – 0.0006 mW/cm ² (Moulder et al, 2012)	Not possible
Living near wind turbines	IS	Sound intensity - up to 72 dB at 85 metres (NHMRC, 2015)	Not possible

1 The scale of likelihood includes: Not possible, Unlikely, Possible, Likely, Certain

2 Overexposure is defined here as exposure above accepted standards or guidelines

5.2 Occupational

Occupational exposures to NIR result from being in closer proximity or dealing with much more powerful sources. Some typical occupational exposures to NIR are shown in Table 5. For example, telecommunications workers and radar technicians near the transmission sources will be exposed to levels of RF much higher than members of the public. This is similar for power supply workers and exposure to ELF. Exposures to high levels of optical radiation (as well as RF) usually occur in industrial settings such as in metal smelting and welding, however, by far the highest and most common exposure comes from solar UV in any outdoor occupation (Karipidis et al, 2008). In general, NIR overexposures are possible in occupational settings, however, a range of mitigations, including personal protective equipment and training are available to minimise overexposure events.

Table 5: Typical scenarios of occupational NIR exposure

Scenario	NIR source	Exposure level/dose	Likelihood of overexposure
Outdoor workers (construction and agriculture)	UV	SED/h - 1.15 - 5.44 SED/h (Karipidis, 2008)	Likely
Lifeguard	UV	SED/h - 2.19 (Karipidis et al, 2008)	Likely
Welders	RF (plastic)	Power density - 1.55 – 9.43 W/m ² (Karipidis et al, 2008)	Possible
	UV (arc)	Effective irradiance - 311.0 W/cm ² (Peng et al, 2007)	Possible
	ELF (arc)	Magnetic field strength - 100-200 µT (WHO, 2007) Electric field strength - a few tens of V/m (WHO, 2007)	Unlikely
	Static (arc)	Magnetic field strength - 5 mT (WHO, 2006)	Not possible
Metal smelter workers	IR	Irradiance - 0.06 – 1.33 W/cm ² (Majidi et al, 2010)	Possible
	Static	Magnetic field strength - 4 – 30 mT, up to 63 mT (WHO, 2006)	Unlikely
	ELF	Magnetic field strength - 330 µT (WHO, 2007)	Unlikely
Induction heating	RF	Electric field strength - 2 – 8000 V/m (HPA, 2012)	Possible
	ELF	Magnetic Field Strength - 25 – 540 µT (WHO, 2007)	Unlikely
		Electric Field Strength - several volts per metre (WHO, 2007)	Not possible

(Table 5 continued over page)

Table 5 (continued)

Scenario	NIR source	Exposure level/dose	Likelihood of overexposure
Diathermy	RF	Electric Field - 60 – 770 V/m (HPA, 2012)	Possible
Military	RF	Electric field - 10 – 500 V/m from radar (Degrave et al, 2008)	Possible
Telecommunications workers	RF	Power Density - 0.4 – 2.3 W/m ² (IARC, 2013)	Possible
Power supply technicians (linesmen, infrastructure engineers)	ELF	Magnetic field strength - typically 0.15 – 0.28 μ T (Karipidis et al. 2008) Electric field strength (linemen) – 10-30 kV/m (WHO, 2007)	Possible
MRI scan	ELF	Magnetic field strength - 0.05 – 28 μ T (WHO, 2007)	Unlikely
	Static	Magnetic field strength - 0.5-1.5 T (WHO, 2006)	Unlikely
Using two way radio (walkie talkie)	RF	SAR - 0.4 – 1.7 W/kg (Vermeeren et al, 2015)	Unlikely
Industrial Sewing	ELF	Magnetic Field Strength - 0.32 – 11.1 μ T (WHO, 2007)	Not possible

5.3 Interventional and aesthetic

Exposure to NIR can also be deliberate to facilitate biological outcomes or assist in diagnostics. Diagnostic procedures including ultrasound imaging and Magnetic Resonance Imaging (MRI) have become useful tools in medicine. NIR devices also have interventional applications including the medical and cosmetic use of optical sources such as lasers, electromagnetic sources and highly focussed ultrasound. Table 6 describes typical interventional and aesthetic applications of NIR and associated exposures.

Table 6: Interventional and aesthetic NIR exposure

Scenario	NIR source	Exposure group	Exposure level/dose
Cosmetic ultrasound	US	Public	Deposited energy: Microfocused Ultrasound (MFU) - 0.4–1.2 J/mm ² (Alam et al, 2010) High-intensity Focused Ultrasound (HIFU) - 165 J/cm ² (Hu et al, 2017)
Cosmetic EMR	ELF	Public	Deposited Energy: Magnetic field Strength - 1.5 mT (Krueger et al, 2012)
	RF		SAR - Peak local of 10 ⁵ W/kg (Johnson et al, 2012)
MRI scan	Static	Patient	Magnetic field strength - 0.5 – 7 T (ICNIRP, 1998)
	Static		Magnetic field strength - 0.2 – 3 T (RANZCR, 2017)
	RF		SAR - 0.1 – 4 W/kg (HPA, 2012)
	ELF		Electric field strength - a few volts per metre
Medical optical treatment (laser eye correction)	IR and UV laser	Patient	Radiant exposure - 2.4 J/cm ² (Kanellopoulos and Asimellis, 2015) Laser fluence rate - 30 mW/cm ² (Kanellopoulos and Asimellis, 2015)
Photothermal and photodynamic therapy	IR and visible laser		Laser fluence rate - less than 300 mW/ cm ² (Peng, 2008)
Diathermy	RF	Patient	SAR - 50 - 235 W/kg (Delpizzo and Joyner, 1987)
Cosmetic optical treatment	Visible	Public	Fluence - 5 – 50 J/cm ² (Royston et al, 2008)
	IR		Fluence - 150 J/cm ² (Tagliolatto et al, 2012)
Ultrasound image or diagnostic	US	Patient	Deposited energy - 0.003 – 1 W/cm ² (HPA, 2010)

6. NIR regulations in Australia

NIR is regulated differently across all Australian jurisdictions. All the different regulations related to NIR for the Commonwealth and states and territories are shown in Table 7. Also shown in Table 7 are work health and safety regulations, which apply general protection to workers that may extend to protection against NIR. There are also specific agencies that regulate particular NIR sources nationally and they are shown in Table 8. The Commonwealth and all states and territories regulate some optical sources including the possession and use of laser pointers and lasers used in the work place. Some laser pointers are also prohibited from being imported into Australia under Customs regulations. Comcare also regulates exposure to lasers in the work place for Commonwealth employees. There are also medical and therapeutic lasers, which are regulated by the Therapeutics Good Administration (TGA). The use of lasers for cosmetic purposes such as hair removal are only regulated in Queensland, Tasmania and Western Australia. The Australian Communication and Media Authority (ACMA) regulates all public exposure to RF from telecommunication sources such as mobile telephony, Wi-Fi, TV and radio broadcasting, etc. Medical devices that use RF to communicate are regulated by TGA through various device requirements set by ACMA. Exposure to ELF is only regulated in Western Australia for workers and the public. MRI is a medical device which produces RF, ELF and static fields. In Australia, The Royal Australian and New Zealand College of Radiologists (RANZCR) has published guidelines for the safe use of MRI (RANZCR, 2017). There are also general regulations administered through the Australian Competition and Consumer Commission that all states and territories apply that require devices and services to be safe for consumers, this also applies to NIR devices.

Table 7: Jurisdiction specific regulations that apply (or may apply) to NIR

Jurisdiction	Radiation protection legislation
Commonwealth	<p>Australian Radiation Protection and Nuclear Safety Regulations 2018 (Part 3, Division 2) Regulates for the use of magnetic field non-destructive testing device, induction heater or induction furnace, industrial RF heater or welder, RF plasma tube, microwave or RF diathermy equipment, industrial microwave or RF processing system, optical source, other than a laser product, emitting UV radiation, IR or visible light, laser products with accessible emission limits which exceed Class 3R and optical fibre that exceed a hazard level 3R.</p>
Australian Capital Territory	<p>Radiation Protection Regulation 2007 (Radiation Protection (Tanning Units) Amendment Regulation 2010 (No 1)) Prohibits cosmetic UV tanning services.</p> <p>Work Health and Safety Act 2011 (Part 4) This part of the Act applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Work Health and Safety Regulation 2011 (Chapter 5, Part 5.1, Division 5.1.7, Subdivision 5.1.7.3, Section 223) (Chapter 3, Part 3.1) Regulates the use of laser equipment at a workplace, sets control measures, training requirements and prohibits the use of some lasers. This part of the regulation applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Work Health and Safety (Welding Process Code of Practice) Approval 2012 Regulates for the exposure to electromagnetic fields during welding.</p> <p>Environment Protection Act 1997 (Part 16, Schedule 2, Part 2.2) Outlines the enforcement of the regulations for the exposure to noise.</p> <p>Environment Protection Regulation 2005 (Part 3) Regulates the exposure to noise and sets limits.</p> <p>Prohibited weapons act 1996 (Part 2, Section 6A) Prohibits the possession of laser pointer with an accessible emission level of greater than 1 mW.</p>

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Table 7 (continued)

Jurisdiction	Radiation protection legislation
New South Wales	<p>Radiation Control Act 1990 (Part 1, Section 3 & 4) The objects of the Act include protection of persons and the environment from exposure to ionising and harmful non-ionising radiation. Act defines ‘non-ionising radiation’ but treats as ‘regulated material’ only those sources of non-ionising radiation that are prescribed in the regulations</p> <p>Radiation Control Regulation 2013 (Division 6, Section 41) Prohibits cosmetic UV tanning services.</p> <p>Work Health and Safety Act 2011 No 10 (Part 2) This part of the Act applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Work Health and Safety Regulation 2017 (Division 7, subdivision 3, Section 223) (Chapter 3, Part 3.1) Regulates the use of laser equipment at a workplace, sets control measures, training requirements and prohibits the use of some lasers.</p> <p>This part of the regulation applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Protection of the Environment Operations Act 1997 No 156 (Part 5.5) Outlines the enforcement of the regulations for the exposure to noise.</p> <p>Protection of the Environment Operations (Noise Control) Regulation 2017 Regulates the exposure to noise and sets limits.</p> <p>Weapons Prohibition Act 1998 No 127. (Schedule 2, Section 8) Prohibits the possession of laser pointer with an accessible emission level of greater than 1 mW.</p> <p>Summary Offences Act 1988 No 25 (Part 2, Division 2, Subdivision 2, Section 11FA) Prohibits people from being in custody of a laser pointer in a public place.</p>

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Table 7 (continued)

Jurisdiction	Radiation protection legislation
Northern Territory	<p>Radiation Protection Act 2004 and Radiation Protection Regulation 2007 (Part 2, Section 6(1)) Applies restrictions to non-ionising radiation apparatus listed in the National Directory for Radiation Protection (NDRP). This means that cosmetic UV tanning services are prohibited.</p> <p>Work Health and Safety (National Uniform Legislation) Act 2011 No 10 (Part 3) This part of the Act applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Work Health and Safety (National Uniform Legislation) Regulations 2011 (Chapter 5, Part 5.1, Division 7, Subdivision 3, Section 223) (Chapter 3) Regulates the use of lasers and laser equipment at a workplace, sets control measures, training requirements, and prohibits the use of some lasers.</p> <p>This part of the regulation applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Northern Territory Noise Management Framework Guidelines 2018 Set limit for the exposure to noise.</p> <p>Weapons Control Regulations 2001 (Schedule 1, Section 11) Prohibits the possession of laser pointer with an accessible emission level of greater than 1 mW.</p>

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Table 7 (continued)

Jurisdiction	Radiation protection legislation
Queensland	<p>Radiation Safety Act 1999(Part 2, Division 2, Section 17) (Part 7, Division 8, section 47A) The Act requires a person who possesses a radiation apparatus to hold a possession licence and a person who uses a radiation apparatus to hold a user licence. This applies to lasers used for cosmetic purposes.</p> <p>Prohibits cosmetic UV tanning services.</p> <p>Radiation Safety Regulations 2010 (Part 2, Division 1, Section 7) Regulates laser radiation apparatus that are used to carry out a diagnostic, therapeutic or cosmetic procedure involving the irradiation of a person and has an accessible emission limit of a Class 3B laser. The laser must comply with dose limits. Only a medical practitioner or a dentist can carry out therapeutic procedures using laser apparatus. There are also requirements for radiation safety and protection.</p> <p>Work Health and Safety Act 2011 (Part 3) This part of the Act applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Work Health and Safety Regulation 2011 (Part 5.1 Division 7, subdivision 3, Section 223) (Chapter 3) Regulates the use of lasers and laser equipment at a workplace, sets control measures, training requirements, and prohibits the use of some lasers.</p> <p>This part of the regulation applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Environmental Protection Regulation 2008 (Part 3) Regulates the exposure to noise.</p> <p>Environmental Protection (Noise) Policy 2008 Regulates the exposure to noise and sets limits.</p> <p>Coal Mining Safety and Health Regulation 2017 (Chapter 2, Part 13, Section 96) The regulation requires a standard operating procedure for laser emissions and other sources of harmful electromagnetic radiation, including solar radiation.</p> <p>Weapons Act 1990 (Part 4, Section 58 and 67) Prohibits the possession of Laser pointer with an accessible emission level of greater than 1 mW.</p>

(Table 7 continued over page)

Table 7 (continued)

Jurisdiction	Radiation protection legislation
South Australia	<p>Radiation Protection and Control (Non-Ionising Radiation) Regulations 2013 (Part 2, Division 1 and 2) Prohibits cosmetic UV tanning services.</p> <p>Work Health and Safety Act 2012 (Part 2) This part of the Act applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Work Health and Safety Regulations 2012 (Chapter 5, Part 1, Division 7, Section 223) (Chapter 3) Regulates the use of lasers and laser equipment at a workplace, sets control measures, training requirements, and prohibits the use of some lasers. This part of the regulation applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Environment Protection (Noise) Policy 2007 Regulates the exposure to noise and sets limits.</p> <p>Summary Offences Regulations 2016 (Part 2, Section 6Q). Prohibits the possession of laser pointers with an accessible emission level of greater than 1 mW.</p>

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Table 7 (continued)

Jurisdiction	Radiation protection legislation
Tasmania	<p>Radiation Protection Regulations 2016 and Radiation Protection Act 2005. (Part 10, Section 43) The act stipulates that optimisation and limiting of radiation doses (lasers) during therapeutic and diagnostic procedures must be in place. Users are to be licensed and the place where the radiation source is used to be registered. The regulations control for the use of lasers Class 3B and Class 4. Incoherent pulsed sources of electromagnetic radiation, in the wavelength range of 100 nanometres to 3000 nanometres are controlled.</p> <p>Public Health Act 1997 Prohibits cosmetic UV tanning services.</p> <p>Work Health and Safety Act 2012 (Part 2) This part of the Act applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Work Health and Safety Regulations 2012 (Part 4.8, Division 7, Subdivision 3, Section 223) (Chapter 3) Regulates the use of lasers and laser equipment at a workplace, sets control measures, training requirements, and prohibits the use of some lasers.</p> <p>This part of the regulation applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Environmental Management and Pollution Control (Noise) Regulations 2016 Regulates the exposure to noise and sets limits.</p> <p>Police Offences Act 1935 (Part 2, Division 2, Section 15F) Regulates the possession and use of laser pointers.</p>
Victoria	<p>Radiation Act 2005 No. 62 (Part 4, Section 23D) Prohibits commercial tanning practice</p> <p>Occupational Health and Safety Act 2004 (Part 3) This part of the Act applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Occupational Health and Safety Regulations 2017 (Part 3.5, Division 1, Section 74) Regulates the use of lasers and laser equipment at a workplace, sets control measures, training requirements, and prohibits the use of some lasers.</p> <p>Environment Protection Act 1970 (Part 8) Regulates the exposure to noise.</p> <p>Control of Weapons Regulations 2011 (Schedule 3, Section 33) Prohibits the possession of a laser pointer with an accessible emission level of greater than 1 mW.</p>

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Table 7 (continued)

Jurisdiction	Radiation protection legislation
Western Australia	<p>The Radiation Safety Act 1975 Regulates radioactive substances, irradiating apparatus and electronic products that are prescribed by regulation. This includes solariums for cosmetic purposes.</p> <p>Radiation Safety (General) Regulations 1983 (Part V, Division 1 and 2) The regulations require regulatory compliance of all new microwaves ovens sold and compliance with the regulations of commercial microwave ovens.</p> <p>The regulations apply safety requirements for the use of lasers including Class 1, Class 2, Class 3R, Class 3B and Class 4. These regulations applies to lasers used for cosmetic purposes.</p> <p>The regulations protect people who are occupationally or non-occupationally exposed and stipulate they shall not be exposed to 50/60 Hz electric and magnetic fields that exceed the limits specified in the publication titled <i>“Interim Guidelines on Limits of Exposure to 50/60 Hz Electric and Magnetic Fields (1989)”</i> published by the NHMRC in December 1989;</p> <p>or RF fields with frequencies from 3 kHz to 300 gigahertz (GHz) which exceed the limits specified in the publication titled <i>“Maximum Exposure Levels to Radiofrequency fields — 3 kHz to 300 GHz”</i> published by ARPANSA in 2002;</p> <p>or UV radiations with wavelengths from 180 nm to 400 nm which exceed the limits specified in the publication titled <i>“Occupational Standard for Exposure to Ultraviolet Radiation (1989)”</i> published by the NHMRC in December 1989 (please note this has been updated to the ARPANSA <i>“Occupational Exposure to Ultraviolet Radiation, Radiation Protection Series Publication No. 12”</i>).</p> <p>Occupational Safety and Health Act 1984 (Part3) This part of the Act applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Occupational Safety and Health Regulations 1996 (Part 4, Division 4, R 4.49) (Part 3) Regulates the use of lasers and laser equipment at a workplace, sets control measures, training requirements, and prohibits the use of some lasers.</p> <p>This part of the regulation applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Environmental Protection Act 1986 Regulates the exposure to noise.</p> <p>Environmental Protection (Noise) Regulations 1997 Regulates the exposure to noise and sets limits.</p> <p>Weapons Regulations 1999 (Schedule 2, 10AA) Regulates the possession and use of laser pointers.</p>

Table 8: National regulation for specific NIR exposure

Organisation	Radiation protection legislation
ACMA	<p>Radiocommunications (Electromagnetic Radiation — Human Exposure) Standard 2014 This Standard regulates the performance of particular radiocommunications transmitters to protect the health and safety of persons who may be exposed to electromagnetic radiation from such transmitters.</p> <p>Radiocommunications Licence Conditions (Apparatus Licence) Determination 2015 Regulates the conditions to which RF transmitter licences are issued and applies the limits of the ARPANSA Standard <i>“Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields – 3 kHz to 300 GHz”</i>.</p>
Comcare	<p>Work Health and Safety Act 2011 (Part 1, Division 2) The objective of the act in broad and may extend to protection against radiation exposure.</p> <p>Work Health and Safety Regulations 2011 (Chapter 5, Part 5.1, Division 1, Section 223) (Chapter 3) Regulates the use of lasers and laser equipment at a workplace, sets control measures, training requirements, and prohibits the use of some lasers.</p> <p>The regulation applies general protection to workers that may extend to protection against radiation exposure.</p> <p>Managing Electrical Risks in the Workplace Code of Practice (Part A, Section 2.1) Section 274 of the Work Health and Safety Regulations 2011 applies this code of practice. The code of practice regulates electromagnetic fields.</p>

(Table 8 continued over page)

Table 8 (continued)

Organisation	Radiation protection legislation
TGA	<p>Therapeutic Goods Act 1989</p> <p>Radiation including non-ionising radiation is likely regulated in this Act as a medical device or a therapeutic device.</p> <p>Australian regulatory guidelines for medical devices</p> <p>TGA states in these guidelines that they regulate the supply of radiating medical devices and cosmetic devices in Australia.</p> <p>Under these guidelines:</p> <p>Medical devices that use telecommunications must comply with the ACMA A-tick requirements and medical devices with radio communication transmitters (for example Bluetooth) must comply with the ACMA C-tick requirements.</p> <p>Different types of medical and surgical lasers are regulated.</p> <p>Therapeutic Goods (Medical Devices) Regulations 2002 (Schedule 1, Part 2, Section 12.5)</p> <p>Radiation including non-ionising radiation is likely regulated as a medical device or a therapeutic device.</p>
Australian Competition and Consumer Commission (ACCC)	<p>Intergovernmental Agreement For The Australian Consumer Law. (This is administered by the ACCC)</p> <p>This agreement regulates the safety of consumer products in all Australian states and territories. NIR devices and procedures may be regulated for under this agreement.</p>
Australian Border Force	<p>Customs (Prohibited Imports) Regulations 1956</p> <p>Prohibits the importation of laser pointers with an accessible emission level of greater than 1 mW</p>
Safe Work Australia	<p>Guide on Exposure to Solar Ultraviolet Radiation 2013</p> <p>The guide discusses UV exposure in general and outlines responsibilities of both employers and employees in the application of sun protection measures in the workplace.</p>

7. NIR risk assessment and management

7.1 Static and extremely low frequency electric and magnetic fields

Static ELF electric and magnetic fields are at the lower frequency end of the electromagnetic spectrum from 0 to 3000 Hz. Static fields at 0 Hz are naturally found in the earth's atmosphere including the geomagnetic field. Man-made static fields occur commonly in transportation, industry and medicine. ELF fields are mainly produced by the generation, distribution and use of electricity including power lines and common electrical appliances. There has been a lot of research on whether exposure to static and ELF fields cause any health effects. Most of the research indicates that exposure to static and ELF fields normally encountered in the environment does not pose a risk to human health. At high levels, there are established acute effects of static fields including vertigo and nausea (WHO, 2006). There is no established evidence that static fields cause long-term health effects and the International Agency for Research on Cancer (IARC) has classified static fields as not classifiable as to their carcinogenicity to humans (Group 3) (IARC, 2002). The only established health effects from ELF also occur at high levels and include electric shock and phosphenes in the eye. Some epidemiological studies have reported a possible association between prolonged exposure to ELF magnetic fields and increased rates of childhood leukaemia. This association is not supported by laboratory or animal studies and no credible theoretical mechanism has been proposed. Based largely on this evidence, IARC has classified ELF magnetic fields as possibly carcinogenic to humans (Group 2B) (IARC, 2002). Overall, the evidence related to childhood leukaemia is not strong and research in this area is continuing.

ICNIRP has developed guidelines for exposure to static magnetic fields and ELF to protect workers and the public against established health effects (ICNIRP, 2009, 2010). There is currently no national guidelines or regulations in Australia for static or ELF fields. The National Health and Medical Research Council (NHMRC) published in 1989 the *"Interim Guidelines on Limits of Exposure to 50/60 Hz Electric and Magnetic Fields"* that have since been rescinded. The Western Australia radiation regulations still require compliance with the 1989 NHMRC guidelines for both occupational and public exposure. Although there are no specific requirements to comply with the ICNIRP guidelines in Australia, ARPANSA lists them as international best practice for NIR protection (ARPANSA, 2019). The relatively low power of public sources of static and ELF fields means that overexposure to the public in the everyday environment is not possible. Occupationally some professions such as metal smelting and power supply workers can be overexposed. While there are no specific occupational exposure regulations in most states or territories, static and ELF fields could be treated as a general occupational hazard protected through Work Health and Safety regulations.

7.2 Radiofrequency Radiation

RF radiation covers the frequency range from 3 kHz to 300 GHz. RF is emitted from both natural and artificial sources. The artificial sources of RF that the public are most familiar with include telecommunication sources such as radio and television broadcasting Wi-Fi and mobile telephony, however, there are also medical, cosmetic and industrial sources of RF. The health effects from RF have been highly researched and the only established effect is heating of tissue, which can cause tissue damage. This effect occurs at high levels which are well above exposure limits set by international guidelines (ICNIRP, 1998) and the ARPANSA Standard (RPS3) (ARPANSA, 2002). At low levels of exposure to RF (those below the levels in RPS3) the evidence of production of harmful biological effects are ambiguous and unproven. Although studies have reported a range of biological effects at low levels, there has been no indication that such effects might constitute a human health hazard. In 2012, IARC classified RF as possibly carcinogenic to humans (Group 2B) (IARC, 2013). This classification was primarily based on evidence of an

association between wireless phone use and certain brain tumours. Research performed since has found no overall increase in the incidence of brain cancers since the introduction of mobile phones (e.g. Karipidis et al, 2018).

ACMA regulates public exposure to RF from telecommunication infrastructure and devices in Australia. The ACMA's regulatory arrangements require wireless devices to comply with the exposure limits in the ARPANSA RF Standard. Other RF devices that are encountered in the environment such as airport scanners or RF identification scanners while not specifically regulated in Australia only produce very low levels of RF which are much lower than the public limits set in RPS3. RPS3 also sets occupational exposure limits; however, the only jurisdiction that requires compliance with these limits is Western Australia. RF equipment that people can be occupationally exposed to includes telecommunication infrastructure, industrial heating and welding and certain medical devices. There are some Commonwealth regulations that apply to industrial and medical RF devices. While there are no specific occupational exposure regulations in most states or territories, RF could be treated as a general occupational hazard and protected through Work Health and Safety regulations. An example where general WHS regulations are applied is exposure to RF communication and radar systems in the Australian military. RF telecommunications are exempt under the ARPANS Act. However, the Department of Defence is required by Comcare to protect workers through general WHS regulations. Defence therefore adopts best practice, which is to apply RPS3 to protect military personnel.

7.3 Optical Radiation

Optical radiation comprises the wavelength range from 100 nm to 1 mm on the electromagnetic spectrum. It is divided into three broad categories; IR, visible and UV radiation.

7.3.1 Infrared

IR spans from 780 nm to 1 mm in the optical range. It is divided further into three sub- categories, IR-A IR-B, and IR-C, each of which have different biological effects. IR-A has the deepest penetration into biological tissue. The depth of penetration into tissue decreases with increasing wavelength through IR-B and IR-C. Exposures to IR increase the risk of cataracts and visual damage at the shorter wavelengths. Thermal stress and burns to biological tissue are possible from exposures to intense IR across the entire spectrum. ICNIRP provides international guidance for exposure to IR radiation from both incoherent sources such as industrial heating sources and coherent sources such as lasers. In Australia, regulation of IR sources is applied to lasers and intense light sources used for medical and cosmetic treatments through national standards adopted from the International Electrotechnical Commission (IEC). ARPANSA regulates and licenses the use of intense IR sources, such as high-powered lasers, by Commonwealth organisations. Tasmania, Western Australia, and Queensland regulate sources as controlled devices used in industry and cosmetics through dedicated radiation regulatory bodies using licensing systems. All other jurisdictions apply oversight through work health and safety bodies in occupational exposure situations.

7.3.2 Visible

Visible is defined between 380 nm and 780 nm (ICNIRP, 2019). The primary hazard from visible radiation is to the eye, even at some typical environmental levels from chronic exposures (e.g. reflection from water and snow). Strong sources of visible radiation, including lasers and ILS can also present an additional hazard to the skin, through photochemical and photothermal effects. Recently, there has been particular attention paid to the effects of blue light at low levels and effects on the circadian rhythm (sleep cycle) through

suppression of the secretion of melatonin (SCHEER, 2018). Blue light, at higher intensities, is associated with photochemical aging of the retina, leading to visual damage or blindness (ICNIRP, 2013). There is no evidence of carcinogenicity due to visible light exposure (ICNIRP, 2019). Visible radiation sources are regulated throughout Australia in the same way as IR sources, mostly being in the form of lasers and ILSS. In addition, all states and territories in Australia have restrictions on the power output of laser pointers (less than 1 mW) through weapons prohibition legislation. Higher powered laser pointers are permitted for special interest public groups such as astronomy associations and clubs with written permission from Australian Border Force and state or territory regulators (ASA, 2008; ABF, 2019).

Recently, there has been extensive research into the effects of white light produced from light-emitting diodes (LEDs) in home and office environments and lighting systems (e.g. car headlights and daytime running lights). Aside from the aforementioned circadian rhythm disruption of exposure to blue light, often a component of LED lighting, there have been implications concerning the health effects of LEDs. LEDs that incorporate temporal light modulation into their design, which results in flicker of the light source have resulted in reports of migraines and headaches and produced effects such as glare, distraction and dazzle (SCHEER, 2018). The Commonwealth Department of the Environment and Energy has made recommendations on exposure limits for flicker from LED lighting products (Department of the Environment and Energy, 2017).

7.3.3 Ultraviolet

UV occupies the wavelength range from 100 nm to 400 nm, with a 20 nm overlap between 380 and 400 nm in the visible region. Of all non-ionising radiations, UV is the only type known to cause cancer. Similar to IR, UV is divided into three regions, UV-A, UV-B and UV-C with different physical properties and biological effects. IARC classifies all sub-types of UV as a Group 1 carcinogen (IARC, 2012). Acute effects of UV exposure at high intensity are the result of photochemical interactions and may result in outcomes including erythema and Welder's flash (ICNIRP 2004). Long term eye exposure to UV increases the risk of cataract development.

Health standards, exposure and health effects advice are provided by ARPANSA. ARPANSA developed the protection standard specific to occupational UV exposure and applies it to its oversight of workers in the Commonwealth dealing with UV emitting devices. This standard is consistent with the position and guidance provided internationally by ICNIRP (ICNIRP, 2004)

Safe Work Australia has specifically developed national advice on exposure to solar UV, the Guide on Exposure to Solar Ultraviolet Radiation (SWA, 2013). The guide discusses UV exposure in general and outlines responsibilities of both employers and workers in the application of sun protection measures. Risk assessment principles are outlined and there is also information available on increased risk factors such as exposure to photosensitising agents. The risk reduction measures are discussed in reference to their effectiveness as mitigation strategies through the work health and safety risk management hierarchy of control principles. This general model is also applied at the jurisdictional level throughout Australia. The WHS laws governing work health and safety legislation and regulation in Australia have been implemented in all jurisdictions except Victoria and Western Australia; Western Australia is currently consulting on options to implement elements of the model. In Victoria solar UV protection is governed by Victorian Health and Safety Legislation.

Cancer Council Australia are partners to non-government organisations that lead cancer prevention, research and support in Australia. Each Australian jurisdiction also hosts a state or territory specific Cancer Council. The Cancer Councils provide messaging on cancer prevention through SunSmart advice including

sun protection behaviour and protection measures such as shade, sunscreen, protective clothing and sunglasses. They also provide information on skin cancer and conducting self-checks. Cancer Council Australia promote advocacy through developing policy on prevention, early detection, clinical practice and supportive care. They may also make submissions to government on behalf of their stakeholders.

Commercial solaria were banned from operating in every Australian state and territory by January 2016 (ARPANSA, 2019). The tanning beds used in these services had the potential to expose the user to very high levels of UV (Gies et al, 2011). However, the national ban on commercial services does not apply to the personal use of tanning beds or their import into Australia.

7.4 Ultrasound and Infrasond

Ultrasound is a mechanical form of energy transfer. Unlike radiation on the electromagnetic spectrum, ultrasound relies on a medium to facilitate energy transfer (e.g. air, water). It is defined as acoustic energy above a frequency of 20 kHz (HPA, 2010). Like all sound energy, there is a risk of hearing damage or loss at high environmental intensities of ultrasound. There have also been subjective reports of symptoms including tinnitus, nausea, headaches and fatigue. In situations where highly focussed ultrasound is used for interventional or aesthetic applications, deposition of high amounts of energy into tissue can lead to localised effects including burns, edema and pain. Infrasond consists of acoustic energy below 20 Hz (HPA, 2010). There is international guidance on the safe use of ultrasound in medicine by the World Federation for Ultrasound in Medicine and Biology (WFUMB, 2019), which has been adopted by the Australasian Society for Ultrasound in Medicine (ASUM, 2018). Infrasond can cause audio damage at high intensities and can be a source of annoyance if intense enough to be audible. Adverse health effects from long term exposure to infrasond from sources such as wind turbines have been studied, however, there has been no evidence of any biological effects (HPA, 2010). International guidance on airborne ultrasound was developed by the International Radiation Protection Association (the predecessor of ICNIRP) and remains relevant for protection against environmental and occupational ultrasound currently (IRPA, 1984). There are no international standards or guidance for infrasond exposure. Further, there are no general national standards in Australia for either ultrasound or infrasond exposure.

7.5 Cosmetics

Cosmetic applications of NIR (e.g. hair and tattoo removal, skin rejuvenation, body sculpting, etc.) cover a wide range of exposures depending on the modality. The most common cosmetic devices emit optical radiation and consist of lasers and various intense light sources (e.g. IPLs), however, other devices employ the use of ultrasound, RF and ELF to deliver the desired cosmetic outcome. Regardless of the modality, cosmetic treatments with these devices always result in NIR overexposure to targeted tissue in order to ensure efficacy of treatment. There is therefore always a risk of adverse health effects from these treatments which may include burns, erythema, edema and skin pigmentation changes (Husain and Alster 2016, Gadsden et al 2014, Hitchcock and Dobke 2014).

Currently, Tasmania, Western Australia and Queensland regulate the cosmetic use of lasers through various licensing and qualification requirements while IPLs are only regulated in Tasmania. ARPANSA published advice in 2019 for the use of optical cosmetic devices (ARPANSA, 2019). There are no regulatory frameworks or general safety standards in place within Australia for cosmetic devices which employ other modalities.

8. Benefits from NIR exposure

The discussion about NIR exposure often focusses on the possible detriment but potentially ignores the benefits (Wood and Karipidis, 2017). Unlike ionising radiation, there are several established benefits from exposure to natural NIR. The primary source of NIR is from the different components of solar radiation (ICNIRP, 2019).

IR, also known as thermal radiation, provides the necessary energy to keep our planet within an appropriate temperature range to sustain life. Visible radiation, allows us to interpret our environment through visual processing and is essential for photochemical reactions, most importantly photosynthesis, to occur. Short wavelength visible radiation also regulates our circadian rhythm process, helping the body's endocrine functions regulate sleep patterns (SCHEER, 2018). UV has important biological functions, most importantly for synthesis of vitamin D in the human body (Wood and Karipidis, 2017).

Man-made exposure to NIR has resulted mainly from introducing technology and services throughout society. Exposure to NIR in these cases is not the source of direct benefit, more, it is an unavoidable by-product of enabling the use of the beneficial technological or service. The most obvious everyday benefits of these technologies include communications (RF), power generation (ELF) and artificial lighting sources for homes and offices (visible radiation).

We cannot eliminate NIR from our environment and there are clear benefits from its existence and use (Wood and Karipidis, 2017). We should not ignore the real dangers of NIR exposure and should mitigate any risks; however, greater importance needs to be placed on the net benefit of mitigating risk (e.g. noting that by reducing the risk you may also be reducing the benefit).

9. Perception of NIR risk

In contrast to ionising radiation, there is no established evidence of long term health effects from exposure to NIR (with the exception of UV) (ICNIRP, 1998; WHO, 2007). Acute effects have been shown to occur only at very high levels of NIR exposure. However, risk perception around exposure to NIR has been observed to be complex and polarising in terms of opinions regarding health consequences and the choices individuals make for protective behaviour.

Figure 1 shows the number of inquiries received by ARPANSA regarding radiation exposures during January 2017 – June 2019 for a range of topics. It is evident that enquiries regarding ELF and RF dominate public exposure concern, especially when the sources are not within an individual's control (telecommunications antennas, and electrical distribution infrastructure). This relationship becomes more apparent when taking into account that inquiry numbers reduce when RF exposure is due to controlled behaviour such as using mobile phones or controlled environments with Wi-Fi. There are also fewer enquiries relating to NIR sources that are known to be hazardous i.e. optical sources. The trend of received inquiries declines significantly as exposure to NIR becomes more hazardous towards optical sources. This clearly shows a higher risk perception where science has not demonstrated a hazard from the exposure and more acceptance or even complacency where effects have been shown.

UV has been established to cause both acute and long term health effects from normal environmental exposures to solar radiation, yet there has been a great need for public advocacy programs to reduce complacency around exposure and promote sun protection behaviours for members of the public to avoid these exposures (IARC, 2012 and Cancer Council Australia, 2019). Conversely, Table 5 has shown exposure to levels of RF or ELF radiation that may cause acute effects are rare in occupational settings and virtually impossible for members of the public. Further, extensive and ongoing scientific and health research have not established a link to long term health effects from low level exposures to these radiations. Despite the body of available scientific evidence, there is a high level of activity from various public activist groups and scientists that do not agree with the mainstream view (Bioinitiative Working Group, 2012). This has been particularly apparent for exposures to RF from mobile telecommunications devices and transmission sources. Another influencing factor may be that, unlike solar UV, ELF and RF sources represent a major difference in the NIR exposure profile due to their artificial origin and ubiquitous presence in modern society.

Overall, for occupational exposure to NIR, work health and safety procedures offer strategies and protection against known hazards through various methods of risk mitigation. Consequently, it is plausible that exposure to NIR is generally accepted as a controlled part of the occupation that the worker is aware of. In this case, the greater perception of risk is due to the possibility of overexposure. For public exposure to NIR, the perception of risk indicates an inverse relationship with the known health issues related to the exposure. This may be explained by an individual's lack of control over the exposure and the body of conflicting reports regarding health effects that are freely accessible to the broader community (NZ Ministry of Environment and NZ Ministry of Health, 2000).

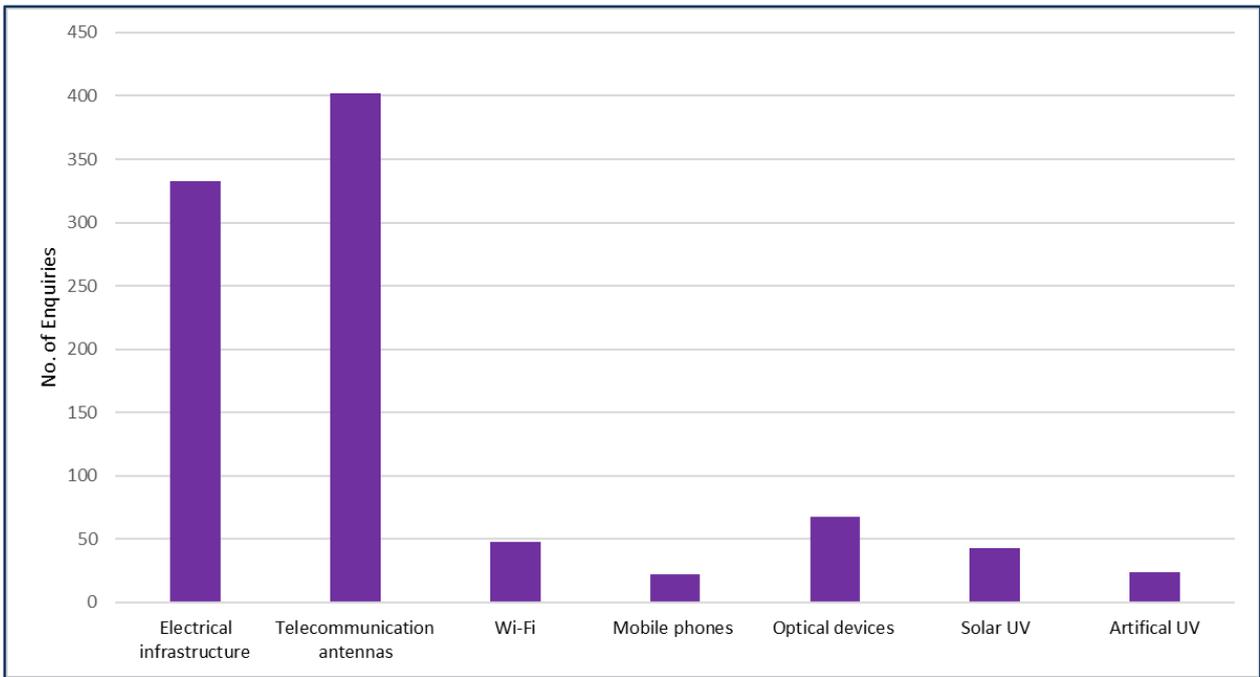


Figure 1: Non-ionising radiation inquiries received by topic during January 2017 – June 2019

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