

Bulletin de veille Polyexpositions hétérogènes N°6 – octobre 2026

Objectif : ce bulletin présente un état de littérature scientifique sur le thème des poly expositions hétérogènes, avec trois situations de coexpositions pouvant être rencontrées en milieu professionnel : expositions aux substances chimiques et agents biologiques, expositions aux substances chimiques et charge physique de travail, expositions aux substances chimiques et travail de nuit.

Ce bulletin périodique a pour but de prendre connaissance des différents travaux internationaux des chercheurs dans ce domaine, d'explorer les données publiées, afin de préciser les effets sur la santé des travailleurs de ces différentes combinaisons et leurs conséquences en milieu professionnel.

La validation des informations fournies (exactitude, fiabilité, pertinence par rapport aux principes de prévention, etc.) est du ressort des auteurs des articles signalés dans la veille. Les informations ne sont pas le reflet de la position de l'INRS. Les éléments issus de cette veille sont fournis sans garantie d'exhaustivité.

Les liens mentionnés dans le bulletin donnent accès aux documents sous réserve d'un abonnement à la ressource.

Actualités web et presse généraliste vues

22 avril 2026. Rapport Anses. **Tri des déchets** : des travailleurs fortement exposés à des multiples facteurs de risques pour leur santé. Expositions à des agents biologiques dangereux, mais aussi à plusieurs substances chimiques dangereuses, avec des conditions de travail pénibles : hautes températures, bruits, vibrations, risques liés à l'utilisation de machines.

<https://www.anses.fr/fr/content/tri-des-dechets-des-travailleurs-fortement-exposes-des-multiples-facteurs-de-risques-pour>

2 avril 2026. **Chemicals and Hearing Loss: A Connection**. NIOSH Science Bulletin / CDC.

<https://www.cdc.gov/niosh/bulletin/2026/ototoxicants.html>

Mai 2026. Preventica magazine. Comprendre les risques des Polyexpositions.

<https://www.preventica.com/magazine/dossiers/comprendre-les-risques-des-polyexpositions-29052026>

Mai 2026. **Réduction des poussières et de la silice cristalline dans les mines : retour d'expérience sur un système développé par le NIOSH.** NIOSH-Developed Dustinator Reduces Airborne Dust and Silica at Mine Sites. Spokane, WA: Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2026-102.

Un article de Technology News (mai 2026), publié par le NIOSH Mining Program, présente un système de maîtrise des poussières mis en œuvre sur un site minier américain, associant une enceinte de confinement des convoyeurs, un dispositif de filtration compacte appelé Dustinator® et une pulvérisation contrôlée d'un mélange eau-tensioactif. Ce système réduit les expositions des travailleurs lors des opérations de manutention et de traitement des matériaux. [En savoir plus](#)

22 juillet 2026. Occupational Health Risk Management | **Multiple Exposures & Combined Effects**
<https://www.linkedin.com/>

4 septembre 2026. Instant-CE. **Maladies professionnelles : votre DUERP prend-il vraiment en compte les polyexpositions ?**
https://www.instant-ce.com/Maladies-professionnelles-votre-DUERP-prend-il-vraiment-en-compte-les-polyexpositions_a2258.html

L'exposition professionnelle aux produits phytopharmaceutiques en 2019 en France et son évolution depuis 2007. Source : Santé publique France. Date : 15 septembre 2026

URL : [Ouvrir l'article](#)

Sommaire

1. Coexpositions agents chimiques et biologiques.....	3
2. Coexpositions agents chimiques et physiques	7
2.1 Chaleur, stress thermique.....	7
2.2 Charge de travail et produits chimiques.....	11
3 Coexpositions avec le bruit	13
3.1 Bruit et agents chimiques	13
3.2 Bruit et horaires de travail	17
4. Coexpositions aux champs électromagnétiques, bruits, et horaires de travail	18
5. Coexpositions travail de nuit et agents chimiques	19
6. Coexpositions vibrations main-bras et chaleur	19
7. Méthodes d'analyse des multiexpositions.....	21
8. Coexpositions contraintes physiques et contraintes émotionnelles, psychosociales.....	24

1.Coexpositions agents chimiques et biologiques

Expositions aux venins d'abeilles et aux fumées anesthésiantes des ruches lors de maintenance.

Mauro, M., Tassinari, A., Cavallo Ronchi, F., Rizzo, M., Larese Filon, F.

Between stings and smoke: prevalence of allergic disorders and exposure to combustion smokes in Northeast Italy's beekeepers.

Occup Environ Med (2026), Vol 83, p.85-90.

OBJECTIVES: Beekeepers are frequently exposed to bee venom and combustion smoke, leading to risks of systemic allergic reactions and respiratory hazards.

This study assesses the prevalence of systemic allergic symptoms among beekeepers in Northeastern Italy and describes current management practices. Additionally, it characterises inhalation exposures to combustion smoke during apiary maintenance.

METHODS: A cross-sectional survey collected data on sting exposure, allergic symptoms and smoke use practices. Combustion smoke exposure assessment was performed using Fourier transform infrared spectroscopy (Gasmeter DX-4030) coupled with an ultrafine particle classifier (DiSCmini) to characterise emissions from commonly used fuels.

RESULTS: Among 553 beekeepers surveyed, 21.3% reported systemic allergic reactions after bee sting, mostly males (66.7%). Of these (n=118), only 31.4% were confirmed sensitised to *Apis mellifera* and prescribed epinephrine autoinjector; 16.1% received venom immunotherapy, while others had no specific allergological assessment. Multivariate analysis showed that allergic symptoms during apiary work and extended local reactions increased the likelihood of systemic reactions fivefold. Almost all participants used smoke during inspections, with 39.1% frequently inhaling smoke; only 0.9% used respiratory protective equipment. Environmental monitoring detected multiple volatile organic compounds-including formaldehyde exceeding at different time points the threshold limit value-short term exposure limits-and high concentrations of ultrafine particles, particularly from hay and pellet combustion.

CONCLUSIONS: Systemic allergic reactions to bee venom are common but often undertreated in beekeepers. Combustion smoke is a significant respiratory hazard. Targeted interventions are needed to improve health outcomes and safety in this occupational group.

<https://oem.bmj.com/content/83/2/85>

Gomiero, A., Skogerbo, G.

From waste to workplace: Airborne microplastics and endotoxins in an indoor industrial environment.

Int J Hyg Environ Health, Vol. 274, (2026), 114789.

Airborne microplastics (MPs) and endotoxins are emerging occupational hazards, yet their co-occurrence in real workplaces is poorly documented. The study examined combined exposure in sludge-based fertilizer plant, where digestate handling and drying generate both polymer-rich dust and bioaerosols.

Personal and stationary air samples were collected with calibrated pumps at three indoor hotspots: conveyor pipe, dryer, loading dock with an outdoor site. Microplastics were extracted in an ultra-clean laboratory and characterized by μ -FTIR imaging. Endotoxin levels were quantified by the LAL assay.

Indoor air contained significantly higher MP counts (24-312 MP m⁻³) than outdoor (13 MP m⁻³), dominated by fragment-shaped particles (74%) vs fibres (26%) within the inhalable size fractions. Concentrations peaked near the sludge dryer unit and the conveyor, indicating process-related sources and resuspension of contaminated dust. Endotoxins (<0,7 - 30 EU m⁻³) were consistently above outdoor levels and highest where sludge-derived material was agitated yet remained below occupational reference values (90 EU m⁻³). Positive covariation between MP and endotoxin levels suggested that tasks and zones with high dust emissions also drive combined particle-biological exposure.

The study provides one of the first integrated datasets on airborne MPs and endotoxin in a circular-economy fertilizer facility and demonstrates a practical, contamination-controlled protocol for joint assessment using coordinated sampling.

The results show that workers can be simultaneously exposed to elevated levels of polymer particles and endotoxin, underscoring the need to include microplastics in exposure monitoring, risk assessment, and control strategies across biological-waste and related industrial environments.

<https://doi.org/10.1016/j.ijheh.2026.114789>

Evaluation de l'exposition aux bioaérosols dans un site d'extraction pétrolière avec produits chimiques polluants.

Yang, H., He, S., Yao, Z., Li, H., Feng, Q., Huang, S., *et al.*

Bioaerosols in the atmospheric environment of oil exploitation sites: spatial and temporal distribution, sources, influencing factors, health risks, and reduction efficiency of masks.

Environmental Pollution 2026, Vol. 409, p 129020

Particle-bound microorganisms have attracted increasing attention due to their health effects and pollutant metabolic activity. However, the characteristics of airborne microbes in oil exploitation sites with heavy particulate matter and volatile organic chemicals (VOCs) pollution remain unclear. This study collected bioaerosol samples in a city polluted by oil exploitation in the Beijing-Tianjin-Hebei region of China, and investigated the spatial and temporal distributions, sources, influencing factors, health risks, and filtration efficiency of bioaerosols.

The results showed that the average culturable and total bioaerosol levels in autumn were significantly higher than in summer, whereas microbial activity exhibited an inverse seasonal trend. Higher concentrations were found in steel plants, inland oilwell, and chemical industry park, suggesting that industrial activities may increase bioaerosol levels. No significant correlation was observed between microbial activity and concentration. The microbial communities' diversity and abundance varied significantly between seasons, with crude oil degradation bacteria, *Anoxybacillus* and *Curtobacterium* as dominant bacteria, *Cladosporium* and *Alternaria* as dominant fungi.

SourceTracker analysis showed that airborne bacteria were primarily derived from leaf surface, while the contribution of leaf surface and soil communities to atmospheric fungi is more prominent. Airborne bacteria were more influenced by VOCs, while environmental factors have greater impact on fungal community structures. The hazard quotient (<1) of inhaling bioaerosols was negligible, but long-term exposure to dominant pathogens, *Bacillus* and *Mycobacterium*, could be harmful. Actual wearing masks could only remove 13.7% of bioaerosols, far lower than laboratory-measured values.

In summary, this study elucidates the influence of oil exploitation activities on shaping the airborne microbial community, offering practical insights for risk assessments and control of bioaerosols in oil

exploitation sites.

<https://doi.org/10.1016/j.envpol.2026.129020>

Todorov, D., Ceballos, D. M., Sack, C., Reeb-Whitaker, C.

Occupational toxic inhalation injury to cleaning chemicals during the COVID-19 pandemic, including a case series for disinfectants aerosolized through spray and fog application.

J Occup Environ Hyg, 2026, Vol. 23 (7), p.406–416.

The occupational burden of injury caused by exposure to cleaning chemicals during the pandemic is not well described. The objective of this study was to determine whether the COVID-19 pandemic was associated with a change in the rate of toxic inhalation (TI) injuries following occupational exposure to cleaning chemicals.

This retrospective study spanned from July 1, 2017, to June 30, 2022, with January 1, 2020, designated as the pandemic start. TI cases were identified among workers' compensation claims filed in Washington State, USA using keyword text search and diagnostic and insurance codes. Qualitative claim data were reviewed to determine the frequency of cases with exposure to aerosolized disinfectants following spray or fog application. Rates of TI claims per full-time equivalent (FTE) workers were compared in the pre- and pandemic periods. Out of the 440 TI claims identified, 30% involved exposure to disinfectants and 13% had a diagnosis of work-related asthma. There was a decline in the overall rate of TI claims in the pre- vs. pandemic period (8.9/100,000 FTE vs. 7.4/100,000 FTE, respectively).

However, the proportion of exposures to disinfectants increased during the pandemic period. Four industries, particularly "Transportation and Warehousing," experienced an increase in TI injury rate. Fog or spray application of disinfectants was involved in 20 cases (including 14 in bus transportation) during the pandemic, compared to zero cases in the pre-pandemic period.

In Washington State, the COVID-19 pandemic was associated with industry-specific increased TI injury rates due to cleaning chemicals, but not an overall increased rate. A case series emphasizes that aerosolized disinfectants are a toxic inhalation risk for workers. Studies to further characterize this practice and these injuries are warranted. Prevention efforts should utilize the hierarchy of controls as well as address hazard awareness, product over-application, and the need to estimate and uphold a safe re-occupation time after fog or spray application of disinfectants.

<https://doi.org/10.1080/15459624.2026.2650648>

Lauvås, A. J., Straumfors, A., Alsaedi, S. Et Al.

TLR/NF-κB activation in vitro as a tool in the assessment of occupational bioaerosol exposure and health risks in wastewater treatment plants.

J Expo Sci Environ Epidemiol, 2026, Vol. 36, p. 939–950.

Background : Wastewater treatment plant (WWTP) workers are exposed to biological hazards, including bacteria, fungi, and viruses with pathophysiological properties, posing a risk to workers' health. Due to the complexity of WWTP bioaerosol composition, exposure assessment is challenging, and new methods are needed for a more holistic evaluation.

Objectives : (1) Characterize bacterial exposure in three Norwegian wastewater treatment plants (WWTPs), (2) Assess the bioaerosol's and cultivated viruses' ability to activate toll-like receptors in vitro,

and (3) Elucidate adverse health effects in WWTP workers.

Methods : Inhalable bioaerosol fractions were collected with personal and stationary sampling, and endotoxin levels and 16S rRNA gene as a biomarker for bacteria were quantified. The inflammatory potential of the bioaerosol was assessed in vitro with HEK-Blue reporter cells, and we investigated the applicability of these cells for viral ligand detection by exposing them to cultivated Influenza A virus, Adenovirus F/40, E. coli phage MS2, and bovine Coronavirus. We used self-reported questionnaire data for an observational health assessment.

Results : TLR2 and TLR4 were activated in 85 and 91% of bioaerosol samples and activation correlated with airborne endotoxin levels. Airborne bacteria were present in all samples, with higher levels in personal (2.7×10^4 gc/m³) versus stationary samples (1.3×10^4 gc/m³). Endotoxin levels ranged from <LOD to 4800 EU/m³ in stationary, and <LOD to 920 EU/m³ in personal samples, with median levels of 54 and 47 EU/m³, respectively. Workers reported a higher prevalence of respiratory symptoms, skin dryness, diarrhea, and fever than unexposed controls. No bioaerosol sample activated TLR3 and 7, while moderate activation was observed by bovine Coronavirus.

Significance

Workers are continuously exposed to high levels of airborne bacteria levels of endotoxins exceeding 90 Endotoxin units/m³, which can induce a TLR2- or TLR4/NF-κB immune response. This exposure occurs throughout their workday, independent of workstations and workers' tasks.

<https://doi.org/10.1038/s41370-026-00880-9>

Schmied, A., Berger, M., Marske, L., Hopfner, M., Kujath, P.

Organic waste treatment: Biomonitoring of workers exposed to mycotoxins.

Int J Hyg Environ Health, 2026, Vol. 274, 114768 p.

In organic waste treatment facilities, bioaerosols containing microorganisms (e.g., bacteria, fungi) as well as biomolecules (e.g., debris from membranes, mycotoxins) are released during the movement of material. We conducted a human biomonitoring study to investigate the possible occupational exposure of workers to mycotoxins.

In total, 50 workers from three organic waste treatment facilities in Germany and 37 volunteers without expected occupational exposure to moulds provided spot urine samples. These were analysed for the presence of ten urinary mycotoxin biomarkers using liquid chromatography with tandem mass spectrometry. Deoxynivalenol (DON) was detected in nearly all (96%) of the samples of workers and controls followed by deepoxy-deoxynivalenol (21%) and ochratoxin A (OTA, 16%). Aflatoxins, gliotoxin and ochratoxin alpha could not be detected in any of the samples. Total DON concentrations in post-shift samples of workers were significantly higher than those observe in samples of controls (medians 2.94 vs. 1.69 mug/g creatinine). Additionally, total DON concentrations increased over the working shift. No exceedance of the tolerable daily DON intake was observed.

Thus, the results point to an occupational exposure to DON that is unlikely to pose a health risk. Contrary, urinary OTA levels reveal no differences between workers and controls, and thus, mainly reflect the dietary background exposure.

<https://doi.org/10.1016/j.ijheh.2026.114768>

Madsen, A. M., Vermaere, L., Wagtberg, M., Al-Saidi, A., Hoet, P.

Bioaerosol exposure, inflammation, and symptoms in waste collectors: Work tasks, waste types, and hygiene practices.

Int J Hyg Environ Health, 2026, Vol. 276, 114851

Waste collection is a critical sector, and maintaining a healthy working environment is essential. This study aimed to (i) characterize waste collectors' exposure to bioaerosols, (ii) examine associations between workday exposure to bioaerosols and serum inflammatory markers, and between week-exposure and self-reported symptoms, and (iii) identify hygiene practices, work tasks, and waste types associated with reported symptoms.

In a cross-sectional study, exposure was measured among 56 waste collectors using personal air samplers. Blood samples collected at the end of the workday were analyzed for three inflammatory markers. Participants completed a questionnaire on health symptoms, hygiene practices, and work tasks. Individual week-exposure estimates were derived from exposure measurements among 105 collectors, accounting for season, waste type, and work task. Inflammatory markers indicated low-grade systemic inflammation and were positively associated with workday exposure to anaerobic bacteria. Week-exposure to anaerobic bacteria was associated with increased odds of runny nose and sore throat. Eating in the truck cab was associated with eye symptoms and diarrhea. Use of hand sanitizer was associated with lower odds of nasal symptoms and colds. Cleaning of the truck waste compartment was associated with higher exposure and increased odds of eye and airway symptoms. These findings suggest that anaerobic bacterial exposure, work tasks, and hygiene behaviors may contribute to inflammatory responses and symptoms among waste collectors.

The results should be interpreted as hypothesis-generating and support the need for confirmatory intervention studies to evaluate causal relationships and preventive measures related to residual and biowaste collection, truck cleaning, and hygiene practices.

<https://doi.org/10.1016/j.ijheh.2026.114851>

2. Coexpositions agents chimiques et physiques

2.1 Chaleur, stress thermique

Etude du mécanisme physiologique de l'interaction chaleur et zinc chez un petit crustacé.

Dong, Y., Verheyen, J., Stoks, R.

Bio-energetic traits and hemoglobin as drivers of tolerance to combined exposure to metals and warming.

Aquatic Toxicology, 2026, Vol 298, 107929.

Warming is increasingly recognized to magnify the toxicity of chemicals. Yet, limited understanding of the underlying physiological mechanisms constrains our ability to predict these interactions between warming and toxicants, and how these may evolve under global climate change scenarios. Here, a common-garden experiment was conducted with two resurrected subpopulations of *Daphna magna*, separated by ca. 40 years in time, of which the recent subpopulation evolved a higher heat tolerance. *Daphnia* were exposed to low (150 µg L⁻¹) and high (300 µg L⁻¹) zinc levels across a large thermal

gradient (12 °C - 30 °C). After 96-h exposure, bioenergetic traits, oxidative damage to lipids and hemoglobin levels were quantified.

Both zinc levels caused stronger reductions in net energy budget at higher temperatures in both subpopulations. At the highest temperature, low zinc reduced energy consumption in the old subpopulation, whereas the recent subpopulation evolved an increased energy consumption, resulting in a greater decline in the net energy budget. Across treatment groups, survival correlated positively with the net energy budget, and negatively with oxidative damage, while the hemoglobin levels correlated positively with the acute heat tolerance.

These findings suggest reductions in the net energy budget to be a key driver of the widespread phenomenon whereby toxicants become more lethal at higher temperatures, and reductions in hemoglobin to contribute to the toxicant-induced declines in heat tolerance. Overall, our study underscores the importance of incorporating physiological mechanisms to understand and predict the current and future sensitivity of organisms to contaminants under ongoing climate change.

<https://doi.org/10.1016/j.aquatox.2026.107929>

Revue de littérature sur les maladies rénales chroniques et l'exposition à la chaleur, le stress thermique chez les travailleurs en extérieur.

Long Holt, K.

Occupational Heat Stress and Chronic Kidney Disease of Uncertain Etiology : An Emerging Public Health Crisis in the Outdoor Workforce.

International Journal of Medical and Health Research, 2026, Vol. 4 (2), 116–122.

Chronic kidney disease of unknown cause (CKDu) is now considered an important occupational and public health problem. It affects predominantly outdoor workers in agriculture, construction, and industries. Whereas typical cases of CKD are usually caused by diabetes and/or hypertension, recent studies have linked CKDu to repeated occupational heat stress, dehydration, and nephrotoxicity in hot work environments.

This review incorporates relevant literature on the subject to demonstrate the possible pathways through which chronic heat exposure can lead to renal damage.

These pathways include repetitive acute subclinical injury to the kidneys from dehydration and hyperthermia; fructokinase pathway activation from dehydration; oxidative stress pathways; and nephrotoxic effects due to co-exposure to agrochemicals and heavy metals. Considerations regarding occupational health practice are discussed. The rising temperatures due to climate change make heat-related disorders common not just in outdoor occupations but in most industries.

Thus, CKDu is a preventable occupational disorder that warrants the attention of environmental health experts, policymakers, and employers.

<https://doi.org/10.61424/ijmhr.v4i2.836>

Exposition combinée aux hydrocarbures aromatiques polycycliques générés par la cuisson et charge de travail physique chez des cuisiniers.

Yadoun, S., Jeeno, P., Tongchai, P., Ounjaijean, S., Boonyapranai, K., Kawichai, S., *et al.*

Occupational Exposure to Cooking-Generated Polycyclic Aromatic Hydrocarbons and Associated

Oxidative Stress and DNA Damage Among Grill Restaurant Workers.

Toxics, 2026, Vol. 14 (6), p. 512

Street-food grilling is a common occupation in Asia, yet the occupational health risks associated with cooking-generated polycyclic aromatic hydrocarbons (PAHs) exposure, occurring alongside plausible unmeasured co-exposures such as ambient heat and physical workload, remain under-researched. This study investigated the internal dose of PAH exposure and its association with early biological effects and physiological strain among grill restaurant workers.

A cross-sectional study was conducted involving grill workers and 20 age/BMI-matched controls. Urinary 1-hydroxypyrene (1-OHP) was utilized as the primary exposure biomarker.

The study assessed early biological effects such as oxidative stress (8-OHdG, F2-isoprostanes), lung epithelial integrity (CC16), and genotoxicity (BPDE-DNA adducts) via ELISA. Physiological parameters, including blood pressure and heart rate, were recorded to evaluate acute cardiovascular strain. Workers had significantly elevated urinary 1-OHP levels compared to controls (Hodges-Lehmann ratio = 3.66, 95% CI: 1.68-7.12, representing a 3.7-fold median increase), with exposure levels increasing proportionally to smoke proximity. Notably, workers demonstrated a significantly higher median resting heart rate (HL ratio = 1.13, 95% CI: 1.05-1.23; +12.9%) and systolic blood pressure (HL ratio = 1.09, 95% CI: 1.00-1.18; +8.9%) compared to their office-based peers. Although strong correlations were observed among biological effect biomarkers ($r_s = 0.42-0.63$), there were no significant differences between groups for 8-OHdG, CC16, or BPDE-DNA adducts, suggesting that cardiovascular parameters reflect acute short-term responses, while genomic damage markers may require higher cumulative exposure thresholds to become detectable.

The study revealed that grill restaurant workers face substantial internal PAH exposure and significant cardiovascular strain, occurring alongside plausible unmeasured co-exposures including ambient heat and physical workload. The prevalence of chronic cough and elevated heart rate is a critical early warning sign for occupational health. Our findings indicate that current general ventilation is inadequate, highlighting an urgent need for localized engineering controls and comprehensive health surveillance, including cardiovascular monitoring in the service sector.

<https://doi.org/10.3390/toxics14060512>

Coexposition aux hautes températures et aux composés volatiles chez les travailleurs du secteur pétrolier.

Li, M., Xu, R., Zhang, Y., Du, S., Xu, R., Zu, Q., *et al.*

Additive effects of heat and volatile organic compounds co-exposure on metabolic syndrome: evidence from petrochemical workers in China.

Int Arch Occup Environ Health, 2026, Vol. 99 (6), article number 36.

OBJECTIVE: To investigate the independent and joint associations of heat and volatile organic compounds (VOCs) exposure with metabolic syndrome (MetS) among petrochemical workers. **METHODS:** A cross-sectional study was conducted among 1140 petrochemical workers in the Quangang Petrochemical Industrial Park, China. Occupational heat and VOCs exposures were assessed following national occupational standards, and MetS was defined according to the 2020 Chinese Type 2 Diabetes Prevention and Treatment Guidelines. Multivariable logistic regression and interaction analysis using the relative excess risk due to interaction (RERI) were performed to evaluate additive associations. Machine

learning models were further applied to explore the relative contributions of exposures.

RESULTS: The prevalence of MetS among workers was 27.8%. After adjustment for demographic, behavioral, and occupational factors, heat exposure (OR = 1.53, 95% CI: 1.12-1.94) and VOCs exposure (OR = 1.38, 95% CI: 1.08-1.79) were both associated with higher MetS risk. Workers exposed to both heat and VOCs showed a stronger association with MetS (OR = 2.08, 95% CI: 1.32-2.96), with evidence of a positive additive interaction (RERI = 0.405, Pinteraction = 0.012). Exploratory machine-learning analyses further suggested that combined heat and VOC exposure contributed more to MetS than either exposure alone.

CONCLUSIONS: Combined exposure to heat and VOCs showed evidence of a positive additive interaction in relation to MetS among petrochemical workers. These findings underscore the need for integrated occupational health strategies in heat-sensitive industries under a warming climate.

<https://doi.org/10.1007/s00420-026-02227-1>

Armstrong, A. F., Zabaneh, I. D., Maluli, I. A., Dafoe, P., Sheu, A., Swenson, W.

Health Effects of Smoke Exposure in Wildland Firefighters.

Atmosphere, Vol. 17 (6), (2026), p 601.

Wildland firefighters play a critical role in protecting communities and natural resources, yet comparatively little research has examined the occupational health risks associated with repeated smoke exposure. This narrative review analyzed documented health effects, contributing exposure determinants, and mitigation strategies across 38 studies meeting pre-specified inclusion criteria. Included studies were predominantly quantitative field investigations evaluating pulmonary, cardiovascular, metabolic, and chemical exposure outcomes.

Consistent findings documented decreased lung function, elevated oxidative stress, increased carbon monoxide (CO) exposure, and cumulative cardiovascular risk. Wildland firefighters were associated with polycyclic aromatic hydrocarbon (PAH) levels 2.2-26.7 times higher than controls. Prescribed burns produced CO concentrations 233% higher than off-fire-line days. Cardiovascular disease accounts for approximately 45% of annual line-of-duty fatalities among U.S. firefighters. Contributing factors included career duration, fire type, and operational role. Altogether, these findings underscore the severe, multi-system health risks faced by wildland firefighters and highlight a pressing need for modern mitigation strategies and firefighter-specific protective technologies to safeguard long-term health.

<https://doi.org/10.3390/atmos17060601>

Li, M., Zhang, Y., Zhang, Z. Et Al.

Occupational heat exposure and chronic kidney disease risk under climate warming: a retrospective cohort study of petrochemical workers with mechanistic insights.

Environ Health, 2026, Vol. 25 : 52.

Background : The modifying role of climate warming in the association between occupational heat exposure and chronic kidney disease (CKD), and the related biological mechanisms, remains incompletely understood among petrochemical workers.

Methods : We conducted a retrospective cohort study of 2,649 petrochemical workers in southeastern China between 2013 and 2022. Occupational heat exposure was assessed using on-site wet-bulb globe

temperature (WBGT) measurements, reflecting the overall workplace thermal load arising from ambient temperature, process-related heat sources, humidity, and air movement. Incident CKD was defined according to the 2024 Kidney Disease: Improving Global Outcomes (KDIGO) guidelines. Long-term ambient temperature data were incorporated to evaluate effect modification by climate warming and ambient temperature background. In addition, mediation analyses of blood-based biomarkers and a nested case–control metabolomics study were conducted to explore potential biological mechanisms.

Results : During a median follow-up of 7.1 years, 386 incident CKD cases were identified. Occupational heat exposure was significantly associated with an increased risk of CKD (HR = 1.40, 95% CI: 1.13–1.71). This association was significantly amplified under conditions of greater climate warming and higher annual mean ambient temperatures (P-interaction < 0.001). Mediation analyses indicated that uric acid, hemoglobin, and albumin partially mediated the association between occupational heat exposure and CKD risk. Metabolomic analyses further revealed shared metabolic alterations related to the accumulation of gut-derived uremic toxins and disturbances in amino acid metabolism.

Conclusions : Occupational heat exposure was associated with an elevated risk of CKD among petrochemical workers, and this risk is likely further intensified in the context of ongoing climate warming. These findings highlight the importance of incorporating climate context into occupational heat-related health risk assessments and suggest that integrating routine biomarkers with metabolomic features may enhance early identification and prevention of CKD among occupational heat-exposed workers.

<https://doi.org/10.1186/s12940-026-01305-8>

2.2 Charge de travail et produits chimiques

Exposition aux polymères d'epoxy dans un lieu de production de pâles d'éoliennes et tâches physiques.

Pinheiro, V., Botelho-Rodrigues, G., Da Silva, R. B., Pacheco, V., Marques, A., Marques, C., *et al.*

Skin Sensitisation and Dermatitis Among Epoxy-Exposed Workers in a Wind Turbine Plant : Influence of Occupational Factors.

Contact Dermatitis, 2026, Vol 95, (1) p 65–73

BACKGROUND: Epoxy polymers, widely used in industries such as wind turbine production, are common causes of allergic contact dermatitis (ACD). However, gaps remain mostly regarding the type of occupational exposure (specific tasks) and protective strategies.

OBJECTIVES: To evaluate epoxy resin sensitisation in a wind turbine blade plant and assess its associations with tasks, medical history, clinical patterns, and personal protective equipment (PPE) use.

METHODS: A cross-sectional study was performed in a large wind turbine blade facility. A group of volunteer workers completed a questionnaire on occupational/medical history, PPE use, and symptoms. Onsite patch testing included the European Baseline-, epoxy-, and isocyanate series. Data were analysed using SPSS and R (p < 0.05).

RESULTS: Among 131 workers tested (7.4% of the workforce), seven (5.3%), all from high-exposure tasks, showed positive reactions to epoxy compounds: Bisphenol F resin (5), Bisphenol A resin (4), and hardeners/additives (5). Hand dermatitis was the predominant ACD pattern, with a median time to onset of 8 months after employment. No associations were found between sensitisation and previous medical history or PPE compliance.

CONCLUSIONS: The ACD to epoxy resin is a significant concern in wind turbine blade manufacturing. Accurate diagnosis requires patch testing with epoxy-specific series, beyond the European Baseline series. Prevention should extend beyond PPE, addressing airborne exposure and cross-contamination.

<https://doi.org/10.1111/cod.70138>

Secteur de la sidérurgie : exposition combinée physique et chimique.

Liu, M., Chen, X., Ma, X., Zhang, M., Xu, X., Luo, Z., *et al.*

Development and validation of an Occupational Hazards Index (OHI) and its association with hypertension-diabetes comorbidity in steel workers: a prospective cohort study.

BMC Public Health, 2026, Vol. 26, 1636.

Contexte : Les ouvriers sidérurgistes sont exposés à des risques professionnels complexes ; cependant, les preuves concernant les effets conjoints de ces dangers sur la comorbidité hypertension-diabète (HDC) restent limitées en raison de l'absence d'un outil complet d'évaluation de l'exposition.

Méthodes : Une étude de cohorte prospective a été menée à partir de données de la « Cohorte sur l'effet sur la santé des populations professionnelles dans la région Beijing-Tianjin-Hebei ». Un total de 5 310 ouvriers sidérurgistes sans HDC au départ (2017) ont été suivis jusqu'en 2024. L'Indice des Risques Professionnels (OHI) a été élaboré en intégrant des niveaux mesurés de 22 dangers physiques et chimiques (par exemple, haute température, bruit, poussière, monoxyde de carbone [CO], métaux) à l'aide du modèle de norme euclidienne, basé sur les quotients de risque (concentration mesurée/Limite d'exposition professionnelle [OEL]). La HDC a été définie comme la cooccurrence de l'hypertension et du diabète de type 2. Des modèles de risques proportionnels de Cox ont été utilisés pour estimer les rapports de risques (HR) et les intervalles de confiance (IC) à 95 % pour l'association entre l'OHI (analysé à la fois comme une variable continue et catégorisé en groupes à risque élevé/faible sur la base d'une valeur de coupure limitée dérivée de spline cubique de 102,75) et le risque HDC, avec un ajustement pour les facteurs de confusion potentiels.

Résultats : Sur une période de suivi médiane de 72 mois, 595 cas incidents de CDH ont été identifiés, avec une incidence cumulative de 11,2 %. L'OHI montrait une distribution asymétrique à droite (médiane : 102,76 ; plage interquartile [IQR] : 79,38-132,38). Une relation dose-réponse non linéaire significative a été observée entre le risque d'IHO et de CDH (P pour l'association globale < 0,001, P pour la non-linéarité < 0,001). Après ajustement complet pour les caractéristiques démographiques, les antécédents familiaux de maladies chroniques, les facteurs de mode de vie, les mesures anthropométriques et les facteurs professionnels, chaque augmentation d'une unité de l'OHI était associée à un risque de HDC supérieur de 0,3 % (HR = 1,003 ; IC à 95 % : 1,001-1,005). Les travailleurs du groupe à haut risque OHI ($\geq 102,75$) présentaient un risque 30,8 % plus élevé de HDC que ceux du groupe à faible risque (HR = 1,308, IC 95 % : 1,108-1,543). Des analyses stratifiées ont suggéré que l'association pourrait être plus marquée chez les hommes, les individus âgés de 40 à 49 ans, les fumeurs actuels et ceux ayant des modes de vie malsains (par exemple, mauvaise alimentation, obésité).

Conclusion : Nous avons développé un nouvel Indice des Risques Professionnels (OHI) qui quantifie efficacement l'exposition professionnelle combinée. Nos résultats prospectifs indiquent que des scores OHI plus élevés sont significativement associés à un risque accru de CDH chez les ouvriers de l'acier, soulignant l'importance d'une évaluation complète des risques professionnels pour la prévention primaire de cette comorbidité.

<https://doi.org/10.1186/s12889-026-27229-z>

3 Coexpositions avec le bruit

3.1 Bruit et agents chimiques

Expositions combinées bruit et métaux lourds dans une industrie de fonderie.

Zhang, J., He, J., Zhang, Y., Chen, M., Deng, J.

Effects of mixed blood metals on hearing loss among steel workers : a case-control study.

Front Public Health, Vol. 14, (2026), 1863565.

OBJECTIVES: To investigate the associations of single and multiple blood metal exposures with hearing loss, and evaluate the interactions between metals and noise exposure, thereby providing scientific evidence for the prevention and control of hearing loss in occupational populations.

METHODS: This study investigates the associations between 17 blood metals and hearing loss among steel workers. A matched case-control study was conducted, including 300 cases with hearing loss and 300 age- and sex-matched controls, selected from 4,081 eligible workers. Metal concentrations were measured by inductively coupled plasma mass spectrometry (ICP-MS). Associations were estimated by multivariable logistic regression, LASSO regression, weighted quantile sum (WQS) regression, and Bayesian kernel machine regression (BKMR). The most important metals were identified, and their additive interactions with noise exposure were further assessed.

RESULTS: Cases and controls were comparable in age, sex, and work tenure (all $P > 0.05$). Blood levels of Mn, Cu, As, Se, and Sr were significantly higher in cases than in controls (all $P < 0.05$). Logistic regression showed that Mn (OR = 4.68, 95%CI: 2.88-7.59), Cu (OR = 3.30, 1.55-7.04), As (OR = 1.14, 1.05-1.22), Se (OR = 4.25, 2.16-8.37), and Sr (OR = 8.22, 4.56-14.80) were associated with increased hearing loss risk. WQS analysis indicated a positive association between metal mixture and hearing loss (OR = 6.52, 95%CI: 3.61-11.78), with Se (0.261) and Sr (0.256) having the highest weights. BKMR further identified Mn and Sr as the most important predictors. Significant additive interactions were found respectively for Mn and Sr with noise exposure: RERI = 11.36 (5.72-39.38) and 17.53 (8.07-66.64).

CONCLUSION: Noise and multiple metals (particularly Mn and Sr) were significantly associated with hearing loss in steel workers, with potential additive interactions observed between these exposures. Therefore, comprehensive occupational health strategies addressing both noise and metal exposures may be important for hearing loss prevention.

<https://doi.org/10.3389/fpubh.2026.1863565>

Combinaison bruit et poussière, agents chimiques : facteurs de risque cardiovasculaires.

Liu, J. H., Li, Q., Liu, J. M.

Cardiovascular composite events and the healthy worker effect among noise-exposed workers: a retrospective cohort study.

Frontiers in Public Health, Vol. 14, (2026), p 1889187.

Background: Occupational noise exposure is prevalent, but its cardiovascular effects are under recognized. Most studies are cross-sectional, focus on single endpoints, and rarely account for the healthy worker effect (HWE). This study aimed to identify risk factors for cardiovascular composite events in noise-exposed workers and further assess this effect.

Methods: This retrospective cohort study enrolled 1,381 noise-exposed workers with normal blood pressure and normal electrocardiogram at baseline in 2020. All participants were followed annually through 2023. The primary endpoint was a composite cardiovascular event (hypertension or electrocardiographic abnormality). Cox proportional hazards models were used to identify associated factors. Restriction analysis, restricted cubic spline analysis, and sensitivity analyses were performed to assess robustness.

Results: Multivariable Cox regression identified systolic blood pressure (SBP) (HR = 1.012, 95% CI 1.005-1.020, $p < 0.001$) and smoking (HR = 1.191, 95% CI 1.029-1.377, $p = 0.019$) as independent risk factors. Work duration >120 months showed an apparent protective effect (HR = 0.621, 95% CI 0.466-0.826, $p = 0.001$). After excluding pre-employment workers, the reduced risk for >120 months persisted (HR = 0.787, 95% CI 0.638-0.969, $p = 0.024$). Forcing age into the multivariable model did not materially change the effect estimates. Sensitivity analysis showed that baseline SBP ≥ 130 mmHg was associated with a 66.3% increased risk of composite events (HR = 1.663, 95% CI 1.327-2.085, $p < 0.001$). For the hypertension endpoint, combined exposure to noise and dust (HR = 1.896, 95% CI 1.219-2.949, $p = 0.005$) and combined exposure to noise and chemical agents (HR = 1.580, 95% CI 1.013-2.463, $p = 0.044$) significantly increased risk.

Conclusion: Smoking and elevated SBP are independent risk factors for cardiovascular composite events in noise-exposed workers. The apparent protective effect of work duration is consistent with the HWE. Combined exposure to noise with dust or chemical agents significantly increases the risk of hypertension.

<https://doi.org/10.3389/fpubh.2026.1889187>

Etude chez le rat de l'exposition combinée bruit et aluminium.

Biganeh, J., Zakerian, S. A., Esmaeelpour, M. R. M., Mohammadi, S., Khosravi, A., Shahtaheri, S. J.

Effects of Noise and Aluminum Co-Exposure on Behavioral and Cognitive Indices and Biomarkers in a Wistar Rat Model.

Journal of Health and Safety at Work, 2026, Vol. 16 (1), 80–98.

Introduction: Combined exposures, such as noise and aluminum exposure, are present in many occupational workplaces. Nevertheless, the neurocognitive effects resulting from this co-exposure have been scarcely investigated. The present study aimed to determine the effects of noise and aluminum co-exposure on behavioral and cognitive indices and biomarkers in a Wistar rat model.

Material and Methods: This experimental study investigated 20 adult male Wistar rats over a period of 45 days, divided into four groups: 1. Control group (no exposure), 2. Noise exposure group (95 dB, 4 hours daily), 3. Aluminum chloride exposure group (10 mg/kg, daily intraperitoneal injection), and 4. Combined noise and aluminum exposure group (a combination of Group 2 and Group 3). Spatial memory performance was assessed using the Morris Water Maze test. The serum concentrations of total tau protein and beta-amyloid 42 were measured in blood samples using the ELISA method. Data were analyzed using SPSS software, version 27.

Results: Behavioral test results indicated that the control group spent the least time searching for the

platform. Exposure to aluminum and the combination of noise + aluminum led to a significant decrease in cognitive performance. Furthermore, serum levels of tau protein and beta-amyloid were significantly increased in all exposed groups ($p < 0.01$), and a strong positive correlation was observed between these two biomarkers ($r = 0.70$, $p < 0.001$).

Conclusion: Findings demonstrated concurrent noise and aluminum exposure can synergistically impact cognitive performance and neurodegenerative biomarkers. These alterations likely occur through shared mechanisms such as oxidative stress, neuroinflammation, and disruption of protein homeostasis. Increased tau and amyloid, coupled with memory decline, underscore this combined role in worsening neurodegeneration. These results suggest monitoring combined exposure and using blood biomarkers for early cognitive assessment.

<https://doi.org/10.18502/jhsw.v16i1.21890>

Nunes, M. J. G., Quelhas, O. L. G., Domingos, M. D. L. C.

Combined exposure to noise and ototoxic solvents: contributions to the revision of legal limits based on the literature.

Revista brasileira de medicina do trabalho : publicacao oficial da Associacao Nacional de Medicina do Trabalho-ANAMT, 2026, Vol. 24 (1) e20261489–e20261489

Work-related hearing loss resulting from combined exposure to noise and ototoxic solvents remains underestimated in occupational prevention practices. Substances such as toluene, xylene, and styrene, which are widely present in industrial environments, potentiate auditory damage even at levels below the tolerance limits considered safe.

By conditioning the implementation of the Hearing Conservation Program solely on the action level for isolated noise exposure, Brazilian legislation proves insufficient in addressing the complexity of contemporary occupational risks.

This opinion article proposes a critical reflection on the current regulatory limits and advocates for the revision of occupational hearing health prevention policies. Integrated strategies are discussed, including the simultaneous monitoring of exposure to noise and ototoxic chemical agents, the revision of occupational exposure limits, the continuous training of professionals in the field, and the adoption of hierarchical control measures. Protecting workers' hearing health requires more comprehensive approaches capable of recognizing the interaction among different risk agents and promoting truly safe work environments.

<https://doi.org/10.47626/1679-4435-2026-1489>

JOHNSON Z. ; SLAGLEY J. ; SCHAAL N. ; MATTIE D. ; ET COLL.

Retrospective cohort study of pure tone audiometry hearing changes from ototoxic metals and solvents, continuous noise, and impulse noise exposures at Hill Air Force Base from 2005 to 2019.

(Etude de cohorte rétrospective des modifications de l'audition évaluées par audiométrie tonale en lien avec l'exposition à des métaux et solvants ototoxiques, au bruit continu et au bruit impulsif à la base aérienne de Hill, de 2005 à 2019).

Journal of Occupational and Environmental Hygiene, vol. 23, n° 2, février 2026, pp. 100-112

Cette étude rétrospective évalue le risque de perte auditive lié à l'exposition professionnelle combinée à des métaux et solvants ototoxiques, au bruit continu et au bruit impulsionnel chez 893 travailleurs d'une base aérienne américaine suivis entre 2005 et 2019. Les données d'exposition et de surveillance audiométrique ont été analysées selon différents groupes d'exposition. Les travailleurs exposés à des substances ototoxiques présentent globalement un risque de perte auditive supérieur à ceux exposés uniquement au bruit, sans différence statistiquement significative dans cette population. L'analyse combinée avec les données d'une autre base aérienne met toutefois en évidence des augmentations significatives du risque pour certaines expositions. Le risque le plus élevé est observé lors de l'exposition simultanée aux métaux, aux solvants et au bruit continu. L'âge et la durée du suivi audiométrique sont également associés à la perte auditive.

Référence INRS-Biblio : 773335

<https://doi.org/10.1080/15459624.2025.2569365>

Zhihao Shi, G. L., Zhehua Zhou

Combined effects of xylene and noise exposure at realistic low levels on hearing impairment: a cross-sectional study in China.

Prev Med Rep, (2026), Vol. 16 (68), p. 103546

Objectives: To investigate the combined effect of low-level xylene and noise exposure on hearing impairment in Chinese manufacturing workers and to provide evidence for occupational hearing protection strategies in China.

Methods: A cross-sectional survey was conducted among 899 workers (295 co-exposed, 604 noise-only) in Jiaying City, China from 2023 to 2025. Workplace noise and xylene concentrations were monitored, and pure-tone audiometry was performed with age-gender correction. Binary logistic regression and stratified regression analysis were used to evaluate risk factors for high-frequency hearing loss (HFHL).

Results: The HFHL prevalence was 5.76% in the combined exposure group and 2.48% in the noise-only group ($P = 0.01$). Logistic regression model shows that the combined exposure group had a 5.49-fold higher HFHL risk ($P < 0.01$). Hypertension, longer exposure duration, higher noise intensity and higher xylene concentration were independent risk factors for HFHL. Stratified analyses confirmed a higher HFHL risk in the combined exposure group across subgroups of age $< 40/ \geq 40$ years, male workers, and exposure duration 0-5/6-10 years.

Conclusions: Combined xylene and noise exposure exerts a significant synergistic ototoxic effect even when both exposures are within Chinese national occupational exposure limits.

<https://doi.org/10.1016/j.pmedr.2026.103546>

Ma, J., He, Y., Meng, J., Li, B., Song, R., Liu, B., *et al.*

Association between combined occupational exposure to coal dust and noise and high-frequency hearing loss among workers: a cross-sectional study.

Frontiers in Public Health, (2026), Vol. 14.

Background : Occupational environments contain a wide variety of harmful factors, with noise often

coexisting with other physical, chemical factors, leading to combined exposure that may increase the risk of hearing impairment among workers. This study aims to investigate the association of occupational noise and coal dust combined exposure on noise-induced hearing loss in workers, providing evidence for the prevention and control of occupational noise-induced hearing loss in occupational populations.

Methods: We conducted a cross-sectional study of 1,187 occupationally exposed workers. These workers who underwent occupational health examinations at a certain occupational health examination institution in Baiyin City in 2023 were selected as study subjects and divided into a noise only group (276 participants) and a combined noise-coal dust exposure group (911 participants). Pure-tone air-conduction audiometry was used to assess hearing loss, and the chi 2 test and multivariate logistic regression analysis were applied to identify risk factors for high-frequency hearing loss (HFHL).

Results: The prevalence rates of HFHL were 35.5 and 46.8% in the noise group and the combined noise-coal dust exposure group, respectively, with a statistically significant difference ($p < 0.001$); the prevalence of speech-frequency hearing loss was relatively low. Hearing abnormalities were primarily concentrated in the high-frequency range, with a marked decline around 4,000 Hz. Multivariate logistic regression analysis indicated that age, gender, and exposure to occupational hazards were independent risk factors for HFHL. After multivariable adjustment, combined exposure to occupational noise and coal dust was associated with higher odds of HFHL compared with noise exposure alone (OR = 1.620, 95% CI: 1.198-2.190, $p = 0.002$).

Conclusion: Occupational noise-induced hearing loss is predominantly HFHL, and Workers classified as jointly exposed to occupational noise and coal dust had higher adjusted odds of HFHL than workers classified as exposed to occupational noise alone. Comprehensive protection and occupational health surveillance for workers exposed to combined hazards should be strengthened.

<https://doi.org/10.3389/fpubh.2026.1929586>

3.2 Bruit et horaires de travail

Jiang, P. S., Li, Y. H., Bai, L. X., Kuang, X. Y., Zhao, Y., Tang, Y. X., *et al.*

Effects of noise exposure and long working hours on oxidative stress levels and high-frequency hearing threshold damage in occupational populations.

Frontiers in Public Health, Vol. 14, (2026), p.

Introduction Occupational noise-induced hearing loss remains a significant public health concern in China. This study aimed to investigate the associations between combined exposure to occupational noise and long working hours with oxidative stress levels and high-frequency hearing loss (HFHL) in an occupational population.

Methods A total of 547 Chinese workers from eight manufacturing enterprises in Guangzhou who were engaged in noise-exposed occupations were recruited. Participants were divided into a noise exposure group (weekly working hours ≤ 40 h, $n = 332$) and a combined exposure group (weekly working hours >40 h, $n = 215$). Pure-tone audiometry was performed, and serum levels of superoxide dismutase (SOD), catalase (CAT), malondialdehyde (MDA), and glutathione peroxidase (GPx) were measured using colorimetric microplate assays. Nonparametric tests and binary logistic regression analyses were conducted.

Results The study included 532 males (97.3%) and 15 females (2.7%). Compared with the noise exposure

group, the combined exposure group presented significantly lower SOD activity and CAT activity ($p < 0.05$) and significantly higher MDA concentration ($p < 0.05$). The overall prevalence of HFHL was 43.14%, with significantly higher rates in the combined exposure group ($p < 0.001$). Logistic regression analysis revealed that the levels of SOD (OR = 0.869), CAT (OR = 0.963), and MDA (OR = 1.496) were significantly associated with HFHL. In forward stepwise multivariate analysis, only CAT remained an independent influencing factor (OR = 0.963, 95%CI: 0.941-0.985; $p = 0.001$). Conclusion Combined exposure to noise and long working hours is associated with exacerbated oxidative stress and high-frequency hearing loss in occupational populations. CAT acts as an independent protective factor against HFHL, suggesting its potential as a biomarker for hearing damage assessment, although prospective validation is needed.

<https://doi.org/10.3389/fpubh.2026.1827520>

4. Coexpositions aux champs électromagnétiques, bruits, et horaires de travail

Soumilion, M., Remy, V. F. M., Petrovic, D., Dil, J. H., Guseva Canu, I.

Occupational electromagnetic field exposure and sleep disturbances: The predominant role of high-frequency electric fields.

Int J Hyg Environ Health, Vol. **277**, (2026), 114886 p.

Electromagnetic fields (EMFs) are ubiquitous and include low-frequency magnetic fields (LF-MF) from alternating currents, low-frequency electric fields (LF-EF) from wiring and equipment, and high-frequency electric fields (HF-EF) from wireless technologies and broadcast antennas. Bus drivers are exposed to an EMF mixture and report higher rates of sleep disorders than the general population. This study aimed to examine associations between sleep disturbances and cumulative occupational EMF exposure over 12 months, considering individual components and the mixture. EMF exposure estimates from the Swiss bus-exposure matrix were matched to the occupational history of 351 TRAPHEAC study bus drivers. Sleep quality, insomnia, and excessive daytime sleepiness (EDS) were assessed using the Global Sleep Assessment Questionnaire. Associations with cumulative EMF exposure were evaluated using multivariable linear regression controlled for age, sex, occupational noise, and nightshift work, and heat exposure.

Mixture effects were analyzed with Bayesian Kernel Machine Regression (BKMR), and the influence of non-occupational EMF exposure was examined via stratification. Multivariable linear regression showed positive associations of HF-EF, but not LF-EF or LF-MF, with insomnia and EDS, although models explained little variance. BKMR confirmed the predominance of HF-EF in the mixture effect, with a positive but statistically non-significant dose-response for the EMF mixture. Stratified analyses suggested stronger associations among drivers with low non-occupational EMF exposure.

These findings suggest a dose-response relationship between occupational EMF mixture exposure and sleep disturbances, primarily driven by HF-EF. However, the overall variance explained by EMF exposure is small, highlighting the role of other risk factors in sleep disturbances among bus drivers.

<https://doi.org/10.1016/j.ijheh.2026.114886>

5. Coexpositions travail de nuit et agents chimiques

Parks, J., Zanif, U., Bhatti, P.

Occupational exposure to carcinogenic substances in night versus day shift jobs.

Scand J Work Environ Health, 2026, 52(4):434-441

OBJECTIVES: This study aimed to determine whether night shift work was associated with exposure to carcinogenic hazards, independent of occupation and industry.

METHODS: We conducted a cross-sectional analysis of 16 250 job records reported by 7023 participants. Participants provided lifetime job histories, including shift schedules and exposures to hazardous agents. Carcinogenic agents included established carcinogens classified by the International Agency for Research on Cancer, as well as broader exposure categories that may potentially contain carcinogenic constituents. Jobs involving ≥ 1 and ≥ 7 night shifts/month were compared with day-shift jobs. Occupations and industries were coded using National Occupational Classification (2016) and North American Industry Classification System (2017) codes. Generalized linear mixed models with random intercepts for participant, occupation code (2-digit level), and industry code (2-digit level) were used to estimate odds ratios (OR) for exposures associated with night- versus day-shift work, adjusting for biological sex and job start year.

RESULTS: Night shifts were associated with greater odds of any hazardous exposure [≥ 1 night shift/month: OR 3.1, 95% confidence interval (CI) 2.6-3.8; ≥ 7 night shifts/month: OR 3.1, 95% CI 2.5-3.8]. Significant associations were observed for multiple agents, including asbestos, degreasing agents, diesel engine exhaust, gasoline engine exhaust, ionizing radiation, mineral/cutting/lubricating oil, paints/stains/varnish, welding fume, and wood dust.

CONCLUSIONS: Night-shift work was associated with an increased likelihood of self-reported exposure to multiple potentially carcinogenic agents, independent of broad occupational and industry groupings. Future research with more granular task-level information and quantitative exposure assessment will be important for clarifying the mechanisms underlying these differences.

<https://doi.org/10.5271/sjweh.4307>

6. Coexpositions vibrations main-bras et chaleur

Yang, S.

Occupational Exposure to Hand-Arm Vibration (HAV) and Heat and Associated Effects on Vascular Health.

United States -- Alabama: The University of Alabama at Birmingham; ProQuest Dissertations & Theses, 2026. 32785491.

Grounds maintenance workers in the southeastern United States are exposed to hand-arm vibration (HAV) and heat during the summer. However, knowledge gaps remain in exposure assessment of these unregulated occupational hazards and their potential combined effects on vascular health. The purpose of this dissertation research was to examine the effects of combined exposure to HAV and heat on peripheral vascular health among groundskeepers in Alabama through simultaneous assessment of personal HAV and heat exposure. Three manuscripts aligned with the study purpose included:

7. Méthodes d'analyse des multiexpositions

Clerc, F.

L'exploitation conjointe de bases de données pour progresser dans la prévention des polyexpositions.

Archives des Maladies Professionnelles et de l'Environnement, Vol. 87 (3-4), (2026), article : 103270.
38ème Congrès National de Médecine et Santé au Travail.

Les travailleurs sont rarement exposés à une seule nuisance et la prévention des effets des polyexpositions professionnelles, chimiques, physiques, biologiques ou organisationnelles, devient un enjeu important pour les institutions et les entreprises. Pourtant, les connaissances sur les polyexpositions demeurent fragmentées, en dépit de l'existence de données portant sur différents aspects de la santé au travail. Cette étude vise à démontrer la faisabilité et la pertinence de l'intégration de plusieurs bases de données afin d'améliorer la connaissance des polyexpositions. Dix bases nationales couvrant les vingt dernières années ont été intégrées. Une harmonisation des données fondamentales – métiers, secteurs, maladies et nuisances – a été réalisée à partir des nomenclatures existantes. *(Texte tronqué)*

<https://doi.org/10.1016/j.admp.2026.103270>

Clerc, F., Barbey, C., Weibel, L.

Portrait des travailleurs polyexposés aux substances chimiques et au travail de nuit et/ou au travail posté.

Archives des Maladies Professionnelles et de l'Environnement, Vol. 87 (3-4), (2026), article : 103220.
38ème Congrès National de Médecine et Santé au Travail.

Les travailleurs de divers secteurs peuvent être exposés à de multiples risques professionnels, notamment aux substances chimiques et au travail de nuit ou posté. Cette étude vise (1) à éclairer sur les effets possibles sur la santé, (2) à quantifier le nombre de travailleurs français co-exposés et (3) à proposer des bonnes pratiques de prévention. L'analyse s'appuie sur la littérature scientifique pour identifier les effets potentiels sur la santé et sur les données des enquêtes SUMER 2010 et 2017 pour décrire les travailleurs co-exposés.

Pour la même dose d'une substance donnée, des effets différents peuvent être observés en fonction du moment de l'exposition. Il a été constaté que cette co-exposition peut entraîner un risque plus élevé de sommeil de mauvaise qualité, de syndrome métabolique, de maladies respiratoires, de maladies coronariennes et des avortements spontanés. En France, environ 6,5 millions sont exposés au travail de nuit et/ou au travail posté, avec une prévalence plus élevée chez les hommes (4,2 millions) que chez les femmes (2,3 millions). La proportion de travailleurs exposés à au moins une substance chimique est nettement plus élevée chez les travailleurs de nuit ou postés (36 % à 49 %) que chez les travailleurs de jour (26 %). Les secteurs les plus touchés sont ceux de la santé, des transports, de la construction et de l'industrie manufacturière. Les produits chimiques identifiés sont le plus souvent des désinfectants (alcools, composés d'ammonium quaternaire, eau de Javel), des gaz d'échappement diesel et des lubrifiants industriels.

Ces résultats soulignent l'ampleur de la co-exposition aux substances chimiques et au travail de nuit ou posté chez les travailleurs français. De façon plus générale, l'évaluation des risques professionnels se devrait de prendre en compte la question du « quand », c'est-à-dire les horaires de travail et les

périodes d'exposition afin d'appréhender la complexité de la relation exposition/effet et d'adapter les mesures de prévention. Par exemple, une des traductions pratiques des connaissances pourrait être la réalisation de certaines tâches ou opérations potentiellement exposantes à certains agents chimiques aux moments où les effets toxiques anticipés sont les plus faibles. Il s'agirait d'une mesure de prévention organisationnelle supplémentaire, en plus des mesures classiques de prévention collective et individuelle. De plus, les résultats de ces recherches pourraient permettre de réévaluer les valeurs limites d'exposition professionnelles (VLEP) pour les adapter aux salariés en horaires atypiques.

<https://doi.org/10.1016/j.admp.2026.103220>

Pilorget C, D. L., Ducamp S, Garras L, Rabet G, Houot Mt, Et Al.

Expositions professionnelles des travailleurs du bâtiment et des travaux publics en 2019 en France hexagonale, évaluées à partir des matrices emplois-expositions du programme Matgéné.

Bulletin épidémiologique hebdomadaire, (2026), Vol. (9), 158–172.

Introduction – Le secteur du bâtiment et des travaux publics (BTP) emploie environ 1 500 000 équivalents temps plein dont 20% de non-salariés. L'objectif de cette étude était d'estimer le nombre et la proportion de travailleurs de ce secteur exposés en France hexagonale à différentes nuisances en 2019, à partir des évaluations fournies par des matrices emplois-expositions (MEE) du programme Matgéné.

Méthode – Les MEE sélectionnées étaient celles relatives aux poussières de silice cristalline libre, aux poussières de bois, aux laines minérales, au formaldéhyde, aux carburants et solvants pétroliers, aux solvants oxygénés, aux solvants chlorés, au bruit et au travail de nuit. Elles ont été croisées avec les données du recensement de la population de 2019 fournies par l'Insee, restreint aux travailleurs et aux intérimaires du secteur du BTP, afin d'obtenir les indicateurs d'exposition aux nuisances avec leurs intervalles de sensibilité (IS) pour prendre en compte l'incertitude liée à l'évaluation de l'exposition.

Résultats – Le bruit est la nuisance avec la plus forte proportion de travailleurs exposés (62,1% [45,2-70,0], 1 066 340 travailleurs), suivi par les poussières de silice et les laines minérales. La proportion d'exposés était plus élevée qu'en population générale des travailleurs pour le bruit, les carburants et solvants pétroliers, le formaldéhyde, les poussières de bois, les laines minérales, les poussières de silice, et plus faible pour le travail de nuit et les solvants oxygénés.

Conclusion – Pour de nombreuses nuisances, les proportions d'exposés sont plus élevées qu'en population générale des travailleurs, ce qui montre que les travailleurs du BTP constituent une population particulièrement à surveiller compte tenu de la variété des risques professionnels rencontrés dans ce secteur et pour laquelle la prévention est primordiale.

https://beh.santepubliquefrance.fr/beh/2026/9/2026_9_1.html

Mcgrath, S., Wang, Y., Lin, Y. T., Meeker, J. D., Park, S. K., Warren, J. L., *et al.*

A comparison and evaluation of statistical methods for mediation analysis with mixtures of environmental exposures.

BMC Med Res Methodol, Vol 26, 93 (2026).

BACKGROUND: Environmental studies often evaluate how exposures influence health outcomes through intermediate biological processes. In practice, researchers are often interested in complex exposure

mixtures rather than single agents, creating challenges for mediation analysis due to strong correlations among exposures, sparsity of active exposures, and possible nonlinear and interactive effects. This study compares and evaluates approaches for mediation analysis when exposures involve complex mixtures.

METHODS: We review four strategies: (1) single-exposure mediation analysis that analyzes each exposure separately; (2) principal component-based mediation analysis that summarizes correlated exposures into orthogonal components; (3) environmental risk score-based mediation analysis that constructs a supervised prediction score for the exposure set and treats the score as the exposure; and (4) Bayesian kernel machine regression causal mediation analysis that flexibly models nonlinear and interactive mixture effects. For each approach, we clarify the target estimand and the assumptions required for causal interpretation. We conduct a simulation study to systematically evaluate the operating characteristics of these four methods to estimate global indirect effects and to identify individual exposures contributing to the global mediation under varying sample sizes and effect sizes. We then illustrate an application of these approaches in an observational birth cohort.

RESULTS: In the simulation study, the single-exposure mediation analysis approach often produced highly biased estimates when not adjusting for co-exposures, and this bias was substantially reduced after co-exposure adjustment. For the mediation analysis methods designed to address the correlation and complexity in exposure mixtures, the performance often depended on a number of method-specific analytic choices, such as the number of principal components retained or the variable selection approach used in the Bayesian kernel machine regression method. In the data application, all methods found limited evidence of non-null global indirect effects and had broad agreement in which individual exposures were identified as potentially active, despite differences in their assumptions and causal estimands.

CONCLUSION: Multiple strategies are available for mediation analysis with exposure mixtures, each with distinct strengths. The study provides guidance on selecting and applying methods according to study aims and data features.

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Clerc, F., Barbey, C., Aachimi, A., Bonvallot, N., Chatelot, J., Homère, J., *et al.*

Utilisation de dix bases de données françaises pour l'analyse des polyexpositions des travailleurs.

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Introduction: Plusieurs acteurs de la santé au travail en France organisent la collecte, la production ou bien colligent des données de santé et/ou d'exposition au travail. Les données des bases de l'enquête Surveillance médicale des expositions des salariés aux risques professionnels (Sumer), du Réseau national de vigilance et de prévention des pathologies professionnelles et environnementales (RNV3PE), de l'observatoire Évolutions et relations en santé au travail (Evrest), des matrices emplois-expositions MatGéné, du programme de surveillance Maladies à caractère professionnel (MCP), des bases de données d'exposition de l'INRS (Colchic, Scola, Colphy), du Compte professionnel de prévention (C2P) et les données de sinistralité de la Caisse nationale de l'Assurance maladie (Cnam) sont utilisées par leurs propriétaires respectifs avec des objectifs variés. Il peut s'agir notamment d'améliorer la reconstitution de parcours professionnels des travailleurs, d'aider les entreprises à mieux identifier et prévenir leurs risques, d'orienter des politiques de prévention des risques professionnels, de documenter l'impact sanitaire des expositions professionnelles ou, à des fins d'expertise, de détecter des risques émergents en santé au travail. Ces bases ne sont pas conçues pour être exploitées conjointement. Toutefois, les informations, de nature différente qu'elles contiennent, peuvent contribuer à mieux connaître les

risques professionnels et notamment ceux liés à la polyexposition.

Objectif: Démontrer la faisabilité de combiner les données disponibles dans ces bases de données afin d'améliorer les connaissances au sujet de la polyexposition en milieu professionnel et présenter des éléments de résultats.

Méthode: Les caractéristiques des dix bases de données sont mises en perspective : objectif de collecte ou de production, population d'intérêt, types d'expositions et/ou de pathologies, unité statistique et nomenclatures utilisées. Les grands enjeux à prendre en compte en vue d'une analyse intégrée sont présentés : les nomenclatures d'emplois utilisées pour encoder les données et le choix du niveau de détail des données pour l'analyse. Un modèle de données qui intègre toutes ces sources pour l'analyse de la polyexposition est proposé. Il s'appuie sur l'hypothèse qu'un groupe de travailleurs de même sexe, exerçant le même métier dans le même secteur d'activités est susceptible d'être exposé aux mêmes dangers et d'être atteint par les mêmes pathologies. Le secteur de la construction a été choisi pour présenter des exemples de résultats concrets : des décomptes des expositions, des co-expositions et des pathologies.

Résultats: Si on colligeait l'intégralité des bases de données, le résultat pourrait apporter des informations à propos de plus de 25 000 groupes professionnels et plus de 250 expositions, 27 000 couples d'expositions et 500 pathologies professionnelles. Dans le secteur de la construction, 92 expositions, 3508 couples d'expositions et 218 pathologies sont identifiées.

Discussion: Ces résultats préliminaires montrent la complémentarité des bases de données et décrivent comment l'hétérogénéité des données qu'elles contiennent peut-être exploitée pour apporter des connaissances supplémentaires sur la polyexposition. Ils illustrent également l'ampleur de la problématique de l'évaluation de la polyexposition à partir de ces données. La principale difficulté rencontrée est la diversité des nomenclatures métier utilisées, ce qui rend complexe leur intégration. Les suites de ce travail consisteront à identifier les analyses statistiques appropriées et à les appliquer sur les données intégrées. ©

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8. Coexpositions contraintes physiques et contraintes émotionnelles, psychosociales.

Sorensen, J. K., Andersen, L. L., Kristiansen, J., Rugulies, R., Clausen, T.

Exposure to high emotional, quantitative and physical job demands. Is there a synergistic effect on risk of depressive disorder?

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OBJECTIVE: We examined prospective associations between three combinations of psychosocial and physical job demands and onset of depressive disorder and whether the combined effects of these demands exceeded what would be expected from their individual contributions (i.e. synergy, measured as departure from additivity).

METHODS: We used data from the 2012, 2014, 2016, and 2018 wave of the Work Environment and Health in Denmark study, including 18,860 employees without depressive disorder at baseline. Onset of depressive disorder at follow-up was assessed using the Major Depression Inventory (MDI; score ≥ 21).

Exposures were high emotional demands, high quantitative demands, and high physical job demands, combined into three two-pair combinations. Prospective associations with depressive disorder were estimated as odds ratios (OR) and 95% confidence intervals (CI) adjusted for age, sex, education, job group, and cohort using logistic regression models. Additive interaction was assessed by the relative excess risk due to interaction (RERI).

RESULTS: Across all three combinations, combined exposure was consistently associated with the highest odds of onset of depressive disorder compared with the unexposed reference groups. The strongest association was observed for the combination of high quantitative and high physical job demands (OR 2.64; 95% CI 2.17 to 3.22), while the combination of high emotional demands and high quantitative demands showed a synergistic interaction beyond additivity (RERI 0.47; 95% CI 0.11 to 0.83).

CONCLUSION: Simultaneous exposure to multiple psychosocial and/or physical job demands was associated with higher odds of onset of depressive disorder, with the combination of high emotional and high quantitative demands reflecting synergy beyond additivity.

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