Bulletin de veille
Polyexpositions hétérogènes
N°2 – 2024

Objectif : ce bulletin présente un état de littérature scientifique sur le thème des polyexpositions hétérogènes, avec différentes co-expositions pouvant être rencontrées dans les situations de travail : associations substances chimiques - charges physiques, co-expositions substances chimiques-travail de nuit, co-expositions agents chimiques-agents biologiques…

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 sur l'exposome, et les polyexpositions en général

- « The Exposome and Precision Medicine ». Présentation sur YouTube du CR de la réunion Icahn School of Medicine at Mount Sinaï : The Exposome and Precision Medicine (youtube.com)
- Publication dans Communications Biology 22 juillet 2024. Une étude finlandaise examine le lien entre le score d'exposome et la santé métabolique au cours de l'enfance. Un score d'exposome mesurant une combinaison d'expositions environnementales et de style de vie a été associé à un grand nombre de métabolites sériques liés à la santé cardiométabolique, un certain nombre de ces métabolites étant uniquement associés au score d'exposome. Lien vers l'article
- Appel à projet Exposome du CNRS : AAP Exposome | CNRS Sciences humaines & sociales. « L'appel à projets pourra concerner tous les aspects de santé environnementale (air, eau, sol, vivant), santé au travail et les approches intégrées qui permettront d'observer, analyser, prédire et prévenir l'impact de l'exposome sur la santé humaine ainsi que sur l'environnement et la santé animale… »
- Article d'une équipe française sur l'exposition à long terme aux polluants atmosphériques, avec des effets néfastes chez les insuffisants rénaux chroniques. Frontiers | Multiple air pollutant exposure

is associated with higher risk of all-cause mortality in dialysis patients: a French registry-based nationwide study (frontiersin.org)

- 28 mai : co-exposition bruit et pollution de l'air en région parisienne. Huit Franciliens sur dix exposés à une pollution sonore et atmosphérique excédant «fortement» les recommandations de l'OMS : Lien vers l'article dans Libération. Lien vers l'étude pdf
- eNews du NIOSH septembre 2024 : « Protéger les travailleurs contre les maladies fongiques » : La Semaine de sensibilisation aux maladies fongiques aura lieu du 16 au 20 septembre. Pour consulter les ressources du NIOSH sur la prévention de l'histoplasmose en milieu de travail, avec des recommandations pour les travailleurs et les employeurs.
- 9 septembre : les National Institutes of Health (NIH) des États-Unis ont attribué plus de 7 millions de dollar à l'Université Columbia pour superviser un nouveau réseau NEXUS : Network for Exposomics aux États-Unis, Centre de coordination pour organiser et stimuler la recherche sur l'exposome humain, la mesure cumulative des expositions environnementales et des réponses biologiques correspondantes.
- 16 septembre : Santé publique France et l'Anses lancent le 16 septembre 2024 la première phase de l'enquête Albane qui permettra d'évaluer en continu la santé de la population française, l'exposition aux substances chimiques et de mieux connaître leurs liens avec l'alimentation et l'environnement. Plus d'info sur https://www.anses.fr/fr/content/albane-actualite

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Co-expositions agents chimiques et agents/charges physiques

Bodin, J., Babin, J., Bertin, M., Roquelaure, Y.
P-100 OCCUPATIONAL EXPOSURE AND CO-EXPOSURE TO PHYSICAL CONSTRAINTS AND NEUROTOXIC CHEMICALS IN FRENCH WORKERS: RESULTS FROM THE SUMER STUDY.
Occupational Medicine 2024; Vol. 74 (Supplement_1), p 0-0.

Given the high incidence of carpal tunnel syndrome in the working population and the co-exposure of workers, it is necessary to improve knowledge of the joint effects of physical and chemical exposures in order to improve prevention strategies. The aim of this study was to assess the prevalence of occupational exposure and co-exposure to physical constraints and neurotoxic chemicals. The study sample was composed of 26,444 workers included in the French cross-sectional survey SUMER 2017s. Occupational exposure within the previous week of work were assessed using a questionnaire during face-to-face interviews with occupational physicians. Four physical constraints were studied: manual handling of loads, forceful joints exertion, repetitive movement and hand-arm transmitted vibrations. Nineteen neurotoxic chemicals were studied: perchloroethylene, trichloroethylene, white-spirit, formaldehyde, etc. Analyses were conducted using weighted data. Approximately 24% of men and 11% of women were exposed to at least one physical constraint, and 14% of men and 12% of women were exposed to at least one neurotoxic chemical. About 6% of men and 3% of women were co-exposed to physical constraints and neurotoxic chemicals. Male and female workers under 30 years old and blue-collar workers were more co-exposed than other workers. Male workers in the construction were more co-exposed than other male workers. Despite the frequency of co-exposures, very few data are available in the literature on the combined effects of physical and neurotoxic chemical exposures on the risk of CTS.Occupational co-exposure to physical constraints and neurotoxic chemicals was observed in a significant proportion of French workers.
https://doi.org/10.1093/occmed/kqae023.0607

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Zhang, B., Yin, X., Guo, Y., Tong, R.
What occupational risk factors significantly affect miners' health: Findings from meta-analysis and association rule mining.
Journal of Safety Research 2024; Vol. 89 p 197-209.

Introduction: The workplace's health hazard remains a significant concern to workers in the mining industry, where miners are continually exposed to various kinds of exposure sources.
Method: First, the determinants of miners' health were systematically extracted from 259 publications, comprising chemical, physical, ergonomic, and psychosocial stressors, vulnerability factors, and common health outcomes. Then, 16 meta-analyses were performed to ascertain the epidemiological evidence for associations between four stressors and three health outcomes. The seven top contributing factors affecting miners' health were identified through 166 available prospective studies. Finally, based on the classic and domestic measurement scales, a cross-sectional survey of 559 Chinese miners was conducted to determine the core psychosocial predictors. In addition to the traditional mechanisms, complex interactive networks among the antecedents and consequences and the reversed effects of consequences were also obtained, where 379 strong association rules were yielded via the Apriori algorithm.

Results: The results showed that occupational dust, NO2, heavy metals, heat, vibration, awkward posture, and job stress are significant risk factors associated with individuals' health conditions. Psychological capital, coping style, job demand, social support, organizational support, justice, and culture are core psychosocial predictors of miners.
Conclusions: This study presents a case for identifying the most significant occupational risk factors related to individuals' health, which could be extended and applied to other industries, as working populations around the world are suffering from various chemical, physical, ergonomic, and psychosocial stressors.
Practical Applications: Identifying the significant occupational risk factors affecting workers' health conditions is essential for comprehensive occupational health risk assessment and management. Therefore, this study could be important for health management in mines and other industries.
https://doi.org/10.1016/j.jsr.2024.02.010

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Coelho, T. R., Pereira, H. M., Bittencourt Guimaraes, A. T.
Physical function as a marker to assess the effects of occupational long-term pesticide exposure.
Plos One 2024; Vol. 19 (5) p

In this cross-sectional study, we determined the relative impact of long-term occupational exposure to pesticides on physical performance and perception of tiredness. Experimental data was collected in locus from agricultural communities and included surveys to assess the duration of exposure to pesticides, social status, habitual physical activity levels, presence of common mental disorders (CMD), and self-reported tiredness. Plasmatic cholinesterase (PChE), body composition and traditional functional performance tests (Handgrip strength-HGS; Time up and go-TUG; and Sit-to-stand-STS) were obtained. From the 127 individuals tested, cluster analysis yielded 80 individuals divided in Direct Exposed (n = 37) and Indirect Exposed (n = 43); Tired (n = 16), and Not Tired (n = 64). PChE values were within the reference values (5209.64-13943.53 U/L). Pesticide exposure had no influence on PChE levels, CMD or fatigue ($p > 0.05$), while Self-reported tiredness had ($p < 0.05$). Principal Component Analyses showed that HGS; STS and TUG (i.e., physical performance variables) are negatively influenced by two independent factors: pesticide exposure and self-reported tiredness.
We conclude that chronic pesticide exposure and tiredness can negatively impact physical performance, independently, without clinically significant changes in PChE levels that is a biomarker used to track pesticide intoxication. Functional physical tests can be a useful tool to identify chronic pesticide exposure, and help with the limitations of commonly used parameters (i.e. PChE and CMD). Self-reported tiredness is a confounding variable.
https://doi.org/10.1371/journal.pone.0300980

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Perez-Lucas, G., Navarro, G., Navarro, S.
Understanding How Chemical Pollutants Arise and Evolve in the Brewing Supply Chain: A Scoping Review.
Foods 2024; Vol. 13 (11) p

In this study, a critical review was carried out using the Web of ScienceTM Core Collection database to analyse the scientific literature published to date to identify lines of research and future perspectives on the presence of chemical pollutants in beer brewing. Beer is one of the world's most popular drinks and the most consumed alcoholic beverage. However, a widespread challenge with potential implications for

human and animal health is the presence of physical, chemical, and/or microbiological contaminants in beer. Biogenic amines, heavy metals, mycotoxins, nitrosamines, pesticides, acrylamide, phthalates, bisphenols, microplastics, and, to a lesser extent, hydrocarbons (aliphatic chlorinated and polycyclic aromatic), carbonyls, furan-derivatives, polychlorinated biphenyls, and trihalomethanes are the main chemical pollutants found during the beer brewing process. Pollution sources include raw materials, technological process steps, the brewery environment, and packaging materials. Different chemical pollutants have been found during the beer brewing process, from barley to beer. Brewing steps such as steeping, kilning, mashing, boiling, fermentation, and clarification are critical in reducing the levels of many of these pollutants. As a result, their residual levels are usually below the maximum levels allowed by international regulations. Therefore, this work was aimed at assessing how chemical pollutants appear and evolve in the brewing process, according to research developed in the last few decades.
https://doi.org/10.3390/foods13111709

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Shi, Y., Zhao, L., Zheng, J., Ding, R., Li, K., Zhao, H.*, et al.*
End-of-life vehicle dismantling activity emits large quantities of phthalates and their alternatives: New insights on environmental sources and co-exposure risks.
Environment international 2024; Vol. 190 p 108933-108933.

Automotive interiors have been identified as significant sources of various chemicals, yet their occupational hazards for end-of-life vehicle (ELV) dismantlers remain poorly characterized. Herein, eight classes of plasticizers, including 11 phthalates esters (PAEs) and 16 non-phthalates esters (NPAEs), were detected in dust samples from inside and outside ELV dismantling workshops. Moreover, indoor dust from ordinary households and university dormitories was compared. The indoor dust from the ELV dismantling workshops contained the highest concentrations of plasticizers (median: 594mug/g), followed by ordinary households (296g/g), university dormitories (186g/g), and outdoor dust (157g/g). PAEs remained the dominant plasticizers, averaging 11.7-fold higher than their NPAE alternatives. Specifically, diisononyl phthalate and trioctyl trimellitate were notably elevated in workshop dust, being 15.5 and 4.78 times higher, respectively, than in ordinary household dust, potentially indicating their association with ELV dismantling activities. The estimated daily intake of occupational ELV dismantling workers was up to five times higher than that of the general population. Moreover, certain dominant NPAEs demonstrated nuclear receptor interference abilities comparable to typical PAEs, suggesting potential toxic effects. This study is the first to demonstrate that ELV dismantling activities contribute to the co-emission of PAEs and NPAEs, posing a substantial risk of exposure to workers, which warrants further investigation.
https://doi.org/10.1016/j.envint.2024.108933

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Co-expositions agent chimique et bruit

Abouee-Mehrizi, A., Kashani, M. M., Rasoulzadeh, Y., Mehdipour, A., Nasirzadeh, N., Shatouei-Gharenjeh, O., Ebrahimi-Kalan, A.
Co-exposure to Toluene and Noise Made Synergistic and Antagonistic Effects on Some Neurotoxic Parameters in New Zealand White Rabbits.

Basic and Clinical Neuroscience 2023; Vol. 14 (6) p 813-826.

Introduction: Numerous physical and chemical agents can induce destructive effects on the brain tissue. Noise and toluene, which are some of these harmful agents, have significant adverse effects on the brain tissue. This work aimed to investigate the neurotoxic changes induced by co-exposure to toluene and noise.
Methods: A total of 24 male white New Zealand rabbits were randomly segregated into four groups, including toluene exposure, noise exposure, co-exposure to noise and toluene, and control. This in vivo study tested the neurotoxic effects of exposure to 1000 ppm toluene and 100 dB noise during two weeks (8 h/day). The serum levels of brain-derived neurotrophic factor-alpha (BDNF-alpha), malondialdehyde (MDA), glutathione peroxidase (GPx), superoxide dismutase (SOD), and catalase and total antioxidant capacity (TAC) values in the brain tissue were measured. Moreover, hematoxylin and eosin (H&E) staining was utilized for brain pathological analysis.
Results: Exposure to noise increased TAC values in the cerebral cortex. Co-exposure to toluene and noise increased the serum levels of BDNF-alpha. Nevertheless, exposure to noise decreased the levels of BDNF-alpha in serum. On the other hand, histopathological examinations using H&E staining exhibited that different signs of inflammation, such as lymphocyte infiltration, pyknosis, vacuolization, and chromatolysis were induced by exposure to noise and toluene in the cerebellum, hippocampus, and frontal section in the brain tissue. In addition, simultaneous exposure to toluene and noise induced antagonistic and synergistic changes in some neurotoxic parameters.
Conclusion: Exposure to noise and toluene, which caused inflammation in the brain tissue cells, could be a noticeable risk factor for the neurological system.
https://doi.org/10.32598/bcn.2022.3301.1

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Ben Attia, T., Nahdi, A., Horchani, M., Ben Ali, R., Ben Jannet, H., Galai, S.*, et al.*
Simultaneous Exposure to Noise and Toluene Induces Oxidative and Inflammatory Damage in the Heart of Wistar Rats: Therapeutic Potential of Olea europaea L. Leaf Extract.
Cardiovascular toxicology 2024; Vol. 24 (7) p 667-686.

Workers in occupational settings often face simultaneous exposure to multiple risk factors, including noise and chemicals. This study aimed to investigate the effects of combined exposure to noise and toluene on the cardiac health of rats, with a focus on assessing the potential mitigating effects of Olea europaea L. (OLE) leaf extract (40mg/kg/day). The evaluation involved scrutinizing biochemical and hematological markers, quantifying oxidative stress levels, determining proinflammatory cytokines in the serum, and conducting an in silico Docking studies. Forty-two male Wistar rats were divided into eight groups-(n=6/group):-Control-group-(C),-OLE-group-(Rats administered OLE), NT-group (rats co-exposed to noise and toluene), NT-4 group-(rats co-exposed to noise and toluene four weeks after the exposure period), NT+OLE1-group (rats co-exposed to noise and toluene treated with OLE for one week), NT+OLE2-group-(rats co-exposed to noise and toluene treated with OLE for two weeks), NT+OLE3-group-(rats co-exposed to noise and toluene treated with OLE for three weeks), and NT+OLE4-group (rats co-exposed to noise and toluene treated with OLE for four weeks). The results revealed that combined exposure to noise and toluene led to oxidative damage and increased serum levels of proinflammatory cytokines. However, OLE treatment attenuated these effects by reducing lipid peroxidation and enhancing catalase and superoxide dismutase activities. Additionally, OLE treatment significantly decreased proinflammatory cytokine levels compared to the noise and toluene co-exposed group. The study highlighted the potential of OLE to attenuate the adverse effects of combined exposure to

noise and toluene, attributed to its anti-inflammatory and antioxidant properties.
https://doi.org/10.1007/s12012-024-09867-0

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Polyexpositions travail horaires atypiques et substances chimiques

Lie, J.-a. S., Zienolddiny-Narui, S., Bratveit, M.
Effects of the combined exposure to chemicals and unusual working hours.
Annals of Work Exposures and Health 2024; Vol. 68 (6) p 647-656.

Objective: Both exposure to occupational chemicals and to unusual working hours have well documented effects on health. Determination of occupational exposure limits is, however, usually based on chemical-only exposure and assumes an 8-h workday, 5 days/week and a 40-h work week. A significant proportion of the workforce is exposed to chemicals while working in other work schedules. This review thus aimed to synthesize and evaluate the scientific support for a combined effect of unusual working hours and chemical exposure and, if possible, give recommendations for OEL adjustments to account for unusual working hours.
Methods: The search for articles was made as part of the preparation of a report for the Nordic Expert Group for Criteria Documentation of Health Risks from Chemicals. In this report, unusual working hours were categorized as shift work or extended (>8 h) working hours. Inclusion criteria were observational studies in the English language published up to November 2021 in peer-reviewed journals, with explicit metrics of exposure (chemicals and unusual working hours) and of health outcome, and which explicitly tested the association between exposure and outcome. Search engines of seven databases were used.
Results : Of the initially 15 400 identified papers, 9 studies published between 1985 and 2021 met the inclusion criteria, 7 of which showed significant associations. Results from a few of the studies, i.e. regarding effects of dust and endotoxin on lung function, effects of acetone on sleep quality and tiredness, effects of carbon disulphide on coronary artery disease and effects of chemicals on spontaneous abortion, suggested more pronounced effects during night shifts compared to during day shifts.
Discussion: The reviewed data is considered insufficient to conclude on recommendations for OEL adjustment for shift work. Suggested areas of future studies are mentioned.
Conclusion: Further studies about the effects of the combined exposure to unusual working hours and chemical exposure are essential for risk assessment, and for recommendation of potential OEL adjustments. What is important about this paper? Effects of chemical agents at the workplace may depend not only on exposure level and duration but also on the time of exposure in relation to the circadian rhythm. This study reviewed the scientific support for a combined effect of unusual working hours and chemical exposure and revealed an obvious need for additional studies regarding the complex interplay of the two different exposures with respect to adverse health effects.
https://doi.org/10.1093/annweh/wxae033

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Dong, H., Cao, Y., Ding, X., Yan, T., Zhou, C., Bi, M.*, et al.*
The influence of night shift work and associated factors on serum uric acid in aircraft maintenance workers.
BMC Public Health 2024; Vol. 24 (1),p 1969.

The prevalence of 12-hour shift work is increasing in various occupations. Shift work has been linked to circadian rhythm disruption, which may lead to hormonal changes and metabolic disorders, including alterations in glucose, lipid, and purine metabolism. Despite this, there is limited research on the potential connection between work shifts and abnormal serum uric acid (SUA) levels. Furthermore, the factors that contribute to abnormal SUA levels in shift workers are not well-understood.
Therefore, this study aimed to analyze the SUA levels of shift workers employed in an aircraft maintenance company, investigate the potential association between shift work and SUA levels, and explore the factors that may influence abnormal SUA levels in shift workers.
https://doi.org/10.1186/s12889-024-18849-4

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Co-expositions Substances chimiques et substances biologiques

Yang, L., Chen, X., Zhang, A., Xu, R., Moreira, P., Mei, D.
Insights into uncovered public health risks. The case of asthma attacks among archival workers: a cross-sectional study.
Frontiers in Public Health 2024; Vol. 12 p

Objective To ascertain the prevalence of asthma attacks among archivists and identify the associated occupational factors in this understudied professional population.
Methods We conducted a cross-sectional, questionnaire-based study among 1,002 archival workers. A multiple logistic regression was conducted to identify the association between asthma attacks and occupational exposures. The Strobe Protocol was applied.
Results 999 workers were included in the final analysis with the asthma prevalence of 33.3%. Main factors associated with asthma attacks (OR [95% CI]) were the presence of chemically irritating odors (2.152 [1.532-3.024]), mold odors (1.747 [1.148-2.658]), and insects (1.409[1.041-1.907]). A significant synergistic effect was observed between chemical irritants and mold, the odds ratio was 7.098 (95% CI, 4.752-10.603).
Conclusion There was a high prevalence of asthma attacks among archival workers, an under-studied population. Chemical irritants, molds and insects were associated with their asthma attacks. Notably, this study's data analysis has revealed a strong synergy (OR = 7.098) between chemical odors and molds in the workplace. While the existing international literature on this specific interaction remains somewhat limited, previous studies have already demonstrated the potential for chemical irritants, such as sulfur dioxide and ozone, to synergistically interact with inhalable allergens, including fungi, molds and dust mites. Consequently, this interaction seems to exacerbate asthma symptoms and perpetuate untreated exposure. Furthermore, in damp and damaged buildings, the presence of microbial components, such as cellular debris or spores released during fungal growth can trigger an inflammatory response, potentially served as a shared pathway for the development of asthma among individuals exposed to these hazardous factors.
https://doi.org/10.3389/fpubh.2024.1397236

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Marcelloni, A. M., Pigini, D., Chiominto, A., Gioffrè, A., Paba, E.
Exposure to airborne mycotoxins: the riskiest working environments and tasks.
(Exposition aux mycotoxines en suspension dans l'air : environnements de travail et tâches les plus risqués).
Annals of Work Exposures and Health 2024; Vol. 68 (1) p 19-35.

Cette étude vise à fournir une analyse complète de la littérature existante sur la présence de mycotoxines inhalables dans les environnements de travail afin de déterminer les secteurs et les tâches qui présentent les risques d'exposition les plus élevés.
Une recherche systématique a été réalisée dans les bases de données PubMed, Scopus et Web of Science de 2010 à aujourd'hui, sans limitation de localisation géographique. 31 articles ont été retenus. Les résultats montrent que les travailleurs les plus exposés sont ceux qui exercent des activités liées aux soins et à l'alimentation des animaux, ainsi qu'au nettoyage des moissonneuses dans l'agriculture. Dans les établissements de santé, les concentrations de mycotoxines sont faibles, mais les systèmes de chauffage, de ventilation et de climatisation peuvent être une source de contamination. Le scénario le plus courant est l'exposition à plusieurs mycotoxines à des concentrations variables en fonction de l'environnement de travail, des produits manipulés ou des tâches effectuées par les travailleurs.
Les résultats présentés dans cette étude peuvent être utilisés par les professionnels de la santé et de la sécurité pour identifier les activités dans lesquelles des travailleurs peuvent être potentiellement exposés aux mycotoxines en suspension dans l'air et prendre ainsi les mesures de prévention et de protection appropriées.
https://doi.org/10.1093/annweh/wxad070

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Autres polyexpositions

Tong, R., Zhang, B.
Cumulative risk assessment for combinations of environmental and psychosocial stressors: A systematic review.
Integrated Environmental Assessment and Management 2024; Vol. 20 (3),p 602-615.

With the growing awareness of stressors, cumulative risk assessment (CRA) has been proposed as a potential method to evaluate possible additive and synergistic effects of multiple stressors on human health, thus informing environmental regulation and protecting public health. However, CRA is still in its exploratory stage due to the lack of generally accepted quantitative approaches. It is an ideal time to summarize the existing progress to guide future research. To this end, a systematic review of the literature on CRA issues dealing with combinations of environmental and psychosocial stressors was conducted in this study. Using typology and bibliometric analysis, the body of knowledge, hot topics, and research gaps in this field were characterized. It was found that research topics and objectives mainly focus on qualitative analysis and community settings; more attention should be paid to the development of quantitative approaches and the inclusion of occupational settings. Further, the roles of air pollution and vulnerability factors in CRA have attracted the most attention. This study concludes with views on future prospects to

promote theoretical and practical development in this field; specifically, CRA is a multifaceted topic that requires substantial collaborations with various stakeholders and substantial knowledge from multidisciplinary fields. This study presents an overall review as well as research directions worth investigating in this field, which provides a historical reference for future study.
https://doi.org/10.1002/ieam.4821

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Carlin, D. J., Rider, C. V.
Combined Exposures and Mixtures Research: An Enduring NIEHS Priority.
Environmental Health Perspectives 2024; Vol. 132 (7), p 075001.

Notre objectif était de décrire les recherches menées par le NIEHS sur les mélanges et les expositions combinées au cours de la dernière décennie et de présenter les domaines d'attention future.
Résultats: Les projets de recherche sur les mélanges intra-muros et extra-muros ont intégré un large éventail de produits chimiques (p. ex., hydrocarbures aromatiques polycycliques, plantes, produits de soins personnels, émissions de feux de forêt) et de facteurs de stress non chimiques (p. ex., facteurs socioéconomiques, adversité sociale) et se sont concentrés sur de nombreuses maladies (p. ex., cancer du sein, athérosclérose, perturbation immunitaire). Nous avons réalisé des progrès significatifs dans certains domaines, tels que le développement de méthodes statistiques pour évaluer plusieurs associations chimiques en épidémiologie et la construction de projets de mélanges translationnels incluant à la fois des modèles in vitro et in vivo.
Discussion: À l'avenir, des travaux supplémentaires sont nécessaires pour améliorer l'intégration des données sur les mélanges, élucider les interactions entre les facteurs de stress chimiques et non chimiques et résoudre la nature géospatiale et temporelle de l'exposition aux mélanges. La poursuite de la recherche sur les mélanges sera essentielle pour éclairer les évaluations des impacts cumulatifs et relever des défis complexes, tels que la justice environnementale et les changements climatiques.
https://doi.org/doi:10.1289/EHP14340

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Faria, S., Marques, A., Queiros, C.
Contributions and Consequences of Organizational Factors in the Occupational Stress of Rescuers: Systematic Review.
International Journal on Working Conditions 2024; Vol. (26) p 105-128.

Occupational stress affects various professions, including emergency professionals such as paramedics/pre-hospital emergency technicians, firefighters, nurses, and police officers. All these workers face demanding, unpredictable, and potentially traumatic events, being exposed to high stress levels. Understanding the organizational factors contributing to occupational stress and its consequences on health is crucial for developing effective interventions, using evidence-based strategies that mitigate stress and promote well-being. Through a systematic review, this study aims to identify the contributions and consequences of organizational factors in the occupational stress of rescue professionals, having identified 32 relevant studies using the PRISMA protocol.
Results revealed the impact of culture and the lack of organizational support, as well leadership issues, poor communication, high workload, exposure to critical incidents/violence, and insufficient human/material resources. These factors often interacted and compounded one another, intensifying

stress, and other psychological indicators, such as burnout. Most of the participants reported high levels of stress and/or psychological distress, underscoring the importance of fostering healthy working environments. Such environments are crucial for protecting the mental and physical health of these professionals, enabling them to perform their duties effectively. The findings will contribute to develop tailored programs addressing the needs and specificities of these professionals.
https://doi.org/10.25762/20zh-2y09

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Dhatrak, S. V., Shah, I. A., Prajapati, S. S.
Determinants of discomfort from combined exposure to noise and vibration in dumper operators of mining industry in India.
Journal of Occupational and Environmental Hygiene 2024; Vol. 21 (6),p 389-396.

In the mining industry, dumper operators are exposed to combined noise and vibration, leading to discomfort. Dumpers are heavy earth-moving machines that are used for carrying bulky material in mining industries. Dumper operators are exposed to physical hazards such as vibration, noise, heat, and humidity, throughout their lifetime of work. Fifty-four dumper operators working in mines were selected for this study. Noise was measured as per the guidelines of the Directorate General Mining Safety, India, and whole-body vibration was measured as per the guidelines of ISO 2631-1::1997. Noise Pro DLX, Type 2 noise dosimeters were used for the measurement of personal noise exposure while SV-106 six channels vibration meters were used for whole body vibration (WBV) exposure measurement. Discomfort was calculated using the regression equation developed by Huang and Griffin (2014). The total discomfort level of mine operators was about 192. A predictive equation was derived by using a regression model to determine the contribution of individual variables causing discomfort. It was observed that for every unit increase in noise (LAeq), discomfort increased by 10.20 units, a one-unit increase in vibration (A (8)) led to a 51.7-unit increase in discomfort, while an increase of one unit of exposure time increased the discomfort level by 5.24 units.
https://doi.org/10.1080/15459624.2024.2328296

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Mohammadian, F., Khotbesara, N. S., Falahati, M., Abbasi, M., Khajevandi, A., Zokaei, M.
Investigating the acute effects of combined exposure to heat and noise on human brain waves and perceived workload.
International Archives of Health Sciences 2024; Vol. 11 (2) p 107-114.

Objectives: The prevalence of multiple health hazards in various industries is on the rise, with noise and heat being common harmful factors in industrial environments in Iran. This study aimed to examine the immediate effects of simultaneous exposure to thermal stress and noise on human brain waves and perceived workload.
Methods: Seventy-two students (36 men and 36 women) participated voluntarily in this study. Participants were subjected to varying levels of noise exposure, including four noise levels and heat stress (three levels of Wet Bulb Globe Temperature) for 30 minutes each. EEG recordings were conducted for 10 minutes, with participants allowed a 30-minute rest period between each test condition.

Results: The combined exposure to noise and heat at two high levels (SPL95+WBGT34 and SPL95+WBGT29) resulted in a significant increase in perceived mental workload compared to the baseline state (P<0.05). EEG analysis indicated a decrease in absolute alpha power in the two high-level conditions compared to the baseline (t<0), while absolute beta power showed a significant increase in the two high-level conditions compared to the baseline mode (SPL45+ WBGT22).
Conclusion: The study demonstrated that simultaneous exposure to noise and heat, leading to an elevated perceived mental workload, was associated with decreased absolute alpha power and increased absolute beta power in the frontal and occipital regions. These findings suggest that these changes serve as reliable indicators of cognitive and physiological performance.
https://doi.org/10.48307/iahsj.2024.407567.1016

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Exposome et santé

Autran, B., Lefrancois, T., Lina, B., Sanitaires, L. M. D. C. D. V. E. D. a. D. R.
La mission du COVARS : comment anticiper les risques sanitaires dans une vision « Une seule Santé » de l'exposome.
Med Sci (Paris) 2024; Vol. 40 (6-7) p 485-486.
Pas d'abstract.
https://doi.org/10.1051/medsci/2024098

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Peters, S., Undem, K., Solovieva, S., Selander, J., Schlunssen, V., Oude Hengel, K. M.*, et al.*
Examen narratif des expositions professionnelles et des maladies non transmissibles.
Annals of work exposures and health 2024; Vol. 68 (6) p 562-580.

OBJECTIF : Dans le cadre du projet Exposome pour la recherche en santé et en travail sur l'application du concept d'exposome à la santé de la vie professionnelle, nous avons cherché à fournir un aperçu général de l'état des connaissances sur les expositions professionnelles et les effets associés sur la santé de plusieurs maladies non transmissibles (MNT) afin d'éclairer les priorités de recherche.
MÉTHODES : Nous avons effectué une revue narrative des facteurs de risque professionnels qui peuvent être considérés comme ayant des « preuves cohérentes d'une association » ou lorsqu'il existe « des preuves limitées/inadéquates d'une association » pour 6 groupes de MNT : maladies respiratoires non malignes ; maladies neurodégénératives ; maladies cardiovasculaires/métaboliques ; troubles mentaux ; les maladies musculo-squelettiques ; et le cancer. L'évaluation a été réalisée lors de sessions d'experts, principalement basées sur des revues systématiques, complétées par des revues narratives, des rapports et des études originales. Par la suite, des lacunes dans les connaissances ont été identifiées, par exemple en raison de l'information manquante sur les relations exposition-réponse, les différences entre les sexes, les fenêtres temporelles critiques, les interactions et la qualité inadéquate des études.
RÉSULTATS : Nous avons identifié plus de 200 expositions professionnelles avec des preuves cohérentes ou limitées/inadéquates d'associations avec une ou plusieurs des 60+ MNT Par exemple, les gaz d'échappement des moteurs diesel et le cadmium, avec des preuves cohérentes pour le cancer du poumon, mais des preuves limitées ou insuffisantes pour d'autres sites de cancer, des maladies respiratoires, neurodégénératives et

cardiovasculaires. D'autres exemples sont le travail physiquement lourd, le travail posté et la latitude de décision/le contrôle du travail. Pour les associations avec des preuves limitées/inadéquates, de nouvelles études sont nécessaires pour confirmer l'association. En ce qui concerne les facteurs de risque pour lesquels des données probantes sont cohérentes, des améliorations dans la conception de l'étude, l'évaluation de l'exposition et la définition de cas pourraient permettre de mieux comprendre l'association et d'éclairer les seuils fondés sur la santé.
CONCLUSIONS : En fournissant une vue d'ensemble des lacunes dans les connaissances sur les associations entre les expositions professionnelles et leurs effets sur la santé, notre revue narrative aidera à établir des priorités dans la recherche en santé au travail. Les futures études épidémiologiques devraient privilégier l'inclusion d'échantillons de grande taille, l'évaluation des expositions avant l'apparition de la maladie et la quantification des expositions. Les sources potentielles de biais et de facteurs de confusion doivent être identifiées et prises en compte dans les études originales et les revues systématiques.

https://doi.org/10.1093/annweh/wxae045

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Barouki, R., Levi, Y., Groupe, T., Comm.
L'Exposome, un apport majeur pour la prévention.
Bulletin De L'Académie Nationale De Médecine 2024; Vol. 208 (5) p

L'exposome correspond à l'ensemble des expositions, notamment aux agents chimiques, biologiques, physiques et aux stress psycho-sociaux subis par les individus tout au long de leur vie. Il a été conçu dès le départ comme étant le complément du génome et comme un facteur majeur influençant la santé et le bien-être des individus et des populations. Les expositions regroupées dans l'exposome sont, pour certaines, évitables et, en ce sens, une meilleure compréhension de l'exposome permettra d'améliorer la prévention. Différentes propositions et initiatives ont contribué à mieux préciser certains aspects de l'exposome pour le rendre plus opérationnel, notamment en ce qui concerne l'exposome chimique.
Pour mieux cibler ce rapport, nous avons exclu les maladies infectieuses et parasitaires, les effets des médicaments et autres accidents thérapeutiques. Dans ce rapport, l'Académie nationale de médecine émet des recommandations pour contribuer à une meilleure prise en compte de l'exposome en prévention. Ils visent à ancrer la notion d'exposome dans la vie quotidienne des populations et à prévenir les impacts sanitaires de la crise environnementale. Des recommandations spécifiques sont formulées pour améliorer la capacité de mesure des expositions, développer des services de santé capables d'explorer et d'interpréter les impacts des expositions, intégrer l'exposome dans les évolutions réglementaires, et développer une prévention à l'échelle de la population et de l'individu en tenant compte notamment du sexe et du stade de développement. La prise en compte de l'exposome dans la pratique clinique est également recommandée. Enfin, un programme de recherche ambitieux sur l'exposome est proposé, notamment à travers le développement d'infrastructures et de méthodes et de projets adéquats pour étudier les impacts de l'exposome sur les maladies. Une meilleure compréhension de la nature des expositions environnementales et de leurs impacts est une étape cruciale dans le développement d'une médecine préventive de haute qualité.

https://doi.org/10.1016/j.banm.2024.03.004

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Fayet, Y., Bonnin, T., Canali, S., Giroux, E.
Putting the exposome into practice: An analysis of the promises, methods and outcomes of the European human exposome network.
Social science & medicine (1982) 2024; Vol. 354 p 117056.

OBJECTIVES: Contemporary research on the exposome, i.e. the sum of all the exposures an individual encounters throughout life and that may influence human health, bears the promise of an integrative and policy-relevant research on the effect of environment on health. Critical analyses of the first generation of exposome projects have voiced concerns over their actual breadth of inclusion of environmental factors and a related risk of molecularization of public health issues. The emergence of the European Human Exposome Network (EHEN) provides an opportunity to better situate the ambitions and priorities of the exposome approach on the basis of new and ongoing research.
METHODS: We assess the promises, methods, and limitations of the EHEN, as a case study of the second generation of exposome research. A critical textual analysis of profile articles from each of the projects involved in EHEN, published in Environmental Epidemiology, was carried out to derive common priorities, innovations, methodological and conceptual choices across EHEN and to discuss it.
RESULTS: EHEN consolidates its integrative outlook by reinforcing the volume and variety of data, its data analysis infrastructure and by diversifying its strategies to deliver actionable knowledge. Yet data-driven limitations severely restrict the geographical and political scope of this knowledge to health issues primarily related to urban setups, which may aggravate some socio-spatial inequalities in health in Europe.
CONCLUSIONS: The second generation of exposome research doubles down on the initial ambition of an integrative study of the environmental effects of health to fuel better public health interventions. This intensification is, however, accompanied by significant epistemological challenges and doesn't help to overcome severe restrictions in the geographical and political scope of this knowledge. We thus advocate for increased reflexivity over the limitations of this conceptually and methodologically integrative approach to public and environmental health.
https://doi.org/10.1016/j.socscimed.2024.117056

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Leloutre, B., Gélis Imbert, P., Mondain, V.
Compte rendu du colloque de l'OMCNC consacré à l'influence du mode de vie sur la santé.
Hegel 2024; Vol. 2 (2) p 237-239.

Organisé par l'OMCNC et l'unité de médecine intégrative du CHU de NICE, le colloque consacré à l'influence du mode de vie, qui a eu lieu le 25 mai 2024 à la Faculté Saint-Jean-d'Angély à NICE, a rassemblé dans une ambiance bienveillante et dynamisante chercheurs, professionnels de santé, thérapeutes, patients, usagers, autour du thème « lifestyle medicine » ou comment se soigner par le mode de vie.
https://shs.cairn.info/revue-hegel-2024-2-page-237?lang=fr

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Song, G., Liu, X., Lei, K., Li, T., Li, W., Chen, D.
ExpoNano: A Strategy Based on Hyper-Cross-Linked Polymers Achieves Urinary Exposome Assessment for Biomonitoring.
Environmental science & technology 2024; Vol. 58 (32) p 14088-14097.

Urinary analysis of exogenous and endogenous molecules constitutes an efficient, noninvasive approach to evaluate human health status. However, the exposome characterization of urinary molecules remains extremely challenging with current techniques.
Herein, we develop an ExpoNano strategy based on hyper-cross-linked polymers (HCPs) to achieve ultrahigh-throughput measurement of exo/endogenous molecules in urine. The strategy includes a simple trapping-detrapping procedure (15 min) with HCPs in enzymatically treated urine, followed by mass spectrometer determination. Molecules that can be determined by ExpoNano have a wide range of molecular weight (75-837 Da) and Log Kow (octanol-water partition coefficient; -9.86 to 10.56). The HCPs can be repeatedly used five times without decreasing the trapping efficiency. Application of ExpoNano in a biomonitoring study revealed a total of 63 environmental chemicals detected in >50% of the urine pools collected from Chinese adults living in 13 cities, with a median concentration of 0.026-47 ng/mL, while nontargeted analysis detected an additional 243 exogenous molecules. Targeted and nontargeted analysis also detected 926 endogenous molecules in pooled urine.
Collectively, the ExpoNano strategy demonstrates unique advantages over traditional urine analysis approaches, including a wide range of analytes, satisfactory trapping efficiency, high simplicity and reusability, and extremely reduced time demand and financial cost.
https://doi.org/10.1021/acs.est.4c01146

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Liang, K. H., Colombijn, J. M. T., Verhaar, M. C., Ghannoum, M., Timmermans, E. J., Vernooij, R. W. M.
The general external exposome and the development or progression of chronic kidney disease: A systematic review and meta-analyses.
Environmental Pollution 2024; Vol. 358 p 124509.

The impact of environmental risk factors on chronic kidney disease (CKD) remains unclear. This systematic review aims to provide an overview of the literature on the association between the general external exposome and CKD development or progression. We searched MEDLINE and EMBASE for case-control or cohort studies, that investigated the association of the general external exposome with a change in eGFR or albuminuria, diagnosis or progression of CKD, or CKD-related mortality. The risk of bias of included studies was assessed using the Newcastle-Ottawa Scale. Summary effect estimates were calculated using random-effects meta-analyses. Most of the 66 included studies focused on air pollution (n = 33), e.g. particulate matter (PM) and nitric oxides (NOx), and heavy metals (n = 21) e.g. lead and cadmium. Few studies investigated chemicals (n = 7) or built environmental factors (n = 5). No articles on other environment factors such as noise, food supply, or urbanization were found. PM2.5 exposure was associated with an increased CKD and end-stage kidney disease incidence, but not with CKD-related mortality. There was mixed evidence regarding the association of NO2 and PM10 on CKD incidence. Exposure to heavy metals might be associated with an increased risk of adverse kidney outcomes, however, evidence was inconsistent. Studies on effects of chemicals or built environment on kidney outcomes were inconclusive. In conclusion, prolonged exposure to PM2.5 is associated with an increased risk of CKD incidence and progression to kidney failure. Current studies predominantly investigate the exposure to air pollution and heavy metals, whereas chemicals and the built environment remains understudied. Substantial heterogeneity and mixed evidence were found across studies. Therefore, long-term high-quality studies are needed to elucidate the impact of exposure to chemicals or other (built) environmental factors and CKD.
https://doi.org/https://doi.org/10.1016/j.envpol.2024.124509

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Nobile, F., Dimakopoulou, K., Astrom, C., Coloma, F., Dadvand, P., De Bont, J.*, et al.*
External exposome and all-cause mortality in European cohorts: the EXPANSE project.
Frontiers in epidemiology 2024; Vol. 4 p 1327218.

Background: Many studies reported associations between long-term exposure to environmental factors and mortality; however, little is known on the combined effects of these factors and health. We aimed to evaluate the association between external exposome and all-cause mortality in large administrative and traditional adult cohorts in Europe.
Methods: Data from six administrative cohorts (Catalonia, Greece, Rome, Sweden, Switzerland and the Netherlands, totaling 27,913,545 subjects) and three traditional adult cohorts (CEANS-Sweden, EPIC-NL-the Netherlands, KORA-Germany, totaling 57,653 participants) were included. Multiple exposures were assigned at the residential addresses, and were divided into three a priori defined domains: (1) air pollution [fine particulate matter (PM2.5), nitrogen dioxide (NO_2), black carbon (BC) and warm-season Ozone (warm-O3)]; (2) land/built environment (Normalized Difference Vegetation Index-NDVI, impervious surfaces, and distance to water); (3) air temperature (cold- and warm-season mean and standard deviation). Each domain was synthesized through Principal Component Analysis (PCA), with the aim of explaining at least 80% of its variability. Cox proportional-hazards regression models were applied and the total risk of the external exposome was estimated through the Cumulative Risk Index (CRI). The estimates were adjusted for individual- and area-level covariates.
Results: More than 205 million person-years at risk and more than 3.2 million deaths were analyzed. In single-component models, IQR increases of the first principal component of the air pollution domain were associated with higher mortality [HRs ranging from 1.011 (95% CI: 1.005-1.018) for the Rome cohort to 1.076 (1.071-1.081) for the Swedish cohort]. In contrast, lower levels of the first principal component of the land/built environment domain, pointing to reduced vegetation and higher percentage of impervious surfaces, were associated with higher risks. Finally, the CRI of external exposome increased mortality for almost all cohorts. The associations found in the traditional adult cohorts were generally consistent with the results from the administrative ones, albeit without reaching statistical significance.
Discussion: Various components of the external exposome, analyzed individually or in combination, were associated with increased mortality across European cohorts. This sets the stage for future research on the connections between various exposure patterns and human health, aiding in the planning of healthier cities.
https://doi.org/10.3389/fepid.2024.1327218

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Traini, E., Portengen, L., Ohanyan, H., Van Vorstenbosch, R., Vermeulen, R., Huss, A.
A prospective exploration of the urban exposome in relation to headache in the Dutch population-based Occupational and environmental health cohort study (AMIGO).
Environment international 2024; Vol. 188, p 108776-108776.

OBJECTIVE: Headache is one of the most prevalent and disabling health conditions globally. We prospectively explored the urban exposome in relation to weekly occurrence of headache episodes using data from the Dutch population-based Occupational and Environmental Health Cohort Study (AMIGO).

MATERIAL AND METHODS: Participants (N=7,339) completed baseline and follow-up questionnaires in 2011 and 2015, reporting headache frequency. Information on the urban exposome covered 80 exposures across 10 domains, such as air pollution, electromagnetic fields, and lifestyle and socio-demographic characteristics. We first identified all relevant exposures using the Boruta algorithm and then, for each exposure separately, we estimated the average treatment effect (ATE) and related standard error (SE) by training causal forests adjusted for age, depression diagnosis, painkiller use, general health indicator, sleep disturbance index and weekly occurrence of headache episodes at baseline.
RESULTS: Occurrence of weekly headache was 12.5% at baseline and 11.1% at follow-up. Boruta selected five air pollutants (NO2, NOX, PM10, silicon in PM10, iron in PM2.5) and one urban temperature measure (heat island effect) as factors contributing to the occurrence of weekly headache episodes at follow-up. The estimated causal effect of each exposure on weekly headache indicated positive associations. NO2 showed the largest effect (ATE=0.007 per interquartile range (IQR) increase; SE=0.004), followed by PM10 (ATE=0.006 per IQR increase; SE=0.004), heat island effect (ATE=0.006 per one-degree Celsius increase; SE=0.007), NOx (ATE=0.004 per IQR increase; SE=0.004), iron in PM2.5 (ATE=0.003 per IQR increase; SE=0.004), and silicon in PM10 (ATE=0.003 per IQR increase; SE=0.004). CONCLUSION: Our results suggested that exposure to air pollution and heat island effects contributed to the reporting of weekly headache episodes in the study population.
https://doi.org/10.1016/j.envint.2024.108776

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