JOINT TRAUMA SYSTEM CLINICAL PRACTICE GUIDELINE

Suspected Radio Frequency Electromagnetic Field Overexposure

This CPG provides information and instructions for medical providers responsible for military service members following suspected acute radio frequency electromagnetic field overexposure.

CONTRIBUTORS

CDR Hong Gao, MSC, USN
LCDR Jason P. Cole, MSC, USN
LCDR Tavis O. Landry, MC, USN
LCDR Jeffrey D. Biberston, MC, USN
Stephen B. Guetersloh, Ph.D.
Sylvain Cardin, Ph.D.
William J. Erwin, Ph.D.
Capt Isabella M. Muffoletto, USAF, BSC
Capt Joshua A. Benda, USAF, BSC
Edward R. Kelly
Roel F. Escobar
William B. Voorhees
COL Kenney H. Wells, MS, USA
Randolph Stone II, Ph.D.
Romeo J. Gallamoza
CAPT Matthew D. Tadlock, MC, USN
Lt Col Remealle A. How, USAF, MC
LCDR J. Michael Van Gent, MC, USN
COL Jennifer M. Gurney, MC, USA

Publication Date: 12 Jul 2024

TABLE OF CONTENTS

Suspected Radio Frequency Electromagnetic Fields (RF-EMF) Overexposure

Overexposure Effects

- Bulk tissue heating with > 5MHz frequencies
- Painful sparks with < 5MHz frequencies

Penetration Depth

- Superficial (frequencies >3GHz) → burns/eye damage
- Deep (frequencies <3GHz) → heat exhaustion, heat stroke, localized tissue damage due to hyperthermia

RF-EMF health effects are NOT cumulative

RF-EMF Emitting Sources
- Communications
- Navigation
- Radar
- Directed energy weapons
- EM countermeasures

Common symptoms
- Warm sensation
- Pain
- Sweating
- Skin burns

Suspected RF Injury
- First treat life-threatening conditions
- Teleconsultation with 711 HPW/PATH/HELP

Treatment & Disposition

Burns
- Majority of RF-EMF burns heal on their own with no intervention
- 2nd and 3rd degree burns with TBSA >20% - Acute fluid resuscitation per protocol
- Wound care per Burn CPG

Hyperthermia
- Monitor/treat for heat exhaustion
- Monitor/treat heat stroke

Ocular Injuries
- Standard of care for keratitis, hemorrhage, optic nerve injury

Neuropsychological symptoms
- No established causal relationship between RF EMF and TBI
- Rule out TBI from other causes

Persisting symptoms /neurological complaints need urgent evacuation

Reporting Requirements

- Incident facility/vessel
- Individual involved
- Describe incident
- List likely causes
- Distance from emitting source
- Exposure duration
- Which body part vs whole body affected
- Severity of incident: critical, major, minor
- Medical action taken

Incident Reporting

1. Chain of Command
2. DoD EMF Hotline: ESOH Service Center
   (800) 473-3764; Comm (937) 938-3764
   DSN 798-3764; esoh.service.center@wpafb.af.mil

METRICS

Document comprehensive medical evaluation ASAP after exposure:
- type of RF-EMF injury
- severity
- treatment
- outcomes

This information is pulled from the evidence-based Joint Trauma System (JTS) Suspected Radiofrequency Electromagnetic Fields Overexposure Clinical Practice Guideline (CPG). JTS CPGs can be found at the JTS CPG website or the JTS Deployed Medicine site.

KEY POINTS

- Awareness of the potential adverse health effects of Radio Frequency Electromagnetic Fields (RF-EMF) overexposure is critical for all deployed medical providers.
- Early treatment is essential to maximize recovery. Overexposed service members require comprehensive evaluation by a medical provider as soon as possible.
- The most common symptoms are sensation of warmth potentially escalating to pain, profuse sweating, and skin burns if the exposure dose is sufficiently high.
- Life-threatening medical emergencies, permanent injury to the eye and visual system are less common.
- Service members with persistent symptoms or worsening neurological complaints require priority medical evacuation.
- Medical treatment for injuries from RF-EMF overexposure are like the same injuries from other causes.
- Treatment recommendations and proper patient management depend on consistent and timely documentation and reporting of RF-EMF overexposures and injuries.
- Unlike with ionizing radiation, health effects from RF-EMF exposures are not cumulative.

INTRODUCTION

Acute Radio Frequency Electromagnetic Field (RF-EMF) overexposures pose safety hazards to service members. Overexposures caused by RF-EMF emitting sources (e.g., navigation or radar systems, electromagnetic countermeasures, or Directed Energy EMF Weapons) can compromise essential military functions.[1]

An overexposure is defined as exposure to RF-EMF radiation in excess of Exposure Reference Level (ERL) limits at which harmful health effects may occur. Because the ERL limits also have a built-in safety margin, a relatively low amount of overexposure may not result in bodily injury; but the probability of injury increases with rising exposure dose above the ERL limits.[2,3]

The goals of this clinical practice guideline are to review potential injuries and adverse health effects related to RF-EMF overexposure at frequencies between 100 kilohertz (kHz) and 300 gigahertz (GHz), and to establish a clinical care guideline for first-line medical responders and military health care providers. Care for overexposures to frequencies outside of this range (e.g., electric shock or contact burns) will not be addressed by this CPG.

This CPG was developed based on expert consensus to include key elements of the service member's medical history, examination, disposition, and medical record coding following RF-EMF overexposure. In general, early recognition and treatment of potential injuries are essential to maintain optimal treatment outcome. Timely reporting is vital to assess operational impact and carry out additional medical evaluation and care.

BACKGROUND

Life exists in the presence of electromagnetic radiation, natural or man-made. The sun is a major source of natural ionizing and non-ionizing electromagnetic radiation. Although the earth's atmosphere shields people from most ionizing radiation (e.g., x-rays and gamma rays), we are routinely exposed to non-ionizing electromagnetic radiation. Natural non-ionizing electromagnetic radiation can be categorized into ultraviolet, visible light, infrared, and radio frequency radiation.

Technological advancement has resulted in increasing amounts of non-ionizing radio frequency electromagnetic radiation from man-made sources (e.g., high-voltage power lines, TV and radio broadcasts, mobile phones, microwaves, or satellite signals).[4] Military service members may encounter additional duty-related RF-EMF devices.

In response, the Department of Defense (DoD) and the North Atlantic Treaty Organization have been evaluating potential health and safety impact of human exposure to emissions of RF-EMF systems that we develop or use.[5] DoD Instruction 6055.11, Protecting personnel from electromagnetic fields, May 12, 2021 also established guidelines and policies for protecting personnel in military environments from overexposure to electromagnetic fields between the 0 hertz (Hz) and 300 GHz frequency spectrum and directs DoD components to follow the Institute of Electrical and Electronics Engineers (IEEE) Standard C95.1-2345 for ERL limits (Appendix A).[3,6]

The IEEE established two military exposure environments (i.e. restricted and unrestricted) that can be further divided into three zones. Zone 0 applies to unrestricted environments and Zone 1 and Zone 2 apply to restricted environments.[3] Appendix A shows IEEE safety exposure limits for Zone 0 and Zone 1.[3] Aboard Navy ships, for example, high-power RF-EMF emitters (e.g., antennas below 100 MHz) can induce current through human body when in close proximity.[7] The US Navy defined almost all topside of a ship as restricted "controlled" areas whereas RF-EMF radiation risk mitigation, protection, and management are essential for military operations.

Examples of military RF-EMF emitting sources are listed below based on application categories:[8]

- **COMMUNICATIONS:** Military Auxiliary Radio System, Combat-net radio, Land Mobile radio, airborne and ground DataLink or terminal, satellite communication terminal, tropospheric scatter system, wireless local area network, or AM and FM broadcast station.
- **NAVIGATION:** fixed navigation systems such as VHF Omni-Directional radio, Tactical Air Traffic Navigation, or Instrument Landing System; airborne systems such as radar altimeter, doppler radar, or terrain-following radar.
- **RADAR:** air defense ground-based radar, airport surveillance radar, counter-battery radar, synthetic aperture radar, moving target indicator, height-finding radar, fire control radar, side looking radar, weather radar, or mapping radar.
- **ELECTROMAGNETIC COUNTERMEASURES:** electronic countermeasures, threat recognition system, counter-Improvised Explosive Device equipment, or radio and radar jammers.
- **INDUSTRY/COMMERCIAL:** RF welders or heat sealers, RF induction heating, plasma processing, or microwave heaters.
- **MEDICAL:** MRI, RF diathermy, patient monitors, cauterization electrosurgery, and interstitial microwave hyperthermia.
- **DIRECTED ENERGY WEAPONS:** the Active Denial System, Vigilant Eagle, the Tactical High-power Operational Responder, and the Counter-electronics High-power microwave Advanced Missile Project.

Historically, RF-EMF overexposures were less common in military environments and most reported cases were below exposure limits (see Clinical Scenarios below).[9,10] Over the nine-year period from 2014 to 2022, the U.S. Air Force reported and investigated 126 suspected cases

CLINICAL SCENARIOS

CASE 1. A worker and supervisor were overexposed to electromagnetic countermeasures (ECM) pod radiation at an electronic warfare maintenance facility. The worker turned on an ECM pod without its required Radiofrequency Termination Hat (RTH). The supervisor noticed the problem upon entering the room and immediately placed the RTH on the ECM. The supervisor had approximately 30 seconds overexposure that resulted in 1st degree burns (i.e., skin reddening) to the left ear and face. The worker reported feeling nausea with no thermal injury. Investigator determined that the applicable ERL was exceeded by more than a factor of 10 based on physical signs and symptoms of the two individuals.

CASE 2. A service member was performing routine maintenance on a Patriot ground-based radar during a field training exercise. The service member worked directly in front of the radar for 10-15 minutes before learning that the radar was on and active. The service member moved away from the radar and reported profuse sweating, metallic taste, nausea, vomiting, headache, and blurred vision. Symptoms resolved and the Soldier was discharged the next day. Investigator calculated the exposure exceeded the ERL by a factor of 10.

CASE 3. A worker walked past a cordon, which was located 120 ft and 60 degrees away from the cone of a running F-16 radar (i.e. AN/APG68). Then, the worker walked toward the F-16 radar at ~100 ft from the cone before turning back out of the cordon. The exposure duration was 3-5 seconds. Calculated power density was 9.44 W/m2 at 100 ft, which was below the ERL. The worker reported feeling warm and headache. Symptoms resolved with no further effects.

among 38,000 personnel who routinely worked closely with high-power RF-EMF emitters.[10] Only one patient had EMF-related injury confirmed by these investigations.[10]

HEALTH EFFECTS OF RF- EMF OVEREXPOSURE

MECHANISM

Potential hazards associated with RF-EMF depend primarily on frequency, exposure duration, and incident power density (i.e. power per unit area).[11] The only consensus mechanism for adverse health effects from exposure to RF frequencies > 5 megahertz (MHz) is bulk tissue heating. RF energy is absorbed by the body and converted to heat at a rate and distribution primarily determined by the oscillating frequency and incident power density of the exposure, along with geometrical considerations (e.g., incident angle, polarization of the energy, body posture and morphology). In contrast, overexposures below 5 MHz may result in painful spark discharges. Unlike with ionizing radiation, cumulative health effects do not occur at RF frequencies (100 kHz - 300 GHz).[3]

PENETRATION DEPTH

The depth that the energy penetrates the body before being absorbed is a function of RF frequency and physical properties of the tissue (i.e. tissue penetration depth is inversely related to RF frequency). Thus, overexposure injuries will be more "superficial" in nature at higher RF frequencies, and more "whole body" in nature at lower RF frequencies. For example, the penetration depth of a 3 GHz exposure on human skin is approximately 19 mm (with relatively similar values for other tissue types) so that the primary adverse health effect for > 3 GHz overexposures will be skin burns and eye damage.[12-15]

Between 100 kHz and 3 GHz (i.e. < 3 GHz), however, RF energy can penetrate deeper (i.e. > 19 mm). Potential systemic adverse health effects of overexposure include heat exhaustion and heat stroke, and partial body exposures could result in localized tissue damage due to hyperthermia.

BELOW EXPOSURE LIMITS

Because RF-EMF hazards follow a dose response relationship, adverse health effects should not be expected with doses below the safety limits. Few RF-EMF health effects were documented and characterized below exposure limits.[16] In 2020, the U.S. Food and Drug Administration (FDA) concluded "insufficient evidence to support a causal association between RF radiation and tumor formation."[17] The National Toxicology Program has not included RF-EMF radiation in the Report on Carcinogens.[18]

For effects on testes, one of the most sensitive organs to RF-EMF exposures, Grajewski et al. observed minor semen quality and hormonal change among 12 industrial RF heater operators.[19] Yet, a recent meta-analysis of pooled human cross-sectional studies showed no significant association of mobile phone use and decline in sperm quality.[20,21]

The microwave auditory effect, described by subjects as hearing a "click, buzz, hiss, knock, or chirp" sound from pulsed RF energy, led to the development of the thermoelastic expansion theory.[22] A computational model suggested that theoretically, thermal expansion could be induced in the human brain by extremely high-power (> 15 MW/m2), pulsed RF-EMF sufficient to cause neuropathological effects.[23,24] These pulses would be less than 50 microseconds in duration so despite the high instantaneous power densities would be well below the safety standard. It has been speculated that this could result in audio vestibular and cognitive symptoms (e.g., ear popping, vertigo, pounding headaches and nausea).[25] However, this effect has not been observed in any confirmed human RF exposures nor has a repeatable effect been observed in animal studies.[26] There is currently no well-established scientific evidence of a causal relationship between RF-EMF radiation and TBI. This CPG will be updated if such scientific evidence emerges.

ABOVE EXPOSURE LIMITS

The Standard for Military Workplaces includes a 50X safety margin for unrestricted and a 10X safety margin for restricted military environments (Appendix A).[3] Additionally, the safety standard is based on the levels required for subtle behavioral change in animals and not on human adverse health effects. As a result, most overexposure incidents may not result in

adverse health effects. With increasing dose above the standard, however, the risk and severity of adverse health effect will increase.

RF health effects continue to be investigated under an international EMF project sponsored by the World Health Organization (WHO).[27] Most studies were performed using cell or animal models.[28-30] These studies provided basic information on biological effects of RF-EMF overexposure, but how to effectively apply the study results to humans are yet to be determined.[20] Further epidemiological studies are needed to confirm possible long-term biological effects of RF-EMF exposure to humans.

POTENTIAL ACUTE HEALTH EFFECTS

Overexposure to RF-EMF may result in various acute health effects:

1. Skin heating effects that induce skin burns;
2. Thermal effects that increase body temperature;
3. Electro-stimulatory effects that cause painful nerve impulses; and
4. interaction with medical devices or metallic implants.[3,8,22,25,31]

Proper medical documentation and prudent RF-EMF incident reporting are essential for proper diagnosis and management of patients with RF-EMF overexposure.

In the U.S. Air Force, most reported cases had no or mild signs/symptoms (see clinical scenarios).[10] In the few cases resulting in injury, Erwin et al observed skin burns and profuse sweating were common while other symptoms, such as nausea, were found to be nonspecific to RF-EMF overexposure.[10] Heat exhaustion and heat stroke may occur when thermoregulation becomes inefficient at high RF-EMF heating levels.[16]

The safety standard may not protect Service members with implanted medical devices.[3,32] Medical assessment and screening for implanted medical devices (e.g., metallic contraceptive implants, artificial joints, surgical screws, stents, implanted drug infusion pumps, etc.) are vital.

OCULAR INJURIES

High dose RF-EMF radiation has been documented to induce ocular injures in non-human primates and rabbits.[33,34] Liu et al. reported a case of bilateral vision loss in human due to optic nerve damage from misuse of a medical device at 90 to 580 kHz RF radiation.[35] However, Adibzadeh et al. observed no serious acute ocular injuries in 16 patients undergoing treatment of cancer in the head and neck region by hyperthermia induced by prolonged (60 min) and intense exposure of 434 MHz RF-EMF radiation.[36] In general, the presence and extent of eye damage will be frequency and dose dependent and can be substantially mitigated by facial aversion and the blink reflex.[37] Because eye damage is possible at sufficiently high doses, comprehensive eye exam is recommended as a part of the initial medical evaluation for patients with ocular or visual complaints.

SIGNS & SYMPTOMS OF RF- EMF OVEREXPOSURE

Although non-specific to RF-EMF overexposure, any combination of the following signs and symptoms may be related to the incident:

1. Sensation of warmth, perspiring, and/or intense heating of the exposed body part(s).
2. Skin erythema – reddening of the skin.
3. Shocks and burns.
4. Pain, neuropathy, or any sensory injury of the peripheral or central nerve system, e.g., oversensitivity to touch.
5. Headache, lethargy, concentration, dysesthesia, paresthesia, numbness, balance, or tinnitus.
6. Malaise – an overall sense of feeling unwell (mentally or physically).

7. Labored breathing.
8. Nausea, diarrhea.
9. Visual phosphenes, sensitivity to light, blurred vision, keratitis.
10. Transient reduced sperm count.
11. Compartment syndrome – internal heating without obvious burns, thrombosis.
12. Signs and symptoms Post-Traumatic Stress Disorder (PTSD).

EVALUATION OF SUSPECTED INJURY

1. Address any life-threating medical conditions first as directed by Tactical Combat Casualty Care guidelines.
2. Documentation to include:
    - Incident facility: shore-base, harbor facility, vessel at harbor, or vessel at sea, etc.
    - Individual(s) concerned or involved in the incident.
    - Description of the incident.
    - Likely cause(s):
        - Suspected vs. confirmed exposure
        - Type of emitter
        - Transmission power (average and peak power)
        - Estimated average power density incident in the individual
        - Transmission frequency
        - Mode: continuous vs. pulse
    - Exposure duration.
    - Distance from emitting source.
    - Which body part or whole body affected.
    - Severity of the incident: critical, major, or minor.
    - Medical action taken.

    NOTE: *exposure data above may be obtained from the operator(s) of the RE-EMF device/system in question. Contact unit Safety Officer or Bioenvironmental Engineers for additional information as needed.*
3. Physical examination
    - Record and evaluate symptoms (e.g., anxiety, warmth, fatigue, headache, nausea, vomiting, pain, etc.) and any implantable medical devices.
    - Vital signs.
    - Based on initial medical evaluation and overexposure incident investigation/verification, medical providers may consider additional systems-based medical evaluation of potential injury.
        - Neurologic exam and testing for any significant neurologic symptoms or possible injury to the peripheral or central nervous system.
        - Assess and document visual function of each eye, such as visual acuity, pupil, eye lids/lashes, cornea, conjunctiva, iris, lens, vitreous, retina, and optic nerve.
        - Electrocardiogram (EKG).

- Laboratory testing.
- Emergency care testing and evaluation required if suspecting compartment syndrome (e.g., pain, swelling, paleness in the limb and sensory loss signs, etc.). For additional information, refer to JTS Acute Extremity Compartment Syndrome and the Role of Fasciotomy in Extremity War Wounds CPG.

4. Initial evaluation of acute injuries due to thermal burns.
   - Estimate total body surface area (TBSA) burned using the "Rule of Nine":
     - Head and neck: 9%
     - Front and back of each arm and hand: 9%
     - Chest: 9%
     - Stomach: 9%
     - Upper back: 9%
     - Lower back: 9%
     - Front and back of each leg and foot: 18%
     - Genital area: 1%
   - Grading:
     - Superficial burns (1st degree) appear red, do not blister, and blanch readily. (Note: Superficial 1st degree burn should be excluded from TBSA calculation.)
     - Partial thickness burns (2nd degree) are moist and sensate, blister, and blanch.
     - Full thickness burns (3rd degree) appear leathery, dry, non-blanching, are insensate and often contain thrombosed vessels.
   - When the patient is stable and the wounds are cleaned/debrided, re-calculate burn size using the Lund-Browder charts. For additional information, refer to JTS Burn Care CPG.

TREATMENT

Initial treatment guidance for suspected RF-EMF overexposure is limited and mostly comprise of symptomatic care. Treatment of service members with suspected acute RF-EMF injury should consider the following interventions (if not otherwise contraindicated):

BURNS

- Superficial. Majority of RF-EMF skin burns will heal on their own without further intervention. However, medical providers may consider the following steps:
  - Cooling the burn is effective if performed within 20 minutes of the injury. For small size of superficial burns, immersion, or irrigation with running tepid water (15°C) for up to 20 minutes may reduce pain and edema.

    *(**NOTE**: Iced water should not be used as intense vasoconstriction can cause burn progression. Cooling large areas of skin rapidly may lead to hypothermia.)*
  - Analgesia – non-steroidal anti-inflammatory drugs such as ibuprofen.
  - Apply antibiotic ointments for mild open wound burns.
  - Hydration – encourage patients to drink plenty of water.
  - Monitor.
- 2nd- 3rd degree burns with a TBSA ≥ 20%. The patient typically requires acute fluid resuscitation for 24-48 hours and close observation for 72 hours after the incident.

For additional information, refer to JTS Burn Care CPG.

HYPERTHERMIA

- Temperature monitoring:
  - Minimum: Scheduled temperature measurement with vital sign evaluations.
  - Better: Continuous forehead dot monitoring.
  - Best: Continuous core temperature monitoring.
- Monitor for signs and symptoms of heat exhaustion – if present:

  Immediately replace fluids and electrolytes via oral or intravenous (IV) routes depending on acuity and level of consciousness.
- Monitor for signs and symptoms of heat stroke – if present:

  Immediately initiate cooling: place the patient under a cool environment, wetting clothing, fanning after wetting clothing, immersion in water, or apply ice packs (if available) to armpits, groin, neck, and back.
- Maintaining hydration, adding salt to food and/or electrolyte replenishing drinks, resting in shade, staying off hot surfaces (ground or vehicle).

For additional information, refer to JTS Prolonged Casualty Care Guidelines CPG.

OCULAR INJURIES

- Initial treatment guidance for suspected ocular injury from RF-EMF overexposure is limited.
- Readily identifiable injuries such as keratitis, hemorrhage, optic nerve injury should be treated using current standards in coordination with an eye care provider.

For additional information related to eye injuries, refer to JTS Eye Trauma: Initial Care CPG.

NEUROPSYCHOLOGICAL SYMPTOMS

- There is no established causal relationship between RF-EMF overexposure and TBI. For patients with "TBI-like" neuropsychological symptoms, rule out TBI from other causes and refer to JTS Traumatic Brain Injury Management in Prolonged Field Care CPG for neurological assessment and care.
- Treat any additional signs/symptoms (e.g., nausea, vomiting, headache, etc.) following standard of medical care.

TELECONSULTATION SERVICE

The USAF 711th HPW Radiation Consulting Group (DCPH-D/OEC) offers onsite/telephone assistance for EMF injuries, surveys and/or questions. To request support, please email or call the ESOH Service Center.

*(**NOTE**: The ESOH Service Center has 24/7 manning on the phone, but medical guidance is available by reach back.)*

- Defense Health Agency Global Teleconsultation Portal: https://GTP.health.mil (NOTE: Account registration is required prior to consultation.)
- ADVISOR Line 833-ADVSRLN (833-238-7756) DSN 312-429-9089

ESOH Service Center
Toll Free 1-888-232-ESOH (3764)
Commercial (937) 938-3764
DSN 798-3764
DoD EMF Injury Hotline 1-800-473-3764
Email: esoh.service.center@us.af.mil

DISPOSITION

FLIGHT SURGEONS

- Follow service-specific guidelines for aviation personnel.
- Aviation personnel are only to be returned to duty in accordance with service-specific aviation guidelines from the above references and local SOPs.

FORWARD PROVIDERS

- Service members with exposures that return to baseline function (with no new or persistent defects) within 2-4 hours may be returned to full duty without restrictions as long as the service member meets current service-specific standards.
- Full documentation and incident reporting is required for incidents with transient or visible symptoms as well as suspected body injuries.
- Non-aviation personnel may return to duty when body function returns to baseline and allows for effective execution of MOS-specific duties and operational requirements.

FOLLOW-UP CARE

Schedule follow-up care with unit Radiation Safety Officer, Occupational Medicine physician, and/or medical specialists as needed.

MEDICAL CODING

The following ICD-10 coding guidance is recommended for RF-EMF overexposures. This guidance is designed to standardize coding across the MHS for EMF related encounters. Proper documentation and coding of these events allows for optimal tracking and analysis to inform and evaluate treatment recommendations. Uniform and consistent medical documentation and coding is essential to proper surveillance and research efforts.

Table 1. ICD-10 coding guidance for RF-EMF overexposures.

Diagnostic Position	ICD Code	Comments
Principal/First listed Diagnosis	Initial symptoms (headache, dizziness, cognitive impairments, tinnitus, nausea, blurred vision, etc.)	Allows for tracking duration/resolution of symptoms longitudinally
Second Diagnosis	Anatomic findings (e.g., burns-degree, size, location)	Allows for documentation and tracking of injuries longitudinally
Third Diagnosis	W90.0 Exposure to radio frequency nonionizing radiation	ICD-10 codes in the range V00-Y99 describe the cause

INCIDENT REPORTING

1. Notify Chain of Command at the earliest level possible. Upon examination, if the medical facility suspects or confirms the overexposure, contact the injured person's commander or supervisor.
2. Notify the DoD EMF Hotline as soon as time and circumstances permit: Medical personnel can coordinate medical guidance and reporting for RF-EMF injuries from the DoD EMF Injury Hotline through the ESOH Service Center, (800) 473–3764, commercial (937) 938–3764, DSN 798–3764, or email esoh.service.center@wpafb.af.mil (currently manned 24/7)

PERFORMANCE IMPROVEMENT MONITORING

POPULATION OF INTEREST

All patients with RF-EMF overexposures or injuries.

INTENT

The intent is for the Joint Trauma System to monitor performance improvement (PI) of this CPG that includes the following patient categories:

1. Patients in the population of interest are identified as having RF-EMF overexposure.
2. Patients in the population of interest undergo comprehensive medical evaluation as soon as possible after exposure events.
3. Patients in the population of interest have complete documentation of type of RF-EMF injury, severity, treatment, and outcomes.

PERFORMANCE METRICS

1. Number and percentage of patients in the population of interest with documented comprehensive medical exam.
2. Number and percentage of patients in the population of interest with complete documentation of type of RF-EMF overexposure, severity, treatment, and outcomes.

DATA SOURCES

1. Individual medical record
2. DoD EMF Injury Registry (managed by the USAF at Wright Patterson AFB)

REPORTING AND FREQUENCY

The above constitutes the minimum criteria for PI monitoring of this CPG. System reporting will be performed annually; additional PI monitoring and system reporting may be performed as needed.

The system review and data analysis will be performed by the JTS Chief, JTS Program Manager, and the JTS PI Branch.

RESPONSIBILITIES

It is the trauma team leader's responsibility to ensure familiarity, appropriate compliance, and PI monitoring at the local level with this CPG.

ACKNOWLEDGMENT

Special thanks to reviewer: Dr. Martin LaFrance

REFERENCES

1. Air Force Research Laboratory US. Directed Energy Futures 2060: Visions for the Next 40 Years of U.S. Department of Defense Directed Energy Technologies. the Office of the U.S. Air Force's Chief Scientist for Directed Energy, Air Force Research Laboratory;2021.
2. Radio Frequency Radiation Dosimetry Handbook (Fifth Edition). Air Force Research Laboratory, 711th Human Performance Wing, Human Effectiveness Directorate, Directed Energy Bioeffects Division, Radio Frequency Radiation Branch; July 2009.

3. IEEE Technical Committee 95. IEEE standard for military workplaces—force health protection regarding personnel exposure to electric, magnetic, and electromagnetic fields, 0 Hz to 300 GHz. In. New York, NY2014.
4. Barr R, Jones DL, Rodger CJ. ELF and VLF radio waves. Journal of Atmospheric and Solar-Terrestrial Physics. 2000;62(17-18):1689-1718.
5. Radio Frequency Radiation Dosimetry and Its Relationship to the Biological Effects of Electromagnetic Fields. Vol 82. Springer-Science Business Media, B.V.: Kluwer Academic Publishers; 2000.
6. Department of Defense US. DODI 6055.11 - Protecting Personnel from Electromagnetic Fields. In: Department of Defense US, ed. Office of the Under Secretary of Defense for Personnel and Readiness.2021.
7. Department of the Navy US. Electromagnetic Radiation Hazards (Hazards to Personnel, Fuel, and other Flammable material). In. Vol 1. Sixth Revision ed: Naval Sea Systems Command; 2003.
8. Uelen MW, Rogers BZ. Base-Level Guide for Electromagnetic Frequency Radiation. Wright-Patterson Air Force Base: Air Force Research Laboratory, 711th Human Performance Wing, USAF School of Aerospace Medicine, Occupational & Environmental Health Department, Consultative Services Division;2013.
9. Gallucci S, Fiocchi S, Bonato M, et al. Exposure assessment to radiofrequency electromagnetic fields in occupational military scenarios: a review. Int J Environ Res Public Health. 2022;19(2).
10. Erwin W, Kelly E, Miaullis A, Muffoletto I. DoD electromagnetic radiation safety incidents. Health Physics Society (HPS) Annual 2023 Meeting; 2023; National Harbor, MD.
11. D'Angelo C, Costantini E, Kamal MA, Reale M. Experimental model for ELF-EMF exposure: Concern for human health. Saudi J Biol Sci. 2015;22(1):75-84.
12. IT'IS database for thermal and electromagnetic parameters of biological tissues (Version 4.1). 2022. Accessed Retrieved January 25, 2024 from itis.swiss/database.
13. Gabriel C, Gabriel S, Corthout E. The dielectric properties of biological tissues: I. Literature survey. Phys Med Biol. 1996;41(11):2231-2249.
14. Gabriel S, Lau RW, Gabriel C. The dielectric properties of biological tissues: III. Parametric models for the dielectric spectrum of tissues. Phys Med Biol. 1996;41(11):2271-2293.
15. Gabriel S, Lau RW, Gabriel C. The dielectric properties of biological tissues: II. Measurements in the frequency range 10 Hz to 20 GHz. Phys Med Biol. 1996;41(11):2251-2269.
16. Wright BA, Powell E, Dodson WW. Directed Energy: Medical Effects of Radio Frequency Exposure (Microwave & Millimeter Wave) - a Literature Review. Air Force Research Laboratory, 711th Human Performance Wing, School of Aerospace Medicine, Aeromedical Research Department;2013.
17. Food & Drug Administration US. Radio Frequency Radiation and Cell Phone. 2020; https://www.fda.gov/radiation-emitting-products/cell-phones/radio-frequency-radiation-and-cell-phones#
18. American Cancer Society. Known and Probable Human Carcinogens. 2022; https://www.cancer.org/cancer/risk-prevention/understanding-cancer-risk/known-and-probable-human-carcinogens.html .
19. Grajewski B, Cox C, Schrader SM, et al. Semen quality and hormone levels among radiofrequency heater operators. J Occup Environ Med. 2000;42(10):993-1005.
20. International Commission on the Biological Effects of Electromagnetic Fields. Scientific evidence invalidates health assumptions underlying the FCC and ICNIRP exposure limit determinations for radiofrequency radiation: implications for 5G. Environ Health. 2022;21(1):92.
21. Yu G, Bai Z, Song C, et al. Current progress on the effect of mobile phone radiation on sperm quality: An updated systematic review and meta-analysis of human and animal studies. Environ Pollut. 2021;282:116952.
22. Lubner RJ, Kondamuri NS, Knoll RM, et al. Review of audiovestibular symptoms following exposure to acoustic and electromagnetic energy outside conventional human hearing. Front Neurol. 2020;11:234.

23. Dagro A, Wilkerson J. A computational investigation of strain concentration in the brain in response to a rapid temperature rise. J Mech Behav Biomed Mater. 2021;115:104228.
24. Dagro AM, Wilkerson JW, Thomas TP, Kalinosky BT, Payne JA. Computational modeling investigation of pulsed high peak power microwaves and the potential for traumatic brain injury. Sci Adv. 2021;7(44):eabd8405.
25. Lyon RF, Gramm J, Branagan B, Houck SC. Implications of neurological directed-energy weapons for military medicine. J Spec Oper Med. 2022;22(3):104-107.
26. Parker JE, Rodriguez RA, Rivera-Lopez LL, et al. Assessment of rodent behavioral changes induced by multiple, high peak power, 2.8 GHz Microwave Pulses. Air Force Research Laboratory, 711th Human Performance Wing, Airman Systems Directorate: Department of the Air Force;2023.
27. van Deventer E, van Rongen E, Saunders R. WHO research agenda for radiofrequency fields. Bioelectromagnetics. 2011;32(5):417-421.
28. Savchenko L, Martinelli I, Marsal D, et al. Metabolic, Apoptotic and Fibro-Inflammatory Profiles of the Heart Exposed to Environmental Electromagnetic Fields. Int J Mol Sci. 2023;24(14).
29. Maalouf J, Pelletier A, Corona A, et al. Dose- and time-dependent effects of radiofrequency electromagnetic field on adipose tissue: implications of thermoregulation and mitochondrial signaling. Int J Mol Sci. 2023;24(13).
30. Akbari H, Taeb S, Adibzadeh A, Akbari H. Nonionizing electromagnetic irradiations; biological interactions, human safety. J Biomed Phys Eng. 2023;13(4):299-308.
31. Tang M, Yamamoto T. Progress in understanding radiofrequency heating and burn injuries for safer MR imaging. Magn Reson Med Sci. 2023;22(1):7-25.
32. Electromagnetic Fields. In: European Commission Directorate General for Employment Social Affairs and Inclusion Unit B3, ed. Non-binding guide to good practice for implementing Directive 2013/35/EU. Vol 1: Practical Guide: European Union; 2015.
33. Kues H, Monahan J. Microwave-induced changes to the primate eyes. Johns Hopkins APL Technical Digest. 1992;13:244-254.
34. Kojima M, Suzuki Y, Sasaki K, et al. Ocular effects of exposure to 40, 75, and 95 GHz millimeter waves. J of Infrared Milli Terahz Waves. 2018.
35. Liu D, Cruz FM, Subramanian PS. Bilateral vision loss associated with radiofrequency exposure. Clin Ophthalmol. 2012;6:2069-2073.
36. Adibzadeh F, van Rhoon GC, Verduijn GM, Naus-Postema NC, Paulides MM. Absence of acute ocular damage in humans after prolonged exposure to intense RF EMF. Phys Med Biol. 2016;61(2):488-503.
37. D'Andrea J, Cox D, Henry PJ, Ziriax JM, Hatcher DJ, Hurt WD. Rhesus Monkey Aversion to 94-GHZ Facial Exposure. In: Air Force Research Laboratory US, ed2008.

APPENDIX A: EXPOSURE REFERENCE LEVELS (ERL)

Exposure Limits between 100 kHz and 300 GHz radio frequency for Zone 0 and Zone 1. Zone 0 - unrestricted environments. Zone 1 - restricted to informed personnel with appropriate training. Zone 2 (not shown here) – restricted to specialized trained personnel and is allowed under unique circumstance only. All values are in root mean square (rms).

***NOTE**: Appendix A was reproduced according to the IEEE Standard C95.1-2345.3*

Zone 0 - Exposure Reference Levels					
Frequency Range (f in MHz)	**Electric field (E)[a] (V/m)**	**Magnetic field strength (H)[a] (A/m)**	**Power density (S) E-field, H-field (W/m^2)**	**Averaging time[b] |E|^2, |H|^2 or S (min)**	
0.1–1.34	614	$16.3/f_M$	$(1000, 100\ 000/f_M^2)$[c]	6	6
1.34–3	$823.8/f_M$	$16.3/f_M$	$(1800/f_M^2, 100\ 000/f_M^2)$	$f_M^2/0.3$	6
3–30	$823.8/f_M$	$16.3/f_M$	$(1800/f_M^2, 100\ 000/f_M^2)$	30	6
30–100	27.5	$158.3/f_M^{1.668}$	$(2, 9\ 400\ 000/f_M^{3.336})$	30	$0.0636\ f_M^{1.337}$
100–400	27.5	0.0729	2	30	30
400–2000	-	-	$f_M/200$	30	
2000–5000	-	-	10	30	
5000– 30 000	-	-	10	$150/f_G$	
30 000–100 000	-	-	10	$25.24/f_G^{0.476}$	
100 000–300 000	-	-	$6.43\times10^{-4} f_G^{2.096}$	$3.925\times10^5/f_G^{2.572}$	

Zone 1 - Exposure Reference Levels				
Frequency Range (MHz)	**Electric field strength (E)[a] (V/m)**	**Magnetic field strength (H)[a] (A/m)**	**Power density (S) E-field, H-field (W/m^2)**	**Averaging time |E|^2, |H|^2 or S (min)**
0.1–1.0	1842	$16.3/f_M$	$(9000, 100\ 000/f_M^2)$[b]	6
1.0–30	$1842/f_M$	$16.3/f_M$	$(9000/f_M^2, 100\ 000/f_M^2)$	6
30–100	61.4	$16.3/f_M$	$(10, 100\ 000/f_M^2)$	6
100–300	61.4	0.163	10	6
300–3000			$f_M/30$	6
3000–30 000			100	$19.63/f_G^{1.079}$
30 000–300 000			100	$2.524/f_G^{0.476}$

Legend

MHz = megahertz
V/m = volts per meter
A/m = ampere per meter
W/m^2 = watt per square meters
f_M = frequency in megahertz (MHz)
f_G = frequency in gigahertz (GHz).

Notes:

[a]For exposures that are uniform over the dimensions of the body, such as certain far-field plane-wave exposures, the exposure field strengths and power densities are compared with the ERLs in this table. For non-uniform exposures, the mean values of the exposure fields are obtained by spatially averaging the squares of the field strengths or averaging the power densities over an area equivalent to the vertical cross section of the human body (projected area) or a smaller area depending on the frequency; the mean values are then compared with the ERLs in this table.

[b]The left column is the averaging time for |E|2, the right column is the averaging time for |H|2. For frequencies greater than 400 MHz, the averaging time is for power density S.

[c]These plane-wave equivalent power density values are commonly used as a convenient comparison with ERLs at higher frequencies and are displayed on some instruments in use.

APPENDIX B : TELEMEDICINE / TELECONSULTATION

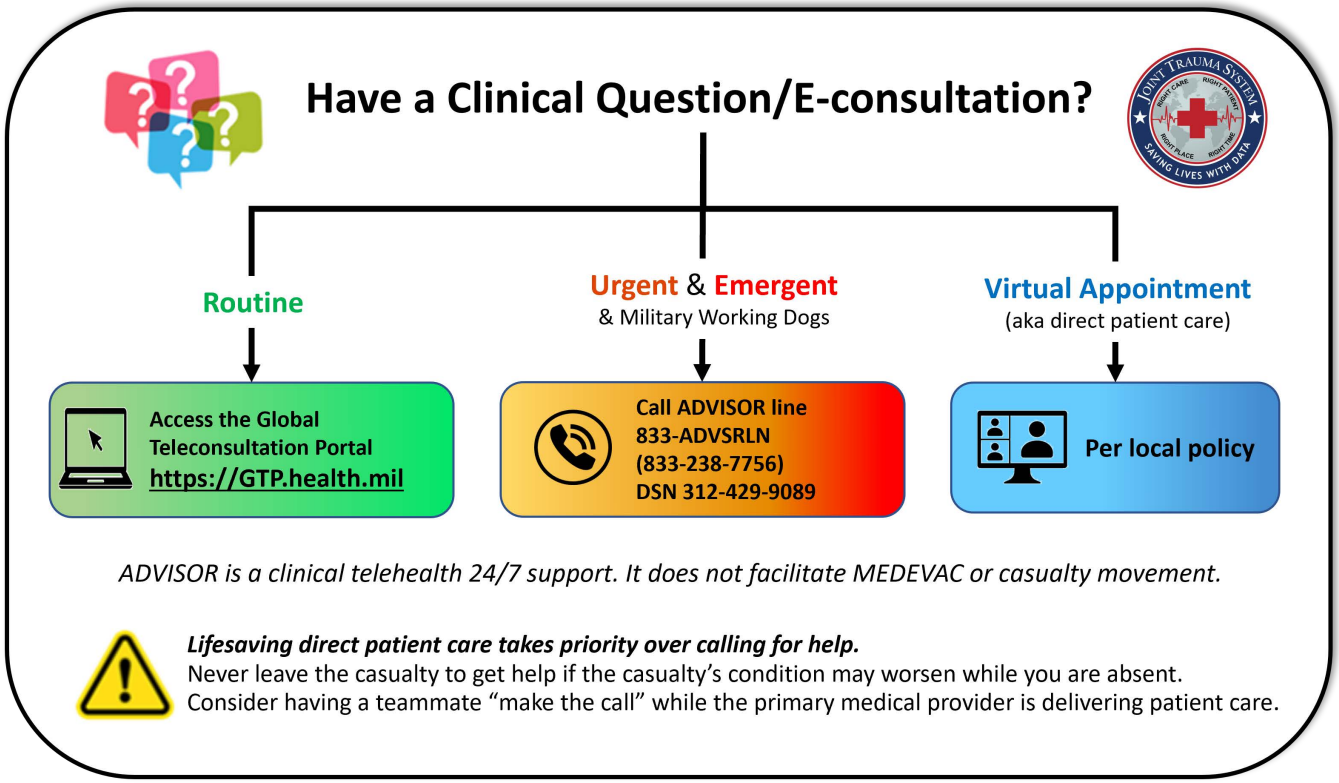

Illustration by Raymond Samonte

GTP: https://GTP.health.mil

APPENDIX C: INFORMATION REGARDING OFF-LABEL USES IN CPGS

PURPOSE

The purpose of this Appendix is to ensure an understanding of DoD policy and practice regarding inclusion in CPGs of "off-label" uses of U.S. Food and Drug Administration (FDA)–approved products. This applies to off-label uses with patients who are armed forces members.

BACKGROUND

Unapproved (i.e. "off-label") uses of FDA-approved products are extremely common in American medicine and are usually not subject to any special regulations. However, under Federal law, in some circumstances, unapproved uses of approved drugs are subject to FDA regulations governing "investigational new drugs." These circumstances include such uses as part of clinical trials, and in the military context, command required, unapproved uses. Some command requested unapproved uses may also be subject to special regulations.

ADDITIONAL INFORMATION REGARDING OFF-LABEL USES IN CPGS

The inclusion in CPGs of off-label uses is not a clinical trial, nor is it a command request or requirement. Further, it does not imply that the Military Health System requires that use by DoD health care practitioners or considers it to be the "standard of care." Rather, the inclusion in CPGs of off-label uses is to inform the clinical judgment of the responsible health care practitioner by providing information regarding potential risks and benefits of treatment alternatives. The decision is for the clinical judgment of the responsible health care practitioner within the practitioner-patient relationship.

ADDITIONAL PROCEDURES

Balanced Discussion

Consistent with this purpose, CPG discussions of off-label uses specifically state that they are uses not approved by the FDA. Further, such discussions are balanced in the presentation of appropriate clinical study data, including any such data that suggest caution in the use of the product and specifically including any FDA-issued warnings.

Quality Assurance Monitoring

With respect to such off-label uses, DoD procedure is to maintain a regular system of quality assurance monitoring of outcomes and known potential adverse events. For this reason, the importance of accurate clinical records is underscored.

Information to Patients

Good clinical practice includes the provision of appropriate information to patients. Each CPG discussing an unusual off-label use will address the issue of information to patients. When practicable, consideration will be given to including in an appendix an appropriate information sheet for distribution to patients, whether before or after use of the product. Information to patients should address in plain language: a) that the use is not approved by the FDA; b) the reasons why a DoD health care practitioner would decide to use the product for this purpose; and c) the potential risks associated with such use.