Occupational Health Profile and Risk Assessment of Military Communications Personnel in Modern Electronic Warfare Environments

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Abstract

Modern military operations depend on advanced communication systems, making communications personnel a strategically vital group. These specialists serve in highly stressful electronic warfare environments with continuous radiofrequency exposure, chronic noise, ergonomic overload, and psychological pressure. This cross-sectional analytical study of 120 military signalers operating mobile and stationary systems assessed neurological, auditory, ergonomic, and psycho-emotional health effects. Personnel with more than five years of service reported markedly higher rates of recurrent headaches, chronic fatigue, sleep disturbances, tinnitus, and lower back pain, indicating a strong link between prolonged exposure and chronic health disorders. Identified deficiencies included inadequate shielding, chronic noise, constrained working postures, and insufficient recovery. The study underscores the need to modernize occupational hygiene through improved RF shielding, noise-canceling equipment, ergonomic redesign of workplaces, structured recovery protocols, and comprehensive health monitoring.

Keywords: *military hygiene, occupational health, RF-EMF exposure, electronic warfare, tinnitus, ergonomic stress, military communications personnel, electromagnetic radiation*

1. INTRODUCTION

The development of modern electronic warfare technologies has fundamentally transformed the operational environment of military communications personnel. In contemporary armed forces, military signalers function as the "nervous system" of the military structure, maintaining continuous information exchange between command centers, operational units, and intelligence systems.

Unlike conventional infantry personnel, military communications operators work in environments saturated with:

- high-frequency electromagnetic radiation,
- chronic acoustic stress,
- prolonged visual concentration,
- psychological tension,
- and restricted ergonomic conditions.

These occupational factors create unique hygiene challenges that differ substantially from those observed in other military professions.

In recent decades, the increasing density of communication equipment within command-staff vehicles (CSV), mobile communication centers, and underground operational bunkers has significantly increased the intensity of non-ionizing radiation

exposure. Modern military radio systems operate across multiple frequencies simultaneously, creating complex electromagnetic environments.

The issue of occupational exposure to radiofrequency electromagnetic fields (RF-EMF) has become a growing concern within military medicine and occupational hygiene. Although RF-EMF is classified as non-ionizing radiation, prolonged exposure may produce biological effects involving:

- neurological dysfunction,
- endocrine imbalance,
- chronic fatigue,
- sleep disorders,
- cognitive decline,
- and autonomic nervous system disturbances.

In addition to electromagnetic exposure, military signalers experience chronic acoustic overload. Continuous radio monitoring, generator noise, engine vibration, and prolonged headset use contribute to progressive hearing impairment and tinnitus development.

Ergonomic factors also play a significant role. Military communication work often requires prolonged static posture in confined operational spaces. Restricted mobility, poor seat design, and repetitive hand movements contribute to musculoskeletal disorders, particularly in the cervical and lumbar spine regions.

Despite the strategic importance of military communications personnel, relatively limited research has focused on their occupational hygiene profile in modern electronic warfare conditions.

The aim of this study was to evaluate occupational health risks among military communications personnel exposed to prolonged RF-EMF, acoustic stress, and ergonomic overload in modern military operational environments.

2. MATERIALS AND METHODS

2.1 Study Design

A cross-sectional analytical study was conducted between January and December 2026.

The research combined:

- occupational hygiene assessment,
- epidemiological survey methods,
- ergonomic evaluation,
- and comparative statistical analysis.

2.2 Study Population

The study involved 120 active-duty military communications personnel.

The average participant age was:

28.4±4.2 years28.4 \pm 4.2 \text{ years}28.4±4.2 years

Participants included operators working in:

- mobile communication vehicles,
- stationary command centers,
- tactical radio systems,
- electronic warfare communication units.

Participation was anonymous and voluntary.

2.3 Group Classification

Participants were divided according to duration of military service:

Group	Service Duration	Number
Group A	<5 years	65
Group B	>5 years	55

This classification allowed evaluation of cumulative occupational exposure effects.

2.4 Research Instrument

The "Signal-Health-2026" questionnaire was developed specifically for occupational hygiene assessment of military signalers.

The questionnaire evaluated:

Neurological Status

- recurrent headaches,
- irritability,
- concentration difficulties,
- chronic fatigue,
- sleep disturbances.

Auditory Status

- hearing clarity,
- tinnitus,
- sensitivity to noise.

Visual Strain

- eye fatigue,
- blurred vision,
- visual discomfort after prolonged monitoring.

Ergonomic Status

- neck pain,
- lower back pain,
- wrist discomfort,
- muscular stiffness.

2.5 Electromagnetic Exposure Assessment

Occupational RF-EMF exposure was evaluated based on:

- proximity to transmitting antennas,
- duration of exposure,
- equipment density,
- operational environment characteristics.

Measurements were compared with WHO safety recommendations for non-ionizing radiation exposure.

2.6 Statistical Analysis

Data analysis included:

- descriptive statistics,
- Chi-square testing,
- comparative prevalence analysis.

Statistical significance was determined at:

P<0.05P < 0.05P<0.05

3. RESULTS

3.1 Neurological Impact of RF-EMF Exposure

The study identified a clear association between duration of service and neurological symptoms.

Symptom	Group A (%)	Group B (%)	P-value
Recurrent headaches	32.3	58.2	<0.01
Chronic fatigue	27.7	45.5	<0.05
Sleep disturbances	18.5	38.2	<0.05

Senior personnel demonstrated significantly higher prevalence of neurological symptoms.

The results suggest cumulative biological effects associated with prolonged RF-EMF exposure.

3.2 Auditory Disorders

Auditory overload represented one of the most severe occupational problems.

Among all participants:

- 42.5% reported persistent tinnitus,
- 31.6% experienced reduced hearing clarity,
- 26.4% reported sound hypersensitivity.

Only 12% of personnel used active noise-canceling (ANC) headsets.

Most personnel relied on conventional communication headsets requiring higher sound volume to compensate for ambient operational noise.

3.3 Ergonomic Disorders

Musculoskeletal symptoms increased significantly with years of service.

Disorder	Group A (%)	Group B (%)
Lower back pain	52.3	78.2
Neck pain	47.7	70.9
Wrist strain	21.5	40.0

The confined environment of command-staff vehicles significantly restricted movement and promoted static posture syndrome.

3.4 Psycho-Emotional Stress

Personnel frequently reported:

- emotional exhaustion,
- irritability,
- reduced stress tolerance,
- concentration decline.

Senior personnel demonstrated higher levels of psychological fatigue.

3.5 Occupational Exposure Duration

The average daily exposure duration was:

9.2±1.8 hours9.2 \pm 1.8 \text{ hours}9.2±1.8 hours

Many operators exceeded recommended exposure periods without adequate recovery intervals.

4. DISCUSSION

4.1 Biological Effects of RF-EMF Exposure

The elevated prevalence of headaches and sleep disturbances suggests cumulative neurological effects of chronic RF-EMF exposure.

Electromagnetic radiation may influence:

- neuronal membrane activity,
- neurotransmitter balance,
- melatonin secretion,
- blood-brain barrier permeability.

These mechanisms may explain chronic asthenic syndrome observed among experienced personnel.

4.2 Acoustic Hygiene and Hearing Loss

The high prevalence of tinnitus indicates chronic acoustic trauma.

Operational noise sources included:

- diesel generators,
- radio interference,
- engine vibration,
- continuous headset use.

Noise levels frequently exceeded:

85−90 dB85-90 \text{ dB}85−90 dB

To compensate, operators increased headset volume above safe auditory thresholds. This phenomenon, known as the "volume compensation habit," contributes to cochlear hair cell damage.

4.3 Ergonomic Deficiencies

The results indicate severe ergonomic limitations in military communication environments.

Restricted space promotes:

- prolonged static posture,
- spinal compression,
- muscular imbalance,
- reduced circulation.

The prevalence of lower back pain among senior personnel demonstrates cumulative musculoskeletal degeneration.

4.4 Occupational Stress and Force Readiness

Occupational fatigue directly affects military operational efficiency.

Chronic fatigue may impair:

- reaction speed,
- concentration,
- decision-making,
- communication accuracy.

These effects may reduce combat readiness and operational safety.

4.5 Comparison with International Studies

International occupational hygiene studies similarly demonstrate increased rates of:

- tinnitus,
- neurological fatigue,

- musculoskeletal disorders,
- sleep disturbances among military communication specialists.

The present findings align with global occupational health trends in high-technology military environments.

5. CONCLUSION

Military communications personnel face complex occupational hazards involving electromagnetic radiation, acoustic overload, ergonomic strain, and psycho-emotional stress.

The study demonstrated that prolonged occupational exposure significantly increases:

- neurological symptoms,
- hearing disorders,
- musculoskeletal pathology,
- chronic fatigue syndrome.

Current military hygiene systems require modernization to preserve force readiness and long-term personnel health.

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