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PRESENTAZIONE

L'idea di una rassegna degli articoli scientifici pubblicati dai ricercatori su riviste internazionali, peer-reviewed e indicizzate, nasce dalla necessità di dare visibilità a questo tipo di trasferimento dei risultati delle attività di ricerca anche al di fuori della comunità scientifica. Infatti, questa produzione, benché contribuisca significativamente al prestigio dell'Istituto, è difficilmente fruibile al di fuori di un ristretto gruppo di specialisti, in quanto gli argomenti sono molto tecnici, viene pubblicata in lingua inglese e non sempre le riviste sono accessibili gratuitamente. Gli articoli vengono menzionati, solo con la citazione, nei consuntivi annuali dei piani di attività, che hanno però una ben diversa finalità e diffusione.

La raccolta dei lavori pubblicati nel secondo trimestre 2026 consta di 20 articoli nei quali almeno uno degli autori è un ricercatore Inail. La multidisciplinarietà che caratterizza le tematiche affrontate, il cui filo conduttore è sempre la salute e sicurezza del lavoro, rispecchia la natura dei dipartimenti scientifici. Gli articoli selezionati sono pubblicati su riviste indicizzate nelle principali banche dati scientifiche internazionali e sono corredati da indicatori bibliometrici censiti in Web of Science (WoS) e/o Scopus, a garanzia della loro tracciabilità e della valutazione del relativo impatto scientifico secondo gli standard riconosciuti a livello internazionale. L'indice degli articoli è presentato in ordine alfabetico e contiene i collegamenti ipertestuali alle schede riassuntive, che riportano il titolo, i nomi degli autori, l'abstract in inglese, un breve sunto in italiano che ne rende il contenuto fruibile ad un'ampia platea di lettori e il link al full text (nel caso di riviste open access) per consentire la lettura dell'articolo originale a chi sia interessato. Tra gli articoli scientifici pubblicati nel presente numero si segnala *Occupational fatal injuries and extreme temperatures: a case-crossover study in Italy*, che affronta un tema di crescente rilievo: l'impatto del caldo estremo sulla sicurezza dei lavoratori. Lo studio, condotto a livello nazionale sui casi di infortunio mortale denunciati all'Inail tra il 2014 e il 2019, mostra che nelle giornate caratterizzate da temperature più elevate aumenta il rischio di eventi fatali. L'associazione risulta più evidente nel giorno stesso dell'esposizione e riguarda in particolare chi svolge attività all'aperto, come agricoltura e edilizia, ma anche alcune mansioni in ambienti chiusi esposti a fonti di calore. I risultati confermano che il caldo estremo rappresenta un fattore di rischio occupazionale concreto e prevenibile, da affrontare con politiche mirate di prevenzione, informazione e adattamento ai cambiamenti climatici.

Si segnala, inoltre, l'articolo *Characterisation of waterborne asbestos fibres to assess the impact on groundwater quality and their role in the risk of secondary migration in the air: the Mount Reventino area in Southern Italy as pilot site*, che approfondisce il tema dell'amianto di origine naturale nelle aree interessate da affioramenti ofiolitici. Lo studio, condotto nell'area del Monte Reventino, in Calabria, analizza presenza, concentrazione e destino delle fibre di amianto disperse nelle acque sotterranee e superficiali, evidenziando il possibile ruolo dell'acqua come vettore di mobilitazione ambientale e di successiva migrazione secondaria in aria. Attraverso un approccio integrato di tipo mineralogico, geochimico e idrogeologico, il lavoro documenta la prevalenza di tremolite, seguita da crisotilo e actinolite, e richiama l'attenzione sulla necessità di strategie coordinate di monitoraggio e prevenzione nelle aree caratterizzate dalla presenza di amianto naturale.

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A METHODOLOGICAL FRAMEWORK FOR OCCUPATIONAL CANCER SURVEILLANCE: ADDRESSING MULTIPLICITY AND UNMEASURED CONFOUNDING IN ITALIAN REGISTRY DATA

Berti M, Stoppa G, Gariazzo C, Consonni D, Massari S, Biggeri A, Catelan D.

SUMMARY

Objectives: The big data and deep learning in the surveillance of occupational cancers (BEST) project aimed to enhance occupational cancer surveillance in Italy by using large-scale registry linkages. It addressed two methodological challenges: controlling for multiple testing/selective inference when profiling occupational categories and cancers and assessing robustness of inference in presence of unmeasured confounding.

Methods: Data were obtained through record linkage between the Italian cause-of-death registry (2005 – 2018) and the National social insurance agency (Inps) database (1974 – 2018). Male blue-collar workers were classified by their longest held occupational sector, censoring the last 5 years before death. The study used a proportional cancer mortality design. Logistic regression models were fitted to estimate cause-specific mortality odds ratios (CMORs) for selected cancers and occupational sectors, adjusting for age, education, last region of residence, and year of death using the service sector as reference. Multiplicity was addressed through Q-Q plots with guide rails, q-values and control of false discovery rate, hierarchical Bayesian models and posterior rankings. E-values were calculated to assess the potential influence of unmeasured confounding.

Results: Elevated CMORs emerged for several cancers and industries, including lung cancer in construction and fishing, pleural cancer in shipyards, and sinonasal cancers in leather and woodworking trades. Findings remained consistent after multiple testing adjustments and sensitivity analyses using E-values.

Conclusions: We propose an integrated methodological framework that combines multiplicity-aware profiling and E-values to address selective inference from multiple testing and sensitivity to unmeasured confounding. The framework improves the interpretation and prioritization of signals in occupational cancer surveillance, providing robust insights to guide prevention strategies.

BREVE SINTESI

Il progetto BEST usa grandi banche dati italiane per migliorare la sorveglianza dei tumori professionali. Collegando registri di mortalità e dati lavorativi utilizzando i settori prevalenti, e applicando modelli statistici corretti per età, istruzione, regione e anno, individua associazioni tra settori produttivi e specifici tumori, come polmone, pleura e seni nasali. Tecniche per test multipli e confondimento non misurato rendono i risultati più solidi per la prevenzione.

CITAZIONE BIBLIOGRAFICA

Berti M, Stoppa G, Gariazzo C et al. A methodological framework for occupational cancer surveillance: addressing multiplicity and unmeasured confounding in Italian registry data. *Hygiene and Environmental Health Advances*. 2026;18:100178.

DOI: <https://doi.org/10.1016/j.heha.2026.100178>

ARTIFICIAL INTELLIGENCE AND OCCUPATIONAL HEALTH: GLOBAL UMBRELLA REVIEW OF APPLICATIONS AND LIMITATIONS

Descatha A, Hawkins D, Sembajwe G, Aloui S, Fadel E, Gagliardi D, Violante FS, Sim MR, Fadel M, Kang SK.

SUMMARY

Background: Artificial intelligence (AI) and information processing are technologies that will likely be transformational for occupational health and safety (OHS). This umbrella review aimed to provide a global overview of AI applications in occupational health, highlighting strengths, limitations and future perspectives.

Methods: Reviews and gray literature reports on AI in OHS were identified in PubMed, Web of Science and Scopus, with data extraction focused on applications, strengths and limitations.

Results: From 1,884 initial records, 33 reviews were included, only 4 of which were systematic reviews and 12 other systematized reviews. AI applications included risk prevention and monitoring, diagnosis, health and well-being, training and skills development, automation and robotics, sector-specific uses and organizational efficiency. Key limitations concerned data security, reliability, impacts on workers, governance and ethics, and methodological weaknesses.

Conclusion: AI application in OHS requires proactive policy, worker participation, evidence-informed risk management, impact assessment and further worker-centered research with attention to health equity.

BREVE SINTESI

La revisione mostra che l'intelligenza artificiale può supportare prevenzione, monitoraggio dei rischi, diagnosi, formazione e organizzazione del lavoro in ambito SSL. Tuttavia, le prove disponibili sono ancora limitate e restano criticità su privacy, bias, affidabilità, sorveglianza, autonomia dei lavoratori ed equità. L'uso dell'AI richiede governance trasparente, partecipazione dei lavoratori e valutazioni d'impatto rigorose.

CITAZIONE BIBLIOGRAFICA

Descatha A, Hawkins D, Sembajwe G et al. Artificial intelligence and occupational health: global umbrella review of applications and limitations. Saf Health Work. 2026.

DOI: <https://doi.org/10.1016/j.shaw.2026.02.004>

B-CELL DNA METHYLATION SIGNATURE IN RESPONSE TO HEPATITIS B VIRUS VACCINATION IN FEMALES AND MALES

Kwiatkowska KM, Anticoli S, Salvioli S, Calzari L, Gentilini D, Sala C, Castellani G, Albano C, Vonesch N, Tomao P, Carsetti R, Garagnani P, Ruggieri A.

SUMMARY

Sex-based differences in immune responses to vaccination are well-documented, yet the underlying epigenetic mechanisms remain poorly understood. This study investigates DNA methylation profiles in B cells following hepatitis B virus vaccination, with a focus on sex-specific patterns. Using high-resolution genome-wide methylation analysis, we examined post-vaccination samples from healthy male and female health care workers. Our results reveal distinct methylation signatures associated with vaccine response, with several loci showing sex-dependent differential methylation. Pathway analysis identified immune-related genes and regulatory elements potentially involved in B cell activation and memory formation. Our findings show that DNA methylation levels differ between responders versus non-responders to HBV vaccination and these alterations vary with biological sex. Understanding these epigenetic variations may open new perspective on vaccination practice. Collecting data on B cell epigenetics in different vaccination protocols could improve our knowledge on immunization function and contribute to more personalized vaccination strategies.

BREVE SINTESI

Le differenze di sesso nelle risposte immunitarie alla vaccinazione sono ben documentate, ma i meccanismi epigenetici che le regolano sono poco chiari. Questo studio ha analizzato i profili di metilazione del DNA in cellule B dopo vaccinazione contro il virus dell'epatite B in operatori sanitari di sesso maschile e femminile, mediante un'analisi ad alta risoluzione. I risultati hanno evidenziato metilazioni distinte associate alla risposta al vaccino, con differenze legate al sesso; i dati potrebbero contribuire a proporre strategie vaccinali personalizzate.

CITAZIONE BIBLIOGRAFICA

Kwiatkowska KM, Anticoli S, Salvioli S et al. B-cell DNA methylation signature in response to hepatitis B virus vaccination in females and males. *Front. Immunol.* 2026;17:1734384.

DOI: <https://doi.org/10.3389/fimmu.2026.1734384>

BIOMONITORING OF OCCUPATIONAL EXPOSURE TO MYCOTOXINS AMONG SWINE FARM WORKERS: AN ITALIAN PILOT STUDY

Paci E, Chiominto A, Proietto AR, Visaggio D, Visca P, Gioffrè A, Aiello R, Fenga C, Pigini D, Paba E.

SUMMARY

The risk of exposure to mycotoxins in livestock farming is still poorly characterized, particularly in Italy where human biomonitoring data are scarce. Livestock farms represent a high-risk setting due to frequent handling of contaminated feed and dust-generating activities. This pilot study applied a human biomonitoring approach to assess internal exposure to multiple mycotoxins among pig farmers in Southern Italy. Urinary biomarkers of aflatoxin B1 (AFB1), aflatoxin M1 (AFM1), ochratoxin A (OTA), and fumonisin B1 (FB1), together with oxidative stress biomarkers (8-oxo-7,8-dihydroguanine (8-oxoGua), 8-oxo-7,8-dihydro-2'-deoxyguanosine (8-oxodGuo), 8-oxo-7,8-dihydroguanosine (8-oxoGuo), 3-nitrotyrosine (3-NO2Tyr), and 5-methylcytidine (5-MeCyt)), were measured in urine samples from 35 workers and 30 non-exposed controls. A sensitive and validated HPLC-MS/MS multi-mycotoxin method was developed and applied. Biomonitoring results were also discussed in relation to previous environmental monitoring. AFM1 emerged as the most frequently detected biomarker in the exposed group, with concentrations above the limit of detection (LOD) in 22.8% of samples; 11.4% exceeded the limit of quantification (LOQ). In contrast, only 10% of the control samples had values above the LOD and none exceeded the LOQ, suggesting a possible contribution linked to occupational tasks. This study provides original biomonitoring evidence of low-dose, mixed mycotoxin exposure among Italian swine farmers and highlights the value of integrating environmental and biological monitoring to improve occupational exposure assessment in livestock production systems.

BREVE SINTESI

Uno studio pilota su 35 allevatori di suini nel sud Italia ha riscontrato un'esposizione a basse dosi di micotossine, con l'aflatossina M1 (AFM1) come biomarcatore urinario più frequente (22,8% dei campioni sopra il limite di rilevamento), evidenziando un rischio occupazionale maggiore rispetto al gruppo di controllo. Il lavoro sottolinea l'importanza di integrare il biomonitoraggio umano con il monitoraggio ambientale per valutare l'esposizione alle micotossine negli allevamenti.

CITAZIONE BIBLIOGRAFICA

Paci E, Chiominto A, Proietto AR et al. Biomonitoring of occupational exposure to mycotoxins among swine farm workers: an Italian pilot study. *Toxics*. 2026;14:562.

DOI: <https://doi.org/10.3390/toxics14070562>

CHARACTERISATION OF WATERBORNE ASBESTOS FIBRES TO ASSESS THE IMPACT ON GROUNDWATER QUALITY AND THEIR ROLE IN THE RISK OF SECONDARY MIGRATION IN THE AIR: THE MOUNT REVENTINO AREA IN SOUTHERN ITALY AS PILOT SITE

Bloise A, Fuoco I, Vespasiano G, Pacella A, Villella S, Piersante C, Malvasi G, Campopiano A, Ballirano P, Bruno MR, Bruni BM, Sinopoli F, Di Carlo MC, Croce A, Apollaro C.

SUMMARY

Waterborne asbestos in affected naturally occurring asbestos (NOA) areas represents a potential route for human exposure via ingestion and secondary aerial pathways. For the first time, this study systematically assesses the occurrence, concentration, and fate of hydrodispersed asbestos fibres in the Mount Reventino area of Calabria (Southern Italy), by using an integrated mineralogical, geochemical, and hydrogeological approach. Twenty-one water samples (16 groundwater, 5 surface water) were collected near ophiolitic outcrops and abandoned quarries and analysed using several advanced techniques. Based on morphological and compositional criteria, tremolite was the most abundant asbestos mineral detected in the water samples, followed by chrysotile, actinolite and anthophyllite. Surface waters show higher asbestos concentrations ($1.5\text{E}+05$ f/L) and longer fibres compared to groundwater ($2.3\text{E}+04$ f/L), suggesting a selective retention within the aquifer. The annual fibrous flux is dominated by tremolite ($3.1\text{E}+14$ f/year) and chrysotile ($2.4\text{E}+14$ f/year), followed by actinolite ($9.2\text{E}+13$ f/year) and anthophyllite ($1.0\text{E}+11$ f/year). The total annual fibre flux was estimated at $6.5\text{E}+14$ (f/year), predominantly from high-discharge watercourses, demonstrating that environmental impact is better quantified by fibre load rather than concentration alone. Water chemistry showed that most samples belong to the Ca-HCO_3 and Mg-HCO_3 hydrogeochemical facies and also provided the first evidence of a link between fibre concentrations and Ni and Cr levels. These new findings suggest a key role for fibres in trace metal mobilization. This study highlights groundwater as a potential pathway for asbestos dispersion and emphasises the need for integrated monitoring and prevention strategies in NOA-affected regions worldwide.

BREVE SINTESI

L'interazione tra rocce ofiolitiche in cui è presente amianto di origine naturale (NOA) e l'acqua comporta la dispersione di fibre di amianto in acqua. Sono stati analizzati 21 campioni di acque potabili e non. Fibre di amianto, principalmente tremolite, ma anche crisotilo e actinolite, sono state osservate in tutti i campioni tranne 1. Le acque sotterranee sono quindi una potenziale via di dispersione dell'amianto e si rende necessario definire strategie integrate di monitoraggio e prevenzione nelle regioni in cui sono presenti NOA.

CITAZIONE BIBLIOGRAFICA

Bloise A, Fuoco I, Vespasiano G et al. Characterisation of waterborne asbestos fibres to assess the impact on groundwater quality and their role in the risk of secondary migration in the air: the Mount Reventino area in Southern Italy as pilot site. J Haz Mat Adv. 2026;23:101254.

DOI: <https://doi.org/10.1016/j.hazadv.2026.101254>

COMPARISON OF DIFFERENT METHODS FOR THE ASSESSMENTS OF EFFECTIVE DOSE DUE TO GAMMA RADIATION EMITTED BY BUILDING MATERIALS

Gagliardo G, Didelot N, Cordelle A, Leonardi F, Trevisi R, Pugliese M, La verde G, Imparato C, Nuccetelli C, Venoso G.

SUMMARY

The circular economy encourages the reuse of industrial by-products, including naturally occurring radioactive materials (NORM) residues, in building materials, requiring reliable radiological risk assessment. The EU Basic safety standards set a 1 mSv/year reference level for indoor gamma exposure and introduced the activity concentration index (I), requiring detailed dose assessment when $I > 1$. Since no calculation method is prescribed, EN 17637:2022 provides a harmonized approach, alongside point-kernel codes and Monte Carlo simulations.

This study compares these methods by calculating effective dose rates per unit activity concentration for relevant radionuclides over mass per unit area values up to about $1,500 \text{ kg m}^{-2}$. EN 17637 agrees well with point-kernel models below 500 kg m^{-2} , with differences generally within 10 – 20%, but assumes a dose plateau at higher values, unlike other models. MCNP estimates were up to 54% higher for Th-232, mainly due to dose conversion factors and cross-wall scattering. EN 17637 remains useful, but adjustment factors can improve accuracy for high-density materials.

BREVE SINTESI

La transizione verso un'economia circolare favorisce il riutilizzo di residui industriali anche nei materiali da costruzione. Alcuni di questi materiali, come i residui NORM, possono contenere radionuclidi naturali e richiedono quindi una corretta valutazione dell'esposizione alle radiazioni gamma negli ambienti interni.

Lo studio confronta diversi metodi di calcolo della dose, tra cui lo standard europeo EN 17637:2022, codici point-kernel e simulazioni Monte Carlo, per verificarne affidabilità e limiti. I risultati mostrano che lo standard EN 17637 fornisce stime generalmente coerenti con altri metodi per materiali con valori di densità e spessore non troppo elevati, mentre può sottostimare la dose per materiali ad alta densità o spessore.

Il lavoro evidenzia quindi l'utilità dello standard come strumento semplice e armonizzato, proponendo al tempo stesso correttivi per migliorarne l'accuratezza in casi specifici.

CITAZIONE BIBLIOGRAFICA

Gagliardo G, Didelot N, Cordelle A et al. Comparison of different methods for the assessments of effective dose due to gamma radiation emitted by building materials. *J Hazard Mater Adv.* 2026;22:101161.

DOI: <https://doi.org/10.1016/j.hazadv.2026.101161>

GENOTOXIC DAMAGE AND MICRORNA DYSREGULATION IN FIREFIGHTERS: AN INTEGRATED BIOMONITORING CASE STUDY

Cipollone C, Mastrantonio R, Mozzoni P, Mastrangeli G, Corradi M, Renzetti S, Saponara V, Nicastro M, Cavallo D, Maiello R, Gentile M, Poli D, Muselli M, Romantini A, Di Gennaro G, Cenci G, Protano C, Vitali M, De Palma G, Ursini CL, Fabiani L.

SUMMARY

Firefighters are potentially exposed to multiple harmful substances, and their activities are classified as carcinogenic to humans. This case study assessed early genotoxic damage (fpg-comet and BMCyt assays) and epigenetic alterations (seven circulating miRNAs) in 35 firefighters compared to 45 non-exposed workers. Occupational exposure to fire smoke was self-reported via questionnaire. Firefighters showed higher median genotoxic DNA damage with respect to the non-exposed group (% DNA tail Buff 19.4 vs. 16.8; % DNA tail Enz 22.2 vs. 19.3; Tail moment 5.5 vs. 4.5; % of apoptotic cells 1.13 vs. 0.97). miRNAs related to air pollution, oxidative stress, tumor suppression, and immune responses, like mir-16, mir-15a, mir-29a, mir-125b, and mir-142, showed significant downregulation ($p < 0.001$) in the exposed group. Mean percentages of early apoptosis biomarkers and composite DNA damage indices among FF also differed significantly from the other participants (‰ Condensed chromatin 0.46 vs. 0.06; ‰ Tot anomalies 5.15 vs. 3.82). Multiple correlations emerged, particularly between miRNAs and comet assay parameters, and between comet assay and BMCyt indicators. The implemented integrated approach provides information about the existence of a relationship between genotoxic and epigenetic effects in firefighters, also influenced by time since exposure. Future studies with bigger sample sizes are required.

BREVE SINTESI

I vigili del fuoco sono esposti a sostanze nocive durante le attività operative, classificate come cancerogene per l'uomo. Lo studio ha valutato danno genotossico, alterazioni epigenetiche e possibili associazioni tra questi biomarcatori in 35 vigili del fuoco confrontati con 45 lavoratori non esposti, con l'obiettivo di contribuire a sviluppare strategie più efficaci di sorveglianza sanitaria. Nei vigili del fuoco sono emersi maggior danno al DNA e deregolazione di microRNA legati a stress ossidativo, risposta immunitaria e processi tumorali.

CITAZIONE BIBLIOGRAFICA

Cipollone C, Mastrantonio R, Mozzoni P et al. Genotoxic damage and microRNA dysregulation in firefighters: an integrated biomonitoring case study. *J Xenobiot.* 2026;16(3):78.

DOI: <https://doi.org/doi: 10.3390/jox16030078>

INDIRECT COSTS RELATED TO PRODUCTIVITY LOSS, WORK-RELATED QUALITY OF LIFE, AND RESOURCE UTILIZATION IN WORKERS WITH MULTIPLE SCLEROSIS

Ponzio M, Grange E, Gualco C, Pignattelli E, Manacorda T, Grasso MG, Presicce G, Inglese M, Leveraro E, Durando P, Debarbieri N, Persechino B, Battaglia MA, Bricchetto G.

SUMMARY

Purpose: Multiple sclerosis (MS) often affects individuals during their most productive working years, resulting in reduced work capacity and quality of life. This study aimed to assess work productivity loss, work-related quality of life (WRQoL), and healthcare and social resource utilization among Italian workers with MS and to identify the predictors of productivity-related indirect costs.

Methods: A cross-sectional study was conducted involving 160 employed people with MS (PwMS) in Italy. Work productivity and activity impairment were measured using the Work productivity and activity impairment questionnaire for MS (WPAI:MS), while work-related difficulties were assessed with the MSQ-Job. WRQoL and healthcare and social support utilization were evaluated using validated instruments. Productivity losses were monetized using national wage data. Two-part regression models were applied to identify the predictors of annual indirect costs.

Results: Overall, 79.4% of PwMS reported productivity loss, predominantly due to presenteeism (76.9%), with a mean overall work impairment of 40.3%. The mean annual cost of productivity loss was € 12,580, 83% of which was attributable to presenteeism. Indirect costs were significantly higher among PwMS reporting work-related difficulties (€ 13,992 vs € 7,098; $p < 0.001$). Lower WRQoL, higher fatigue levels, and greater healthcare needs were associated with increased productivity losses, while higher WRQoL emerged as a protective factor.

Conclusion: MS-related work impairment generates substantial indirect costs, largely driven by presenteeism. Interventions targeting workplace well-being, fatigue management, and vocational rehabilitation may help reduce productivity losses and improve quality of life among PwMS.

BREVE SINTESI

La sclerosi multipla (SM) spesso colpisce le persone durante i loro anni lavorativi più produttivi, con conseguente riduzione della capacità lavorativa e della qualità della vita. Questo studio è finalizzato a valutare la perdita di produttività lavorativa, la qualità della vita correlata al lavoro (WRQoL) e l'utilizzo delle risorse sanitarie e sociali tra i lavoratori italiani con SM e a identificare i predittori dei costi indiretti legati alla produttività.

CITAZIONE BIBLIOGRAFICA

Ponzio M, Grange E, Gualco C et al. Indirect costs related to productivity loss, work-related quality of life, and resource utilization in workers with multiple sclerosis. J Occup Rehabil. 2026.

DOI: <https://doi.org/10.1007/s10926-026-10392-w>

MODERN SOLUTION FOR ANTINEOPLASTIC DRUGS OCCUPATIONAL MONITORING: A GREEN ANALYTICAL CHEMISTRY APPROACH

Mainero Rocca L, Gordiani A, Dalla Torre B, Carbone M.

SUMMARY

Occupational exposure to antineoplastic agents (AAs) poses significant health risks even today, but current biological monitoring strategies are limited, particularly in terms of sensitivity and environmental impact. This study presents a novel and green analytical method for the determination of different classes of AAs in whole blood using the dried blood spot (DBS) technique combined with the sensitivity of an ultra-performance liquid chromatography-tandem mass spectrometry (UPLC-MS/MS). The described method minimises sample volume, eliminates complex pre-treatment, and reduces solvent use, adhering to the principles of green analytical chemistry (GAC). Haematocrit variability was addressed by withdrawing a known volume of whole blood and analysing the entire spot, while capillary versus venous blood unknown differences were addressed approximating correlation factors to 1. The greenness of the method was evaluated using the Green Analytical Procedure Index (GAPI) and white analytical chemistry (WAC) metrics, confirming a low environmental impact compared to conventional urine-based methods. Moreover, its validation demonstrated low limits of detection (0.2–8.3 pg/μL) and quantification (0.7–25.0 pg/μL), satisfactory recoveries (70–98%), and acceptable intra- and inter-day precision. The proposed approach provides a reliable and environmentally sustainable tool for occupational monitoring of antineoplastic drug exposure, offering the undeniable advantage of assessing the risks of healthcare workers while protecting the health of those conducting the assessments. To the best of our knowledge, this is the first biological monitoring method for occupational exposure to antineoplastic drugs explicitly designed in accordance with green analytical chemistry principles.

BREVE SINTESI

Questo studio propone un metodo analitico innovativo e sostenibile per monitorare l'esposizione occupazionale a farmaci antineoplastici nel sangue. Basato su dried blood spot e UPLC-MS/MS, richiede poco campione, riduce solventi e pretrattamenti, garantendo alta sensibilità e buona precisione. Valutato con metriche "green", dimostra basso impatto ambientale rispetto ai metodi tradizionali, offrendo uno strumento affidabile e sicuro.

CITAZIONE BIBLIOGRAFICA

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MULTIPLE FATAL ACCIDENTS AT WORK IN ITALY: HOW THEY OCCUR AND CAUSAL FACTORS FOR IDENTIFYING SPECIFIC PREVENTION MEASURES

Campo G, Guglielmi A, Manni V.

SUMMARY

Workplace accidents represent a significant health problem for workers. In 2022, the EU recorded over 3,000 workplace deaths and nearly 3 million non-fatal accidents. The aim of this paper is to provide an in-depth analysis of multiple fatal accidents in Italy in recent years, analyzing their occurrence patterns and causal factors to increase useful information for risk management. The statistics come from the Inail database and the Infor.MO national surveillance system, which collects detailed information on accident dynamics and uses a multifactorial model to analyze the causes of injuries. In this system, the in-depth analysis of multiple fatal accidents was conducted on a cluster of 181 events that occurred between 2008 and 2022. Data sources show that road accidents are a significant cause of multiple injuries. Other recurring accidents include collapses, fires, explosions, and asphyxiation in confined spaces. The construction and manufacturing sectors are the most affected. The main causes, highlighted particularly in the Infor.MO system, include poor worker training, inadequate workplace organization, and a lack of safety devices.

Conclusions: To reduce workplace accidents, especially those with dramatic consequences such as multiple accidents, the importance of a stronger organizational safety culture is reiterated, in which training enables workers to understand risk analysis and gain greater awareness of hazards.

BREVE SINTESI

L'articolo descrive i principali infortuni plurimi avvenuti in Italia, inquadrati nell'ambito di un contesto europeo, e dei principali fattori causali con le relative suggestioni a scopo preventivo.

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NATURALLY OCCURRING ASBESTOS AND ITS POSSIBLE ENVIRONMENTAL AND HEALTH IMPLICATIONS IN THE BASILICATA REGION (SOUTHERN ITALY)

Bloise A, Ballirano P, Fuoco I, Di Carlo MC, Apollaro C, Vespasiano G, Paccapelo M, Arrizza L, Dyar MD, Sklute E, Altieri A, Campopiano A, Cannizzaro A, Bruno MR, Malvasi G, Pacella A.

SUMMARY

Asbestos that occurs in the environment and has not been extracted for commercial purposes is commonly referred to as naturally occurring asbestos (NOA). Research has shown a higher-than-expected incidence of mesothelioma in populations residing near NOA sites across California, Greece, Turkey, Cyprus, Corsica, and New Caledonia. In Italy, in the area around Pollino Massif (Basilicata region), a total of 124 mesothelioma cases were documented among population living in the villages of Castelluccio Superiore and Inferiore, Lauria, Latronico, Episcopia, San Severino Lucano, and Francavilla in Sinni. In this work for the first time, we report the morphological and chemical structural characterization of asbestos tremolite samples from the NOA outcrops in the Pollino area (Basilicata region). The detailed sample characterization has been attained by using a multi-analytical approach (EMP, SEM-EDS, TEM-EDS, Mössbauer, X-ray powder diffraction, and thermal analysis). Morphological investigation highlighted that a significant fraction of each sample (ca. 50%) consists of long fibres (> 5 µm) having width below 0.25 µm, considered the most carcinogenic fibres. Additionally, all asbestos samples showed the presence of Fe at the octahedral sites of the tremolite structure. This is relevant from the toxicological point of view because the presence of Fe in the fibre structure is a critical factor in asbestos pathogenicity. Obtained results provide a solid foundation for better understanding the potential health risks associated with asbestos tremolite in the Pollino Massif area. They also highlight the importance of constant monitoring and risk assessment to protect local communities from asbestos exposure.

BREVE SINTESI

Nella regione Basilicata negli anni passati è stato evidenziato un cluster di mesoteliomi in alcuni comuni del Massiccio del Pollino, che è stato correlato alla presenza di affioramenti ofiolitici con presenza di minerali di amianto. Le rocce della zona interessata sono state caratterizzate mediante più tecniche analitiche ed è stata riscontrata la presenza di fibre lunghe di tremolite. I risultati ottenuti costituiscono una solida base per comprendere meglio i potenziali rischi per la salute associati all'amianto tremolite nell'area del Massiccio del Pollino. Essi sottolineano inoltre l'importanza di un monitoraggio costante e di una valutazione dei rischi al fine di proteggere le comunità locali dall'esposizione all'amianto.

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OCCUPATIONAL FATAL INJURIES AND EXTREME TEMPERATURES: A CASE-CROSSOVER STUDY IN ITALY

Taiano L, Gariazzo C, Bonafede M, Marinaccio A, Morabito M.

SUMMARY

Background: Climate change is increasing extreme heat events worldwide, with substantial health impacts. Workers are particularly vulnerable to heat exposure due to their limited ability to avoid exposure during physically demanding tasks. Previous studies have documented associations between high temperatures and non-fatal occupational injuries in Italy. However, no nationwide study has yet assessed the association between extreme temperatures and fatal occupational injuries.

Objectives: To investigate the association between exposure to extreme temperatures and the risk of fatal occupational injuries in Italy.

Methods: A time-stratified case-crossover model was constructed on occupational fatal injuries reported to the Italian workers' compensation authority (Inail) between 2014 and 2019, with exposure measured by the Universal thermal climate index (UTCI). Conditional logistic regression with distributed lag non-linear model was used to estimate the association. The odds ratios (ORs) curve was calculated relative to a reference UTCI value corresponding to thermal comfort conditions and a single point measure was calculated comparing the 99th with the 75th percentile. Stratified analyses were performed across demographic and occupational variables.

Results: A clear increase in risk for high UTCI values was found. Compared with the 75th percentile (22.4 °C UTCI), the 99th percentile (31.2 °C UTCI) was associated with an odds ratio of 1.61 [1.22–2.14], corresponding to 84 [9–151] attributable deaths. The association was strongest on the day of exposure and was stronger among men, younger and older workers and in outdoor occupations such as agriculture and construction. Indoor heat producing activities also showed an association.

Conclusions: Extreme heat was associated with an increased risk of occupational death, particularly in agriculture, construction, indoor heat-exposed occupations and vulnerable worker groups. These findings confirm heat exposure as a major preventable occupational hazard and call for urgent, heat-specific nationwide prevention policies in the context of climate change.

BREVE SINTESI

Il caldo estremo aumenta il rischio di infortuni mortali sul lavoro in Italia. Analizzando i casi Inail 2014 - 2019 e l'indice UTCI, lo studio stima un rischio del 61% più alto nei giorni di forte caldo e 84 decessi attribuibili nel periodo. I settori più a rischio risultano l'agricoltura, l'edilizia.

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OCCURRENCE OF FORMALDEHYDE EXPOSURES IN WORK ACTIVITIES AND ITS DIFFUSION IN THE ITALIAN INDUSTRIAL CONTEXT FOLLOWING THE NOTIFICATION REQUIREMENTS

Scarselli A, Gherardi M, Di Marzio D, Marinaccio A.

SUMMARY

Purpose: The aim of this study is to describe data on occupational exposure to formaldehyde in the context of Italian economic activities.

Methods: Measurement data of airborne concentrations (n = 26,216) of formaldehyde in the period 1996-2024 were selected from the national register of occupational exposure to carcinogens (Sistema informativo registri di esposizione professionale, SIREP). Descriptive statistics were calculated for main exposure-related variables. The number of potentially exposed workers was estimated for the best-characterized sectors.

Results: The overall geometric mean was 0.028 mg/m³. Most of the exposure was found in the wood (n = 4,912), chemical (n = 4,090), and plastic industries (n = 3,925). A different distribution of exposure was found according to gender, as women exposures were more common in the healthcare sector. The estimated number of potentially exposed workers in the selected sectors was approximately 100,000.

Conclusions: The implementation of the new European Union (EU) regulation has enhanced the surveillance system, resulting in noteworthy improvements in the monitoring of occupational exposure to formaldehyde.

BREVE SINTESI

Lo studio analizza oltre 26.000 misurazioni di esposizione professionale a formaldeide raccolte in Italia nel registro SIREP tra il 1996 e il 2024. Le esposizioni risultano più frequenti nei settori legno, chimica e plastica, con una maggiore presenza femminile nel comparto sanitario. Circa 100.000 lavoratori sono stimati potenzialmente esposti. I dati confermano l'importanza della sorveglianza per orientare prevenzione e monitoraggio. La recente normativa europea ha notevolmente contribuito a rafforzare il sistema, favorendo una raccolta più strutturata dei dati.

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PREVENTION AND PROTECTION OF HEALTH AND THE ENVIRONMENT IN LABORATORIES USING ADVANCED AND INNOVATIVE BIOTECHNOLOGICAL METHODS: RESULTS OF AN ITALIAN PROJECT

Sturchio E, Zanellato M, Mauro S, Boccia P.

SUMMARY

In recent years, there has been an exponential growth in applying cutting-edge biotechnological techniques in various research fields, such as human health, agriculture and industry, therefore it is essential to provide up-to-date information on national regulations, educate on laboratory practices with genetically modified organisms and microorganisms, create awareness and motivation for biosafety. The Inail Project titled "Prevention and protection of health and the environment in laboratories using advanced and innovative biotechnological methods" was aimed at promoting staff training and awareness to ensure compliance with the directive 2009/41/EC and 2001/18/EC by new biotechnological techniques users, through innovative methodologies characterized by a close synergy between students, safety managers and researchers. A neuromanagement analysis was conducted to test the potential effect of specific biosafety training for biotechnology laboratory users. The neuromanagement techniques can increase awareness and improve safety behaviors. In addition, an inspection body was established, with the Italian Ministry of Health, and inspections were carried out at biotechnology laboratories. Following the awareness-raising activity carried out at the Italian Universities, new ad hoc courses were created on biotechnology safety for PhD students, and degree and master's courses were updated. The success of the project was confirmed by the proportional increase in authorization requests for contained use of genetically modified microorganisms presented to the Ministry of Health in the last three years, with a focus on new genomic techniques (NGT) in agriculture, considering the advent of the NGTs legislation. The innovative aspect of this project was to combine regulatory, technical, and motivational aspects, to promote a safety culture and a greater awareness in the use of biotech techniques.

BREVE SINTESI

L'incremento dell'uso delle biotecnologie in medicina, agricoltura e industria comporta sfide legate a salute e ambiente. Il progetto Inail promuove la sensibilizzazione e la formazione sulla biosicurezza e la conformità alle direttive UE (2009/41/CE e 2001/18/CE). Attraverso la collaborazione con il Ministero della salute, analisi di neuromanagement e nuovi corsi universitari, il progetto unisce normativa, tecnica e motivazione. Il successo è confermato dall'aumento delle richieste di autorizzazione per l'uso confinato di MOGM e focus sulle NGT.

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PROJECTION OF HEAT-RELATED OCCUPATIONAL INJURIES UNDER CLIMATE CHANGE AND DEMOGRAPHIC SCENARIOS IN ITALIAN CITIES

Gariazzo C, Taiano L, Bonafede M, Marinaccio A.

SUMMARY

Introduction: High temperatures have been associated with occupational injuries (OIs). However, studies projecting future OIs under climate change scenarios are scarce, particularly in Europe. To fill this gap, we estimated projected heat-related OIs in 87 Italian cities under climate and demographic scenarios.

Materials and methods: OIs occurring from 2014 to 2019 were collected from the Italian national archive. Daily counts of OIs in each city were merged with ERA5-land Copernicus mean temperatures. City-specific exposure-response functions were estimated using a time-series analysis with distributed lag non-linear model (DLNM) and then meta-analysed to obtain a national estimate. This estimate was applied to project heat-attributable OIs from 2015 to 2100 using downscaled daily temperatures from 19 general circulation models, under three European shared socioeconomic pathways (SSP) scenarios (SSP1-2.6; SSP2-4.5; SSP3-7.0), including demographic projections. Adaptation scenarios were also considered by applying risk attenuation.

Results: Under the lowest mitigation scenario (SSP3-7.0), an increase in the attributable number of OIs is foreseen, with 537 (95% CI 365-709) additional cases in 2070-2079 compared with the baseline decade 2010-2019, corresponding to an attributable relative fraction of 0.38% (95% CI 0.26-0.5). Under the intermediate scenario (SSP2-4.5), 464 (95%CI 312-616) additional cases are projected compared with baseline. Agriculture showed high vulnerability with attributable fraction of 1.20% (95% CI 0.99-1.41) under SSP3-7.0 scenario in 2070-2079.

Conclusions: Heat-related OIs are predicted to increase under future climatic conditions. Workplace mitigation measures and public health actions are recommended to reduce heat-attributable OIs.

BREVE SINTESI

Le alte temperature possono aumentare il rischio di infortuni sul lavoro. Questo studio ha stimato l'impatto futuro del caldo in 87 città italiane, combinando dati sugli infortuni, temperature giornaliere e scenari climatici e demografici fino al 2100. I risultati indicano un aumento degli infortuni attribuibili al caldo, soprattutto negli scenari con minori politiche di mitigazione e nel settore agricolo, evidenziando la necessità di misure preventive nei luoghi di lavoro.

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RICERCA SCIENTIFICA E POLITICHE DI ADATTAMENTO: IL PROGETTO WORKCLIMATE E LE ORDINANZE REGIONALI DI PROTEZIONE DEI LAVORATORI DAL CALDO ESTREMO

Marinaccio A, Morabito M, Taiano L, Scarselli A, Bonafede M.

SUMMARY

Background: Climate change is increasing workers' exposure to extreme heat, with adverse effects on health, safety, and productivity. **Methods:** We describe how evidence generated by the Workclimate project, coordinated by Inail and Cnr-Ibe, was translated into heat-prevention policies through a forecasting system based on the Wet bulb globe temperature (WBGT) index.

Results: In 2025, 18 Italian regions adopted heat-protection ordinances using Workclimate forecasts to trigger preventive measures, including the suspension of outdoor activities during high-risk periods. More than 2.3 million workers in sectors such as agriculture, construction, logistics, and environmental hygiene were covered. Preliminary findings suggest a reduction in occupational injury rates, particularly in construction.

Conclusions: The Italian experience shows how occupational epidemiology can effectively support evidence-based policies for climate change adaptation. Integrating scientific evidence, forecasting tools, and preventive measures represents a promising model for protecting workers from extreme heat and strengthening occupational health policies.

BREVE SINTESI

Il caldo estremo aumenta il rischio di infortuni mortali. Il paper analizza gli strumenti di allerta messi a disposizione dal progetto Workclimate (in particolare la piattaforma che riporta le aree territoriali a rischio per i lavoratori esposti al sole ed impegnati in attività fisiche intense). Vengono poi discussi gli impatti di tali strumenti in termini di provvedimenti di sanità pubblica. Nel corso dell'estate del 2025 (ed analogamente dell'estate di quest'anno) la quasi totalità delle regioni italiane hanno emesso ordinanze di tutela della salute dei lavoratori che fanno riferimento agli strumenti progettuali.

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SPECIES-SPECIFIC PARTICULATE MATTER RETENTION BY SHADE-TOLERANT PLANTS IN MODULAR LIVING WALLS: SEM-BASED QUANTIFICATION AND TRAIT-GUIDED SELECTION

Dalsasso C, Azzella MM, Bruno MR, Campopiano A, Cannizzaro A, Angelosanto F, Tucci F.

SUMMARY

Airborne particulate matter (PM) poses a major health risk, yet species selection for vertical greening systems (VGS) is poorly quantified. We evaluated PM retention by seven commercially available shade-tolerant species grown in a modular living wall system (LWS) on a north-facing façade at Sapienza University of Rome. After 3 months of in situ exposure, leaves were analyzed via SEM (1000×), collecting 210 images, 30 per species. An automated FIJI/ImageJ pipeline segmented particles, computed equivalent circular diameters, and classified them into (PM < 0.5, PM [0.5, 1), PM [1, 2.5), PM [2.5, 10), and PM ≥ 10 µm). Across species, ultrafine and fine fractions dominated deposits, with the < 0.5 µm class typically comprising 60–70% of counts. *Vinca minor* cv. *albomarginata* exhibited the highest densities in ultrafine and fine classes, closely followed by *Fatsia japonica*; *Hedera helix* captured more coarse particles (2.5–10 µm and > 10 µm). *Heuchera sanguinea* consistently displayed the lowest densities across all size classes. Performance patterns aligned with leaf surface traits: wax-coated, moderately rough or gently structured cuticles favored adhesion, whereas highly irregular microrelief did not consistently enhance retention. Methodological considerations include thresholding sensitivity, use of equivalent circular diameter for irregular particles, and an upper area filter that may undercount large aggregates. The findings identify *Vinca minor* cv. *albomarginata* and *Fatsia japonica* as priority species for PM mitigation in shaded VGS, with *Hedera helix* complementing coarse PM capture. The results provide trait-based, design-oriented guidance for living wall species selection in Mediterranean urban and indoor contexts.

BREVE SINTESI

Il particolato atmosferico (PM) rappresenta un grave rischio per la salute. Specie vegetali commerciali sono in grado di ritenere il PM. Per tutte le sette specie vegetali esaminate le particelle depositate sulle foglie appartenevano alle frazioni più sottili, inferiori a 1 µm. La capacità di bloccare il PM dipende altresì dalle caratteristiche della foglia: cuticole ricoperte di cera, moderatamente ruvide o leggermente strutturate favorivano l'adesione delle particelle. I risultati forniscono indicazioni basate sulle caratteristiche e orientate alla progettazione per la selezione delle specie da utilizzare nelle pareti vegetali nei contesti urbani e interni mediterranei.

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UNDERSTANDING HEPATOPANCREAS-ASSOCIATED MICROBIOTA IN THE SUPRALITTORAL *TYLOS PONTICUS* (CRUSTACEA, ISOPODA, ONISCIDEA): INSIGHTS FROM NEXT-GENERATION SEQUENCING APPROACHES

Davolos D, Chimenti C, Fassio G, Russini V, Lepri A, Nocella E.

SUMMARY

Tylos isopods, which are found exclusively in supralittoral beaches, play an important ecological role in the harsh sea-land interface contributing significantly to lignocellulose degradation. Herein, we investigated the hepatopancreatic microbiota in the oniscidean isopod *Tylos ponticus* from an Italian supralittoral zone characterized by the accumulation of beached leaves from the seagrass *Posidonia oceanica*. To characterize this *Tylos*-microbe system, we combined three next generation sequencing techniques: 16S rRNA gene metabarcoding, whole-genome sequencing of cultured hepatopancreatic bacteria and shotgun metagenomic sequencing of uncultured bacterial communities. Comparative analyses revealed that some bacterial taxa were associated with the hepatopancreas of *Tylos ponticus* but were also detected in the supralittoral sandy beach where the detritivores *Tylos* live. However, distinct components of the microbial community may be adapted within the hepatopancreas. Moreover, the assembled and annotated genomes of hepatopancreatic bacteria allowed us to identify genes encoding lignocellulose-degrading CAZymes for a better understanding of the role of symbionts in aiding lignocellulose degradation. Finally, our shotgun sequencing data confirmed the presence of an uncultured *Candidatus* Hepatoplasma (Mollicutes) in the hepatopancreas of *Tylos ponticus*, with the provisional taxonomic assignment as *Candidatus* Hepatoplasma cf. vulgare Tp. We compared this data with recently reported metagenome-assembled genomes of uncultured Hepatoplasmataceae members from isopods, including *Candidatus* Tyloplasma litorale identified from the semiterrestrial isopod *Tylos granuliferus*, *Candidatus* Hepatoplasma vulgare from the terrestrial isopod *Armadillidium vulgare*, and *Candidatus* Hepatoplasma scabrum from the terrestrial isopod *Porcellio scaber*. In such a scenario, a deeper understanding of halophilic bacteria in the supralittoral zone also has broad relevance to applied research, particularly to the biotechnological sector related to marine biomass conversion and plastic degradation.

BREVE SINTESI

La blue biotechnology (biotecnologia blu) rappresenta un ambito strategico in settori quali la valorizzazione sostenibile della biomassa marina e lo sviluppo di processi bioindustriali innovativi. In questo contesto, lo studio, condotto in collaborazione con Sapienza Università di Roma, ha integrato tecnologie avanzate di sequenziamento del DNA e strumenti bioinformatici accessibili, al fine di supportare approcci innovativi alla biosicurezza.

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VERTICAL GREENING SYSTEMS WITH NATIVE SPECIES: AN ECOLOGICAL APPROACH TO URBAN AIR QUALITY IMPROVEMENT

Dalsasso C, Azzella MM, Campopiano A, Bruno MR, Cannizzaro A, Angelosanto F, Di Pietro R, Tucci F, Zarcone R.

SUMMARY

Urbanization and climate change have intensified environmental challenges that pose significant risks to human health. Green infrastructure (GI), such as vertical greening systems (VGS), offers nature-based solutions to improve air quality, mitigate the urban heat island effect, and enhance biodiversity. Despite their benefits, VGS implementation is often constrained by maintenance challenges, species selection issues, and a lack of ecological considerations. This study explores the particulate matter (PM) retention capacity of native plant species that naturally colonize urban walls, evaluating their potential suitability for integration in VGS as a nature-based strategy to enhance air quality in urban environments while promoting biodiversity conservation.

A case study in Rome evaluated five native plant species—*Cymbalaria muralis*, *Capparis spinosa*, *Centranthus ruber*, *Parietaria officinalis*, and *Rubus ulmifolius*—based on their efficiency in capturing PM. The research proposes a framework for selecting native species with differing leaf microstructural characteristics (e.g., wax density, trichomes, and surface wettability) and explores their potential role in PM retention, without quantitatively measuring these traits as explanatory variables. Using scanning electron microscopy (SEM), the study quantified PM accumulation on leaves collected from multiple sites. Statistical analyses showed that *C. ruber* exhibited the highest overall PM capture efficiency, whereas *P. officinalis* demonstrated the lowest. *C. muralis* and *C. spinosa* captured significantly greater amounts of fine particles ($< 1 \mu\text{m}$).

The findings suggest that native species may offer promising potential for integration in VGS to support urban air quality improvement, while their adaptation to local climatic conditions could contribute to reduce maintenance requirements. The study highlights the importance of an ecological approach to plant selection and the integration of biodiversity conservation into urban greening strategies. By optimizing species choice based on functional traits, VGS can become more effective and sustainable tools for air pollution mitigation and urban resilience.

BREVE SINTESI

È stata valutata la capacità di cinque specie vegetali native di Roma di catturare il particolato atmosferico. Tutte le specie studiate trattengono preferenzialmente la frazione fine del particolato. Pertanto, le specie native possono essere utilizzate per favorire il miglioramento della qualità dell'aria urbana.

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VOCATIONAL REHABILITATION FOR PEOPLE WITH MULTIPLE SCLEROSIS: A SYSTEMATIC SCOPING REVIEW OF INTERNATIONAL EVIDENCE

Gualco C, Grange E, Rotondi F, Salivetto M, Pignattelli E, Manacorda T, Grasso MG, Presicce G, Inglese M, Nasone L, Durando P, Dini G, Persechino B, Brichetto G, Ponzio M.

SUMMARY

Introduction: People with multiple sclerosis (pwMS) may encounter challenges in their professional lives, due to a combination of environmental and individual factors. According to Escorpizo et al., 2011 framework, vocational rehabilitation (VR) aims to optimise job participation, providing support in the job access, retention and in the return to work for people with disability. However, the corpus of research on VR for pwMS is poor. This scoping review aims to map the available literature on VR interventions for pwMS, summarising their characteristics, study designs, implementation features, feasibility, and stakeholders' perspectives.

Methods: Following the JBI and the PRISMA-ScR guidelines, seven databases were searched up to October 2025. Studies were eligible if they were related to VR interventions for pwMS, focused on job access, return, or retention and if they were primary articles.

Results: out of 2,360 records, 28 articles describing 28 distinct VR interventions were included. Studies were published between 1996 and 2025, mostly from Western countries. Designs ranged from descriptive to randomized trials, with an increasing number of interventional and feasibility studies in recent years. The 61% of the interventions were multi-dimensional delivering a combination of rehabilitation, educational, and reasonable accommodation services. PwMS highlighted the importance of empathetic and individualized approaches, symptom management, and legal counselling as key elements in VR interventions, while logistical, personal and health issues were barriers to participation. Overall, interventions were considered feasible and acceptable.

Conclusions: This is the first comprehensive overview of VR interventions for pwMS, outlining a progressive shift toward multidisciplinary and goal-oriented approaches over time. Despite promising feasibility and stakeholder satisfaction, further rigorous trials are needed to evaluate effectiveness and inform evidence-based implementation of VR programmes in diverse contexts.

BREVE SINTESI

La Vocational rehabilitation mira a ottimizzare la partecipazione al lavoro delle persone con SM, fornendo supporto nell'accesso, nel mantenimento dell'occupazione e nel ritorno al lavoro per le persone con disabilità. Questa revisione si propone di mappare la letteratura disponibile sugli interventi di VR per le persone con SM, riassumendone caratteristiche, disegni di studio, modalità di implementazione, fattibilità e prospettive degli stakeholder.

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