DCE23 5th DOCTORAL CONGRESS IN ENGINEERING

Book of Abstracts

DCE23 - Symposium on Occupational Safety and Health

U.PORTO
FEUP FACULDADE DE ENGENHARIA
UNIVERSIDADE DO PORTO

DCE 23 5th DOCTORAL CONGRESS IN ENGINEERING

Book of Abstracts

of the

Symposium on Occupational Safety and Health

Editors:

Benjamin Appiah, Felicidade Niquice, Hossein Charkhand,
Kresna Febriyanto, Maria Fernandes, Raquel Martins, Tatiana Teixeira

Porto
June 2023

OUR SILVER SPONSORS

This volume contains the peer reviewed and accepted abstracts, presented at the This volume contains the peer reviewed and accepted abstracts, presented at the Symposium on Occupational Safety and Health, of the 5th Doctoral Congress in Engineering – DCE23, held at FEUP-U.Porto, Porto, Portugal, between June 15th and 16th, 2023.

Title: Book of Abstracts of DCE'23 Symposium on Occupational Safety and Health

Edited by Benjamin Appiah, Felicidade Niquice, Hossein Charkhand, Kresna Febriyanto, Maria Fernandes, Raquel Martins, Tatiana Teixeira

Published by: FEUP Edições

Digital version Symposium on Occupational Safety and Health – DCE 2023

First edition June 2023

ISBN. 978-972-752-310-8

OUR BRONZE SPONSORS

Welcome

The Occupational Safety and Health Book of Abstracts is a collection of the most recent works in the field of occupational safety and health. The included works are focused on the specific topics:

- Occupational Health
- Ergonomics
- Occupational Safety and Hygiene
- Occupational Psychosociology

The abstracts included in this publication are a selection of contributions to the 5th Doctoral Congress in Engineering (DCE). All the included contributions were revised by at least 2 of the 20 international scientific committee members.

The Editors would like to thank all authors for their contributions to the DCE Occupational Safety and Health Symposium. The Editors also thank the Scientific Committee members who, on behalf of their institutions, contributed to the quality of this book:

- Atlantic Technological University, Ireland;
- Delft University of Technology, Netherlands;
- ESALD/IPCB and UCIBIO, Portugal;
- Faculty of Public Health of Burapha University, Thailand;
- Federal Institute of Santa Catarina (IFSC), Brazil;
- Institute of Public Health of the University of Porto (ISPUP), Portugal;
- Institute of Science and Innovation in Mechanical and Industrial Engineering (INEGI), Portugal;
- Portuguese Catholic University, Center for Interdisciplinary Research in Health, Portugal;
- São João University Hospital Centre, Portugal;
- School of Health of the Polytechnic Institute of Porto (ESS.IPP), Portugal;
- University of Algarve (UALG), Portugal;
- University of Porto, Portugal.

Porto, June 2023

Symposium Organizing Committee

Contents

COMMITTEES

Symposium Chairs

Olívia Pinho

João Santos Baptista

Organizing Committee

Benjamin Appiah (Ghana)

Felicidade Niquice (Mozambique)

Hossein Charkhand (Iran)

Kresna Febriyanto (Indonesia)

Maria Fernandes (Portugal)

Raquel Martins (Portugal)

Tatiana Teixeira (Portugal)

Scientific Committee

António Sousa | University of Algarve, Institute of Engineering, Portugal

Felicidade Niquice | University of Porto, Faculty of Engineering, Portugal

Jaqueline Castelo Branco | University of Porto, Faculty of Engineering, Portugal

Joana Duarte | University of Porto, Faculty of Engineering, Portugal

Joana Guedes | University of Porto, Faculty of Engineering, Portugal

Joana Santos | Polytechnic Institute of Porto, School of Health, Portugal

João Rufo | University of Porto, Institute of Public Health, Portugal

João Santos Baptista | University of Porto, Faculty of Engineering, Portugal

Liliana Silva | ESALD/IPCB and UCIBIO, Portugal

Marko Cvetkovic | Delft University of Technology, Netherlands

Maurilia Bastos | Federal Institute of Santa Catarina, Brazil

Olívia Pinho | University of Porto, Faculty of Nutrition and Food Sciences, Portugal

Raquel Martins | University of Porto, Faculty of Engineering, Portugal

Susana Sousa | INEGI, Portugal

Susel Rosário | Consultant, Portugal

Tatiana Teixeira | University of Porto, Faculty of Engineering, Portugal

Teerayut Sa-Ngiamsak | Burapha University, Faculty of Public Health, Thailand

Tomi Zlatar | Atlantic Technological University, Ireland

Vanessa Silva | Portuguese Catholic University, Center for Interdisciplinary Research in Health, Portugal

Vítor Silva | São João University Hospital Centre, Portugal

Symposium Programme – June 16th

Opening Session (9.00am-9.15am)
Chair: Prof. J. Santos Baptista, Assistant Director of DemSSO

Session I (9:15am-10:30am)
Moderated by Benjamin Andoh Appiah

Keynote Speaker (9.15am-9.45am)
PhD Vítor Silva, São João University Hospital Centre, Portugal
"*My DemSSO: challenges, opportunities and accomplishments*"

Oral communications (9.45am-10.30am)
#32 Morphologic and elemental characterization of particulate matter from different firefighters' working environments
Gabriel Sousa, Cristina Delerue-Matos, Xianyu Wang, Francisca Rodrigues, Maria Freitas and Marta Oliveira
#91 Early biomarkers of kidney injury in firefighters exposed to a controlled structure fire
J. Teixeira, F. Rodrigues, C. Delerue-Matos, S. Coimbra, A. Santos-Silva and M. Oliveira
#128 Supervised machine learning for physical fatigue estimation within occupational groups: A brief review
Denisse Bustos, Filipa Cardoso, Ricardo Cardoso, Joana Guedes, José Torres Costa, Mário Vaz, João Santos Baptista and Ricardo J. Fernandes

Coffee-break (coffee lounge) (10:30am-11:00am)

Session II (11:00am-12:15pm)
Moderated by Tatiana Teixeira

Keynote Speaker (11.00am-11.30am)
PhD Marko Cvetkovic, Delft University of Technology, Netherlands
"*Motion Comfort in Automated Driving*"

Oral communications (11.30pm-12.15pm)
#19 The definition of low back pain: a systematic review
Pedro Carretas
#52 Occupational exposure of VOCs in fitness centres
Cátia Peixoto, Gabriela Ventura, M. Carmo Pereira, Simone Morais and Klara Slezakova
#127 Using supervised decision trees to improve physical fatigue management
Denisse Bustos, Diogo D. Carvalho, Manoel Rios, Joana Guedes, José Torres Costa, Mário Vaz, João Santos Baptista and Ricardo J. Fernandes

Closing Session (12.15pm-12.30pm)
Chair: Prof. J. Santos Baptista, Assistant Director of DemSSO

Poster Session (12:30pm-1:00pm) – *B corridor*
Moderated by Kresna Febriyanto

#17 Occupational low back pain: a short systematic review
Pedro Carretas
#18 Diagnostic perspectives in low back pain: a short systematic review
Pedro Carretas
#100 Firefighters' respiratory health
Sandra Lavandeira, Simone Morais, Marta Oliveira and Maria José Alves
#123 Surface contamination by antineoplastic drugs in three Portuguese hospitals
Maria Francisca Portilha Cunha, Arminda Alves, Ana R. L. Ribeiro, Adrián M. T. Silva and Mónica S. F. Santos

List of the Symposium Keynote Speakers

Vítor Manuel da Fonseca e Silva, *São João University Hospital Centre, Portugal*

Topic: "My DemSSO: challenges, opportunities and accomplishments"

Vítor Silva is a Senior Radiographer in Magnetic Resonance Department at Centro Hospitalar e Universitário de São João, EPE, Porto, Portugal. In Magnetic Resonance Department is the radiographers' supervisor.
Graduated in Radiology in Porto Health School, with a Master's degree in Medical Informatics in the Faculty of Medicine of the University of Porto, and a PhD in Occupational Health and Safety at the University of Porto.
Professor at Medical Imaging and Radiotherapy Department in Coimbra Health School, teaching Postgraduate courses and Master's Degrees.
Member of the European Federation of Radiographers Societies (EFRS) Expert Network in Magnetic Resonance, being part of some working groups and EFRS clinical representative in the European Project – "ECSO MRI – European Curriculum for Safety Officers in MRI".
Has participated several times as a guest speaker on the topic "MRI Safety", among others related to MRI, in lectures, courses, workshops and national and international congresses, of which the following stand out: European Congress of Radiology, Portuguese Congress of Radiology, Portuguese Congress of Cardiology and the European P3-Stroke Project.

Marko Cvetkovic, *Postdoc researcher, Delft University of Technology, Netherlands*

Topic: "Motion Comfort in Automated Driving"

Marko Cvetkovic is an enthusiastic Postdoctoral Researcher in the Intelligent Vehicle Research Group at the Faculty of Mechanical Engineering, Delft University of Technology (TU Delft).
With a specialisation in passenger motion comfort in automated driving, he is actively involved in a research project founded by Toyota Motor Corporation focusing on biomechanical modelling and human-seat interaction. With the aim of motion comfort in automated driving, he has undertaken multiple experiments to evaluate human reactions in various driving scenarios, with the primary objective of enhancing motion comfort.
With a master's degree in Occupational Safety and Health from the Faculty of Occupational Safety and Health of the University of Nis, Serbia, and a PhD in Occupational Health and Safety at the University of Porto (2020), with a doctoral thesis titled "Influence of long-time driving on lower limbs musculoskeletal symptoms and physical control". During this time, it was analysed an interaction between prolonged driving exposure and developed driving discomfort on gait performances. In analysing various aspects of this interaction, he has provided valuable insight into the physiological and biomechanical effects experienced by individuals engaged in prolonged driving.

Oral Communications to be presented in the Symposium

The Definition of Low Back Pain: A Systematic Review

Pedro Carretas[1]

1 Faculty of Engineering, University of Porto, PT (up201910164@edu.med.up.pt)

Abstract

Introduction: Low back pain (LBP) is highly prevalent and can cause disability, being a major topic in occupational health. Loss of work due to LBP has substantial social, economic, and personal consequences. In the United States, industrial workers continue to experience high incidence of LBP and report it as the most frequent reason for days away from work. LBP can be divided by duration (acute, sub-acute or chronic) and by origin (specific or non-specific). However, there is not a consensus on these categories neither on the definition of LBP itself. This systematic review aimed to find evidence in the literature of the definitions and categories used to define LBP.

Methodology: This work was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement methodology. The search focused on studies that presented at any stage a definition for LBP. The electronic database searched was Scopus. In the search, the following keywords were used: low back pain AND definition. In the database, the used filters were the year of publication (2018 to 2022), type of document (articles and review), type of source (journals and scientific publications), and language (English). The research was carried out from September to November 2022.

Results and Discussion: According to PRISMA guidelines, 1033 items were initially found in the database. After applied filters date, document type and language remained 255 articles for eligibility. Then 221 articles were excluded because the subject was not related to the scope of the review. So, it was possible to identify 34 relevant publications. From these articles, 9 present the categories for specific and non-specific LBP and 8 describe LBP as leading cause of loss of work. The location of LBP, its temporal presentation and source of pain were described in 6 papers each. Additionally, 4 articles report LBP in a biopsychosocial domain.

Conclusions: After analyzing the included works, was concluded that LBP has a complex and multi-domain definition and has a major impact on disability among workers. There are some known pathological mechanisms that can explain the origin of LBP, mostly the specific type. In contrast, nsLBP due to its non-specificity and spectrum of symptoms, does not have a clear source, and should be considered several other factors. The source of LBP is not clear in most of the cases, and we should face it as a multidomain health issue.

Author Keywords: low back pain, definition, acute low back pain, chronic low back pain, non-specific low back pain

References

Wallace J, Osmotherly P, Gabbett T, Spratford W, Niyonsenga T, Newman P. A Validated Injury Surveillance and Monitoring Tool for Fast Jet Aircrew: Translating Sports Medicine Paradigms to a Military Population. Sports Med Open. 2022;8(1).

Bortsov AV, Parisien M, Khoury S, Martinsen AE, Lie MU, Heuch I, et al. Brain-specific genes contribute to chronic but not to acute back pain. Pain Rep. 2022;7(5):E1018.

Tang R, Kapellusch JM, Hegmann KT, Thiese MS, Wang I, Merryweather AS. Evaluating Different Measures of Low Back Pain Among U.S. Manual Materials Handling Workers: Comparisons of Demographic, Psychosocial, and Job Physical Exposure. Hum Factors. 2022;64(6):973–96.

Gill B, Cheng DS, Buchanan P, Lee DW. Review of Interventional Treatments for Cluneal Neuropathy. Pain Physician. 2022;25(5):355–63.

Boody BS, Sperry BP, Harper K, Macadaeg K, Mccormick ZL. The Relationship Between Patient Demographic and Clinical Characteristics and Successful Treatment Outcomes After Basivertebral Nerve Radiofrequency Ablation: A Pooled Cohort Study of Three Prospective Clinical Trials. Pain Medicine (United States). 2022;23:S2–13.

Mccormick ZL, Sperry BP, Boody BS, Hirsch JA, Conger A, Harper K, et al. Pain Location and Exacerbating Activities Associated with Treatment Success Following Basivertebral Nerve Ablation: An Aggregated Cohort Study of Multicenter Prospective Clinical Trial Data. Pain Medicine (United States). 2022;23:S14–33.

Mccormick ZL, Conger A, Smuck M, Lotz JC, Hirsch JA, Hickman C, et al. Magnetic Resonance Imaging Characteristics Associated with Treatment Success from Basivertebral Nerve Ablation: An Aggregated Cohort Study of Multicenter Prospective Clinical Trials Data. Pain Medicine (United States). 2022;23:S34–49.

Collie A, Sheehan L, di Donato M. Variation in General Practice Services Provided to Australian Workers with Low Back Pain: A Cross-Jurisdictional Comparative Study. J Occup Rehabil. 2022;32(2):203–14.

Lukacs MJ, Kowalski KL, Peters N, Stanley M, Rushton AB. How is recovery defined and measured in patients with low back pain? Protocol for a mixed study systematic review. BMJ Open. 2022;12(5):e061475.

Massé-Alarie H, Angarita-Fonseca A, Lacasse A, Pagé MG, Tétreault P, Fortin M, et al. Low back pain definitions: Effect on patient inclusion and clinical profiles. Pain Rep. 2022;7(2):E997.

Steinmetz A. Back pain treatment: a new perspective. Ther Adv Musculoskelet Dis. 2022;14.

Ibsen C, Schiøttz-Christensen B, Vinther Nielsen C, Hørder M, Schmidt AM, Maribo T. Assessment of functioning and disability in patients with low back pain–the low back pain assessment tool. Part 1: development. Disabil Rehabil. 2022;44(17):4841–52.

Tamminga SJ, Kuijer PPFM, Badarin K, Alfonso JH, Amaro J, Curti S, et al. Towards harmonisation of case definitions for eight work-related musculoskeletal disorders - an international multi-disciplinary Delphi study. BMC Musculoskelet Disord. 2021;22(1).

Long G, Fang ZY, Xiang-sheng T, Feng Y, Hao-ning M, Qing-ying H, et al. Symmetry in Paraspinal Muscles as a Predictor of the Development of Pregnancy-Related Low Back and Pelvic Pain: A Prospective Study. Orthop Surg. 2021;13(8):2255–62.

van der Molen HF, Visser S, Alfonso JH, Curti S, Mattioli S, Rempel D, et al. Diagnostic criteria for musculoskeletal disorders for use in occupational healthcare or research: a scoping review of consensus- and synthesised-based case definitions. BMC Musculoskelet Disord. 2021;22(1).

McPhee ME, Graven-Nielsen T. Medial Prefrontal High-Definition Transcranial Direct Current Stimulation to Improve Pain Modulation in Chronic Low Back Pain: A Pilot Randomized Double-blinded Placebo-Controlled Crossover Trial. Journal of Pain. 2021;22(8):952–67.

Reitman CA, Cho CH, Bono CM, Ghogawala Z, Glaser J, Kauffman C, et al. Management of degenerative spondylolisthesis: development of appropriate use criteria. Spine Journal. 2021;21(8):1256–67.

Wilson F, Ardern CL, Hartvigsen J, Dane K, Trompeter K, Trease L, et al. Prevalence and risk factors for back pain in sports: A systematic review with meta-Analysis. Br J Sports Med. 2021;55(11):601–7.

Ganesh GS, Kaur P, Meena S. Systematic reviews evaluating the effectiveness of motor control exercises in patients with non-specific low back pain do not consider its principles – A review. J Bodyw Mov Ther. 2021;26:374–93.

Ly A, Pelletier S, Dionne CE. Cross-cultural adaptation of Delphi definitions of low back pain prevalence in French (Delphi DOLBaPP-F). Explor Med. 2021;2(6):483–93.

Gabel CP, Mokhtarinia HR, Mokhtarinia HR, Melloh M, Mateo S. Slacklining as therapy to address non-specific low back pain in the presence of multifidus arthrogenic muscle inhibition. World J Orthop. 2021;12(4):178–96.

Elias JP, Longen WC. Classification of low back pain into subgroups for diagnostic and therapeutic clarity | Classificação da lombalgia em subgrupos para clareza diagnóstica e terapêutica | Clasificación de la lumbalgia en subgrupos para claridad diagnostica y terapéutica. Coluna/ Columna. 2020;19(1):34–9.

Miller D, Hasan K, Kirk A, Ayalew D, Walker W. Prevalence and Characteristics of Low Back Pain in a Rural Ghana Primary Care Clinic Population. PM and R. 2020;12(3):251–6.

Miotto R, Percha BL, Glicksberg BS, Lee HC, Cruz L, Dudley JT, et al. Identifying acute low back pain episodes in primary care practice from clinical notes: Observational study. JMIR Med Inform. 2020;8(2).

Vining RD, Shannon ZK, Minkalis AL, Twist EJ. Current Evidence for Diagnosis of Common Conditions Causing Low Back Pain: Systematic Review and Standardized Terminology Recommendations. J Manipulative Physiol Ther. 2019;42(9):651–64.

Jess MA, Hamilton S, Ryan CG, Wellburn S, Martin D. Exploring the origin of low back pain sub-classification: A scoping review protocol. JBI Database System Rev Implement Rep. 2019;17(8):1600–6.

Vivekanantham A, Edwin C, Pincus T, Matharu M, Parsons H, Underwood M. The association between headache and low back pain: A systematic review. Journal of Headache and Pain. 2019;20(1).

Fujii K, Yamazaki M, Kang JD, Risbud MV, Cho SK, Qureshi SA, et al. Discogenic Back Pain: Literature Review of Definition, Diagnosis, and Treatment. JBMR Plus. 2019;3(5).

Ardakani EM, Leboeuf-Yde C, Walker BF. Can We Trust the Literature on Risk Factors and Triggers for Low Back Pain? A Systematic Review of a Sample of Contemporary Literature. Pain Res Manag. 2019;2019.

Delion TPE, Draper-Rodi J. University College of Osteopathy students' attitudes towards psychosocial risk factors and non-specific low back pain: A qualitative study. International Journal of Osteopathic Medicine. 2018;29:41–8.

Weis CA, Barrett J, Tavares P, Draper C, Ngo K, Leung J, et al. Prevalence of Low Back Pain, Pelvic Girdle Pain, and Combination Pain in a Pregnant Ontario Population. Journal of Obstetrics and Gynaecology Canada. 2018;40(8):1038–43.

Amundsen PA, Evans DW, Rajendran D, Bright P, Bjørkli T, Eldridge S, et al. Inclusion and exclusion criteria used in non-specific low back pain trials: A review of randomised controlled trials published between 2006 and 2012. BMC Musculoskelet Disord. 2018;19(1).

Mariano TY, Urman RD, Hutchison CA, Jamison RN, Edwards RR. Cognitive Behavioral Therapy (CBT) for Subacute Low Back Pain: a Systematic Review. Curr Pain Headache Rep. 2018;22(3).

Ardakani EM, Leboeuf-Yde C, Walker BF. Failure to define low back pain as a disease or an episode renders research on causality unsuitable: Results of a systematic review. Chiropr Man Therap. 2018;26(1).

Morphologic and Elemental Characterization of Particulate Matter from Different Firefighters' Working Environments

Gabriel Sousa[1,2], Maria Freitas[1], Cristina Delerue-Matos[1], Xianyu Wang[3], Francisca Rodrigues[1] and Marta Oliveira[1*]

1 REQUIMTE/LAQV-Instituto Superior de Engenharia do Instituto Politécnico do Porto, Porto, Portugal

2 Faculdade de Ciências da Universidade do Porto, Universidade do Porto, Porto, Portugal

3 QAEHS, Queensland Alliance for Environmental Health Sciences, The University of Queensland, Brisbane, Australia

*marta.oliveira@graq.isep.ipp.pt

Abstract

Introduction: Exposure to particulate matter (PM), particularly fine (≤ 2.5 μm) and ultrafine (≤ 0.1 μm), can lead to adverse health effects on the pulmonary and cardiovascular systems (WHO, 2021). Firefighters are susceptible to high levels of exposure to PM in their work environment (e.g., structure/forest fires, and fire station atmosphere) (Demers et al., 2022). However, available information remains scarce. This work characterizes the concentrations of fine and ultrafine PM, its chemical composition, and morphology, in different working environments: distinct fire stations and controlled structure and forest fires.

Materials and Methods: PM collection was accomplished in Porto, Portugal, using a low-pressure impactor (DLPI+, Dekati®) during 24 hours (fire stations), 1 and 6 hours of controlled urban and forest firefighting exercises, respectively. Morphological analysis was performed by Scanning Electron Microscopy (SEM), and elemental characterization was accomplished through Energy-dispersive Spectroscopy (EDS).

Results and Discussion: The mean total PM levels varied from 352.5 μg/m3 (fire stations) to 875.4 μg/m3 and 112.6×103 μg/m3, for the controlled forest and urban fires, respectively. Fire stations' PM was composed mostly of a homogeneous black aggregate (organic matter) but also crystals (sulphates/chlorides) and minerals (aluminosilicates). Samples from fire environments are more heterogeneous and mainly composed of sulphates/chlorides and fibers. Barium and iron were commonly found in fire station PM, while magnesium and lead were only detected in PM from the controlled forest and urban fires, respectively.

Conclusions: PM morphologies and elements found in the different environments were substantially distinct from each other, proving that the materials burned, and the temperatures reached in the fires alter the content under analysis. However, some elements/substances were similar across all environments.

Author Keywords: Occupational exposure, Firefighters, Respirable particles, Electron microscopy.

References

Demers, P.A. et al. (2022). Carcinogenicity of occupational exposure as a firefighter. Lancet Oncol. 23, (8), 985 - 986. https://doi.org/10.1016/S1470-2045(22)00390-4.

World Health Organization. (2021). WHO global air quality guidelines: particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. WHO, Geneva. Retrieved from https://apps.who.int/iris/handle/10665/345329. Accessed in 29/03/2023.

Funding

This work received financial support from the project PCIF/SSO/0090/2019 by the Fundação para a Ciência e a Tecnologia (FCT), Ministério da Ciência, Tecnologia e Ensino Superior (MCTES), through national funds.

Acknowledgements

This work received support from UIDB/50006/2020, UIDP/50006/2020, LA/P/0008/2020, and 2022.05381.PTDC by FCT/MCTES. M. Freitas, M. Oliveira, and F. Rodrigues, are thankful to the scientific contracts 2022.00490.CEECIND, CEECIND/03666/2017 and CEECIND/01886/2020, respectively. G. Sousa thanks the PhD grant 2021.08526.BD, supported by FCT-MCTES, Programa Por_Norte, and European Union through Fundo Social Europeu. The team would also like to acknowledge the commanders and firefighters for the participation in this study.

Occupational Exposure of VOCs in Fitness Centres

Cátia Peixoto[1,2]; Gabriela Ventura[3]; Maria do Carmo Pereira[2]; Simone Morais[1] and Klara Slezakova[2]

1 REQUIMTE-LAQV, Instituto Superior de Engenharia do Porto, Instituto Politécnico do Porto.

2 LEPABE-ALiCE, Faculdade de Engenharia da Universidade do Porto.

3 INEGI-ISA – Laboratório Qualidade do Ar Interior, Investigação de Suporte ao Ambiente.

Abstract

Introduction: Volatile organic compounds (VOCs) are organic compounds with a vapour pressure of 0.01 kPa or more at 293.15°C, or an equivalent volatility under particular conditions of use (Directive 2010/75/EU). They are among the major indoor air pollutants, some of which may cause short- and long-term adverse health effects. Given the possible health risks, World Health Organization identified 30 chemicals relevant to indoor air, out of which 17 were VOCs (WHO, 2021). Thus, identifying and characterising these compounds are especially suitable in spaces like fitness centres (FC), where increased inhalation (due to physical demand) can lead to high exposure. This study assessed VOC levels in two FC and estimated the respective carcinogenic risks for the exposed workers.

Materials and Methods: Indoor air monitoring was performed in December 2022 in two FC (one equipped with a swimming pool) for 8 h for total VOCs (TVOCs; multi-gas sensor probe, model TG 502; GrayWolf Sensing Solutions, USA). Air samples were concurrently collected (stainless steel tube, Tenax TA, 60/80 mesh; AirChek XR5000 pump, SKC Ltd, 100 mL/min) at various locations, i.e., groups classes studios and cardio fitness area. Subsequent individual VOCs quantifications were conducted by thermal desorption (DANI desorption system, model TD Master) coupled with gas chromatography–mass selective detector (GC/MSD; Agilent Technologies, model 7890A; model 5975C). Carcinogenic risks (CR) due to inhalation exposure were calculated using the USEPA methodology (USEPA, 2009).

Results and Discussion: The mean TVOCs (based on 8 h monitoring) were 0.89 mg/m3 in FC1 and 1.89 mg/m3 in FC2, both exceeding the Portuguese protective threshold (0.6 mg/m3; Ordinance nº 138-G/2021). Decamethylcyclopentasiloxane was the predominant contributor to 8.3-9.5% of TVOCs in FC1 and 15-23% in FC2, most likely due to personal care products use. Whereas the information on VOCs in fitness spaces is limited (Andrade & Dominski, 2018; Finewax *et al.*, 2020; You *et al.*, 2022), specifically, 13 VOCs (S13VOC) of the WHO priority indoor air risk chemicals (WHO, 2021) were detected: benzene, m,p-xylenes, styrene, toluene, ethylbenzene, butyl acetate, tetrachloroethylene, α-pinene, limonene, n-decane, naphthalene, o-xylene and trichloroethylene. S13VOC accounted for 18-19% in FC1 and 9.2-11.3% in FC2. Furthermore, VOCs specific to water disinfection were detected only in indoor spaces of FC2 (with a pool), representing 13-14% of the indoor TVOCs. The USEPA individual CR threshold (10-6) was exceeded for benzene (1.1-1.9 times) and trichlorethylene (up to 34 times), indicating non-negligible risks for the respective professionals. Finally, the total CR (SCR) did not exceed the USEPA cumulative threshold of 10-4 (USEPA, 2009).

Conclusions: Whereas VOC concentration profiles were different in both FC, the exceeded TVOCs and the CR due to inhalation exposure indicate possible adverse outcomes for the respective occupational group.

Author Keywords: VOCs; Carcinogenic risks; Indoor air pollutants; Occupational exposure.

References

Andrade, A., & Dominski, F. H. (2018). Indoor air quality of environments used for physical exercise and sports practice: Systematic review. Journal of Environmental Management, 206, 577–586. doi:10.1016/j.jenvman.2017.11.001.

Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions (integrated pollution prevention and control). Official Journal of the European Union L 334/17, 2010.

Finewax, Z., Pagonis, D., Claflin, M. S., Handschy, A. V., Brown, W. L., Jenks, O., … Gouw, J. A. (2020). Quantification and source characterization of volatile organic compounds from exercising and application of chlorine-based cleaning products in a university athletic center. Indoor Air. doi:10.1111/ina.12781.

Ordinance (Portaria) nº 138-G/2021. Estabelece os requisitos para a avaliação da qualidade do ar interior nos edifícios de comércio e serviços, incluindo os limiares de protecção, condições de referência e critérios de conformidade, e a respectiva metodologia para a medição dos poluentes e para a fiscalização do cumprimento das normas aprovadas (in Portuguese). Diário da República 1.ª série – N.º 126: 128(2) - 128(6).

US Environmental Protection Agency (USEPA), 2009. Risk assessment guidance for superfund volume I: Human health evaluation manual (part f, supplemental guidance for inhalation risk assessment), Office of Superfund Remediation and Technology Innovation. Washington, D.C., 1-36. Available from https://semspub.epa.gov/work/HQ/140530.pdf.

World Health Organization (WHO), 2021. Literature review on chemical pollutants in indoor air in public settings for children and overview of their health effects with a focus on schools, kindergartens and day-care centres. ISBN 97-892-890-5564-2.

You, B., Zhou, W., Li, J., Li, Z. & Sun, Y. (2022). "A review of indoor gaseous organic compounds and human chemical exposure: insights from real-time measurements". Environment International 170, 107611. https://doi.org/10.1016/j.envint.2022.107611.

Acknowledgments

This work was financially supported by Portuguese national funds through projects UIDB/50006/2020, UIDP/50006/2020 and LA/P/0008/2020 (REQUIMTE), and by LA/P/0045/2020 (ALiCE) and UIDB/00511/2020 (LEPABE), from the Fundação para a Ciência e a Tecnologia (FCT)/Ministério da Ciência, Tecnologia e Ensino Superior (MCTES). Additional funding was provided by PCIF/SSO/0017/2018 FCT through national funds. Cátia Peixoto would like to acknowledge FCT for her fellowship SFRH/BD/147185/2019.

Early Biomarkers of Kidney Injury in Firefighters Exposed to a Controlled Structure Fire

J. Teixeira[1], F. Rodrigues[1], C. Delerue-Matos[1], S. Coimbra[2,3,4], A. Santos-Silva[2,3], M. Oliveira[1*]

1 REQUIMTE/LAQV, ISEP, Polytechnic of Porto, Porto, Portugal

2 REQUIMTE/UCIBIO, Applied Molecular Biosciences Unit, Department of Biological Sciences, Faculty of Pharmacy University of Porto, Porto, Portugal

3 Associate Laboratory i4HB, Institute for Health and Bioeconomy, Faculty of Pharmacy University of Porto, Porto, Portugal

4 TOXRUN, Toxicology Research Unit, University Institute of Health Sciences, Cooperativa de Ensino Superior Politécnico e Universitário (CESPU), Gandra, Portugal

*E-mail: marta.oliveira@graq.isep.ipp.pt

Abstract

Introduction: Occupational exposure as a firefighter was recently classified as carcinogenic to humans (Group 1) being demonstrated the contribution of this activity to the development of bladder cancer. Firefighters are regularly exposed to occupational factors (e.g., physical stress and dehydration) that can exacerbate the risk of developing kidney injury. Despite the recognized health risks, the characterization of firefighters' renal function remains poorly characterized. This work presents for the first time, the assessment of creatinine and cystatin-C levels, a traditional and a new early biomarker of renal (dys)function, respectively, in firefighter trainees during a controlled structure fire event.

Materials and Methods: Spot urine samples were collected by 10 firefighters (male; 26.9 ± 1.45 years; 24.6 ± 1.88 kg/m2; 40% smokers) before and after participation in fire combat activities and in the morning after the firefighting training. Creatinine levels were determined by a standard protocol based on the Jaffe colorimetric method. Cystatin-C was analyzed through a commercially available kit, according to the manufacturer's instructions (Human Cystatin C, Quantikine ELISA Kit, R&D Systems, Minnesota, USA; sensitivity 0.102 ng/mL). Statistical analysis was performed using SPSS (version 28.0, Armonk, NY, USA). A p-value ≤ 0.05 was considered as significant.

Results and Discussion: The median and interquartile range of urinary creatinine concentrations were slightly increased after firefighting (162.4 mg/dL; 129.2 – 206.5 mg/dL) and on the day after the training (172.8 mg/dL; 148.8 – 183.4 mg/dL) than pre-fire levels (140.6 mg/dL; 120.2 – 154.0 mg/dL). A total of 50% of firefighters presented an increase of, at least, 1.5 times in the urinary creatinine levels after their participation in firefighting. Normalized cystatin-C levels were significantly increased after firefighting (51.5 ng/mg creatinine; 47.0 – 55.2 ng/mg creatinine, $p = 0.009$), and in the day after the training (54.9 ng/mg creatinine; 48.0 – 61.7 ng/mg creatinine, $p = 0.03$), than pre-fire levels (30.4 ng/mg creatinine; 26.0 – 62.9 ng/mg creatinine).

Conclusions: Data from this preliminary study emphasized the importance of early biomarkers of renal injury, as cystatin-C, for detection of renal damage associated with the occupational exposure of firefighters. The impact of firefighters' exposure to health-relevant pollutants, heat, and associated physiological disorders on their renal function should be evaluated in regular health surveillance programs. The reinforcement of hydration levels and reduction of time in excessive physical stress could contribute to protecting the renal function of firefighters. Further studies should include a superior number of individuals and additional biomarkers of kidney damage.

Author Keywords: kidney injury, firefighters, urinary biomarkers, cystatin-c, creatinine

References

Demers P., et al. (2022). Carcinogenicity of occupational exposure as a firefighter, The Lancet Oncology, 23 (8), P985-986.

Ronco, C., et al. (2019). Acute kidney injury. Lancet, 394 (10212), 1949 - 1964.

Schlader, Z. J., et al. (2019). The Potential for Renal Injury Elicited by Physical Work in the Heat. Nutrients, 11, 9 - 34.

Acknowledgments

This work was funded by project PCIF/SSO/0090/2019 by the Fundação para a Ciência e a Tecnologia, Ministério da Ciência, Tecnologia e Ensino Superior (FCT-MCTES), through national funds. This work received support from UIDB/50006/2020, UIDP/50006/2020, LA/P/0008/2020, 2022.05381.PTDC, and PCIF/SSO/0017/2018 by FCT-MCTES. M.Oliveira and F.Rodrigues are thankful for the scientific contracts CEECIND/03666/2017 and CEECIND/01886/2020, respectively. The authors thank all firefighters and the agents of Autoridade Nacional de Emergência e Proteção Civil for their collaboration and support.

Using Supervised Decision Trees to Improve Physical Fatigue Management

Denisse Bustos[1], Diogo D. Carvalho[2], Manoel Rios[3], Joana Guedes[4], José Torres Costa[5], Mário Vaz[6], João Santos Baptista[7] and Ricardo J. Fernandes[8]

1 Associated Laboratory for Energy, Transports and Aeronautics - LAETA (PROA), Faculty of Engineering, University of Porto, PT (ldbs@fe.up.pt) ORCID 0000-0002-4942-7625

2 Centre of Research, Education, Innovation and Intervention in Sport - CIFI2D, Faculty of Sport, University of Porto, Porto, PT; Porto Biomechanics Laboratory, Faculty of Sport, University of Porto, Porto, PT (diogoduarte_03@hotmail.com) ORCID 0000-0001-8871-5614

3 Centre of Research, Education, Innovation and Intervention in Sport - CIFI2D, Faculty of Sport, University of Porto, Porto, PT; Porto Biomechanics Laboratory, Faculty of Sport, University of Porto, Porto, PT (manoel.rios@hotmail.com) ORCID 0000-0002-3574-6692

4 Associated Laboratory for Energy, Transports and Aeronautics - LAETA (PROA), Faculty of Engineering, University of Porto, PT (jccg@fe.up.pt) ORCID 0000-0003-2367-2187

5 Associated Laboratory for Energy, Transports and Aeronautics - LAETA (PROA), Faculty of Medicine, University of Porto, PT (zecatoco@sapo.pt) ORCID 0000-0003-3947-8688

6 Associated Laboratory for Energy, Transports and Aeronautics - LAETA (PROA), Faculty of Engineering, University of Porto, Porto, PT; Porto Biomechanics Laboratory, Faculty of Sport, University of Porto, Porto, PT (gmavaz@fe.up.pt) ORCID 0000-0002-6347-9608

7 Associated Laboratory for Energy, Transports and Aeronautics - LAETA (PROA), Faculty of Engineering, University of Porto, PT (jsbap@fe.up.pt) ORCID 0000-0002-8524-5503

8 Center of Research, Education, Innovation and Intervention in Sport - CIFI2D, Faculty of Sport, University of Porto, PT; Porto Biomechanics Laboratory, University of Porto, PT (ricfer@fade.up.pt) ORCID 0000-0002-5811-0443

Abstract

Introduction: Physical fatigue is a major health and safety issue among occupational groups. Its continuous monitoring and assessment would help prevent its adverse effects. Given the advances in wearable sensor technology, research efforts are based on developing physical fatigue quantification approaches that translate physiological information into actionable indicators. While various approaches have been applied to achieve this (e.g. traditional programming, statistical indices or machine learning algorithms), there is no generalisable procedure to accurately assess physical fatigue for occupational applications. Therefore, this study aimed to contribute to physical fatigue assessment by exploring the applicability of three decision tree classifiers to estimate physical fatigue within a sample of volunteer firefighters.

Materials and Methods: Personal characteristics and physiological information from heart rate, breathing rate and core temperature were recorded from a convenience sample of 24 participants (age 33.0 ± 9.5 years, weight 76.0 ± 10.5 kg and height 172.1 ± 7.9 cm) during an incremental running protocol. Three supervised decision tree algorithms with proven applicability for related occupational goals (Bagged, RUS Boosted and Gradient Boosted Trees) were examined using features extracted from the physiological variables and participants' data to estimate low, moderate and high physical fatigue levels.

Results and Discussion: Outcomes showed that the three classifiers led to average prediction accuracies above 80%, with the highest being 88% with the Gradient Boosted tree algorithm. Predictions using the RUS Boosted and the Bagged Trees were 81 and 85% (respectively). These results are comparable with those from the literature, confirming that these classifiers are an accurate alternative for improving physical fatigue assessment. Also, the found variability among individual prediction accuracies (± 10%) evidenced the importance of individualised monitoring (instead of assessments based on standardised profiles) and the need for more than one physiological indicator to reliably characterise the subject physical fatigue status.

Conclusions: Overall, the current study demonstrates the advantages of using physiological measures and supervised machine learning algorithms for enhancing physical fatigue modelling in the workplace. Although there is room for improvement, Gradient Boosted trees proved to be a feasible alternative to translate physiological information into simple physical fatigue levels that can be used to prevent adverse physical fatigue effects. Future studies will be oriented to test its validity in real-life settings while assessing workers during representative occupational activities.

Author Keywords: machine learning, supervised learning, classification algorithms, physiological signals, occupational health.

References

Adão Martins, N. R., Annaheim, S., Spengler, C. M., & Rossi, R. M. (2021). Fatigue Monitoring Through Wearables: A State-of-the-Art Review [Systematic Review]. Frontiers in Physiology, 12. https://doi.org/10.3389/fphys.2021.790292

Aguirre, A., Pinto, M. J., Cifuentes, C. A., Perdomo, O., Díaz, C. A. R., & Múnera, M. (2021). Machine Learning Approach for Fatigue Estimation in Sit-to-Stand Exercise. Sensors, 21(15). https://doi.org/10.3390/s21155006

Ameli, S., Naghdy, F., Stirling, D., Naghdy, G., & Aghmesheh, M. (2018). Quantitative and non-invasive measurement of exercise-induced fatigue. Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology, 233(1), 34-45. https://doi.org/10.1177/1754337118775548

Aryal, A., Ghahramani, A., & Becerik-Gerber, B. (2017). Monitoring fatigue in construction workers using physiological measurements. Automation in Construction, 82, 154-165. https://doi.org/https://doi.org/10.1016/j.autcon.2017.03.003

Bustos, D., Cardoso, F., Rios, M., Vaz, M., Guedes, J., Torres Costa, J., Santos Baptista, J., & Fernandes, R. J. (2023). Machine Learning Approach to Model Physical Fatigue during Incremental Exercise among Firefighters. Sensors, 23(1). https://doi.org/10.3390/s23010194

Hooda, R., Joshi, V., & Shah, M. (2021). A comprehensive review of approaches to detect fatigue using machine learning techniques. Chronic Diseases and Translational Medicine. https://doi.org/https://doi.org/10.1016/j.cdtm.2021.07.002

Ibrahim, A., Nnaji, C., Namian, M., Koh, A., & Techera, U. (2023). Investigating the impact of physical fatigue on construction workers' situational awareness. Safety Science, 163, 106103. https://doi.org/https://doi.org/10.1016/j.ssci.2023.106103

Kupschick, S., Pendzich, M., Gardas, D., Jürgensohn, T., Wischniewski, S., & Adolph, L. (2016). Predicting Firefighters' Exertion Based on Machine Learning Techniques. Federal Institute for Occupational Safety and Health: Dortmund, Germany. https://doi.org/10.21934/baua:focus20161107

Pluntke, U., Gerke, S., Sridhar, A., Weiss, J., & Michel, B. (2019, 23-27 July 2019). Evaluation and Classification of Physical and Psychological Stress in Firefighters using Heart Rate Variability. 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC).

Techera, U., Hallowell, M., Stambaugh, N., & Littlejohn, R. (2016). Causes and Consequences of Occupational Fatigue: Meta-Analysis and Systems Model. Journal of Occupational and Environmental Medicine, 58(10). https://journals.lww.com/joem/Fulltext/2016/10000/Causes_and_Consequences_of_Occupational_Fatigue_.1.aspx

Acknowledgements

This work was supported by the Foundation of Science and Technology (FCT Portugal) through the PhD studentship SFRH/BD/143608/2019 and the project grant PCIF/SSO/0063/2018. The authors would like to acknowledge the support of the Doctoral Program in Occupational Safety and Health of the University of Porto.

Supervised Machine Learning for Physical Fatigue Estimation Within Occupational Groups: A Brief Systematic Review

Denisse Bustos[1], Filipa Cardoso[2], Ricardo Cardoso[3], Joana Guedes[4], José Torres Costa[5], Mário Vaz[6], João Santos Baptista[7], Ricardo J. Fernandes[8]

1 Associated Laboratory for Energy, Transports and Aeronautics - LAETA (PROA), Faculty of Engineering, University of Porto, PT (ldbs@fe.up.pt) ORCID 0000-0002-4942-7625

2 Centre of Research, Education, Innovation and Intervention in Sport - CIFI2D, Faculty of Sport, University of Porto, Porto, PT; Porto Biomechanics Laboratory, Faculty of Sport, University of Porto, Porto, PT (up201402398@edu.fade.up.pt) ORCID 0000-0001-7829-5222

3 Centre of Research, Education, Innovation and Intervention in Sport - CIFI2D, Faculty of Sport, University of Porto, Porto, PT; Porto Biomechanics Laboratory, Faculty of Sport, University of Porto, Porto, PT (ricardocardoso.coach@gmail.com) ORCID 0000-0001-9722-3910

4 Associated Laboratory for Energy, Transports and Aeronautics - LAETA (PROA), Faculty of Engineering, University of Porto, PT (jccg@fe.up.pt) ORCID 0000-0003-2367-2187

5 Associated Laboratory for Energy, Transports and Aeronautics - LAETA (PROA), Faculty of Medicine, University of Porto, PT (zecatoco@sapo.pt) ORCID 0000-0003-3947-8688

6 Associated Laboratory for Energy, Transports and Aeronautics - LAETA (PROA), Faculty of Engineering, University of Porto, Porto, PT; Porto Biomechanics Laboratory, Faculty of Sport, University of Porto, Porto, PT (gmavaz@fe.up.pt) ORCID 0000-0002-6347-9608

7 Associated Laboratory for Energy, Transports and Aeronautics - LAETA (PROA), Faculty of Engineering, University of Porto, PT (jsbap@fe.up.pt) ORCID 0000-0002-8524-5503

8 Center of Research, Education, Innovation and Intervention in Sport - CIFI2D, Faculty of Sport, University of Porto, PT; Porto Biomechanics Laboratory, University of Porto, PT (ricfer@fade.up.pt) ORCID 0000-0002-5811-0443

Abstract

Introduction: Fatigue is a prevalent and debilitating condition that can lead to detrimental short and long-term health consequences. As a result, managing fatigued workers has become an important health and safety concern, with research efforts being increasingly directed toward this goal. Consequently, the need to systematise up-to-date research progress among workers populations emerges to have a complete perspective on what has been done, with what degree of success and where further research is needed. The current study developed as a part of an extensive review of physical fatigue quantification approaches among occupational groups, aims to identify the supervised machine learning-based physical fatigue assessment methods used to detect and categorise workers' physical fatigue.

Methodology: The PRISMA Statement was used as a guideline to conduct the research and synthesise the findings. Relevant keywords were combined to gather studies addressing the application of supervised machine learning algorithms to detect or categorise physical fatigue. The research was performed in selected electronic databases and multidisciplinary academic journals, focusing on English-written journal articles published since 2018. In a subsequent stage, retrieved items were filtered according to the adequacy of their goals to the objective of the review, to be later examined and categorised by measurement context, assessed variables and applied processing and prediction methods.

Results and Discussion: Of the 427 retrieved items, only 13 studies fulfilled the selection criteria. In general, included studies addressed physical fatigue assessments during short laboratory trials simulating fatiguing occupational tasks. They developed models based on accelerometry-based motion, heart rate, skin and core temperature and respiratory data, mainly using a combination of two or more of these signals. Outcomes also revealed that most studies used different configurations of decision trees and support vector machine

classifiers to delimit two, three and four physical fatigue levels achieving prediction accuracies ranging from 80 to 95%.

Conclusions: The current work evidenced the usefulness of supervised learning to detect and categorise different levels of physical fatigue. However, the heterogeneity of assessed variables, experimental protocols and processing techniques demonstrate that more work is needed to develop generalisable models with real-life applicability. The current review provided possible departure points in this regard while helping define the next steps in the research to retrieve and analyse other physical fatigue quantification approaches, including statistical models and deep learning approaches.

Author Keywords: occupational fatigue, supervised learning, machine learning, physiological signals, occupational health and safety.

References

Adão Martins, N. R., Annaheim, S., Spengler, C. M., & Rossi, R. M. (2021). Fatigue Monitoring Through Wearables: A State-of-the-Art Review [Systematic Review]. Frontiers in Physiology, 12. https://doi.org/10.3389/fphys.2021.790292

Aguirre, A., Pinto, M. J., Cifuentes, C. A., Perdomo, O., Díaz, C. A. R., & Múnera, M. (2021). Machine Learning Approach for Fatigue Estimation in Sit-to-Stand Exercise. Sensors, 21(15). https://doi.org/10.3390/s21155006

Anwer, S., Li, H., Antwi-Afari, M. F., Umer, W., & Wong, A. Y. L. (2021). Evaluation of Physiological Metrics as Real-Time Measurement of Physical Fatigue in Construction Workers: State-of-the-Art Review [Review]. Journal of Construction Engineering and Management, 147(5), Article 03121001. https://doi.org/10.1061/(ASCE)CO.1943-7862.0002038

Billones, R., Liwang, J. K., Butler, K., Graves, L., & Saligan, L. N. (2021). Dissecting the fatigue experience: A scoping review of fatigue definitions, dimensions, and measures in non-oncologic medical conditions. Brain Behav Immun Health, 15, 100266. https://doi.org/10.1016/j.bbih.2021.100266

Hooda, R., Joshi, V., & Shah, M. (2021). A comprehensive review of approaches to detect fatigue using machine learning techniques. Chronic Diseases and Translational Medicine. https://doi.org/https://doi.org/10.1016/j.cdtm.2021.07.002

Ibrahim, A., Nnaji, C., Namian, M., Koh, A., & Techera, U. (2023). Investigating the impact of physical fatigue on construction workers' situational awareness. Safety Science, 163, 106103. https://doi.org/https://doi.org/10.1016/j.ssci.2023.106103

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., McGuinness, L. A., Stewart, L. A., Thomas, J., Tricco, A. C., Welch, V. A., Whiting, P., & Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ, 372, n71. https://doi.org/10.1136/bmj.n71

Sedighi Maman, Z., Chen, Y.-J., Baghdadi, A., Lombardo, S., Cavuoto, L. A., & Megahed, F. M. (2020). A data analytic framework for physical fatigue management using wearable sensors. Expert Systems with Applications, 155, 113405. https://doi.org/https://doi.org/10.1016/j.eswa.2020.113405

Umer, W., Li, H., Yantao, Y., Antwi-Afari, M. F., Anwer, S., & Luo, X. (2020). Physical exertion modeling for construction tasks using combined cardiorespiratory and thermoregulatory measures. Automation in Construction, 112, 103079. https://doi.org/https://doi.org/10.1016/j.autcon.2020.103079

Zhang, L., Diraneyya, M., Ryu, J., Haas, C., & Abdel-Rahman, E. (2019). Automated monitoring of physical fatigue using jerk. ISARC. Proceedings of the International Symposium on Automation and Robotics in Construction.

Acknowledgements

This work was supported by the Foundation of Science and Technology (FCT Portugal) through the PhD studentship SFRH/BD/143608/2019 and the project grant PCIF/SSO/0063/2018. The authors would like to acknowledge the support of the Doctoral Program in Occupational Safety and Health of the University of Porto.

Posters to be displayed in the Symposium

Occupational Low Back Pain: A Short Systematic Review

Pedro Carretas[1]

1 Faculty of Engineering, University of Porto, PT (up201910164@edu.med.up.pt)

Abstract

Introduction: Occupational low back pain (OLBP) is highly prevalent and can cause disability, being a major topic in occupational health. Loss of work due to OLBP has substantial social, economic, and personal consequences. In United States, OBLP accounts for around 30% of workers' compensation claims costs. OLBP is considered one of the most common causes of disability in industrialized and in developing countries. This systematic review aimed to find evidence, in the literature, of the prevalence and management of OLBP.

Methodology: This work was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement methodology. The search focused on studies that presented at any stage an approach for prevalence and management of OLBP. The electronic database searched was Scopus. In the database, the used filters were the year of publication (2013 to 2023), type of document (articles), type of source (journals and scientific publications), and language (English). The research was carried out from September 2022 to May 2023.

Results and Discussion: According to PRISMA guidelines, 207 items were initially found in the database. After applied filters date, document type and language remained 35 articles for eligibility. Then 4 articles were excluded because the subject was not related to the scope of the review. So, it was possible to identify 31 relevant publications. From these articles, 15 describe OLBP as one of the most work-related disorders. OLBP risk factors were describe in 9 studies. Its prevalence among healthcare workers was described in 8 articles, and the management strategies in 8 studies.

Conclusions: After analyzing the included works, was concluded that OLBP is a major burden on occupational health. It affects workers both in industrialized and developing countries and has a great impact on healthcare professionals and even the military forces. The main risk factors are globally identified. Lacking lift assistive devices and poor ergonomic postures are commonly described by hospital workers. Some of the risk factors are identified and with the use of proper equipment and occupational health programs, can be minimized. New self-tracking technologies could be the future in addressing the prevention and treatment of OLBP.

Author Keywords: occupational, low back pain, healthcare workers

References

Al-Eisa, E., & Al-Abbad, H. (2013). Occupational back pain among rehabilitation nurses in saudi arabia: The influence of knowledge and awareness. Workplace Health and Safety, 61(9), 401-407. doi:10.3928/21650799-20130816-91

Bootsman, R., Markopoulos, P., Qi, Q., Wang, Q., & Timmermans, A. A. (2019). Wearable technology for posture monitoring at the workplace. International Journal of Human Computer Studies, 132, 99-111. doi:10.1016/j.ijhcs.2019.08.003

Borges, T. P., Kurebayashi, L. F. S., & Da Silva, M. J. P. (2014). Occupational low back pain in nursing workers: Massage versus pain. Revista Da Escola De Enfermagem, 48(4), 670-676. doi:10.1590/s0080-623420140000400014

Brauneis, S., Sorrentino, E., Di Lisa, V., Galluccio, G., Piras, B., Carella, F., . . . La Torre, G. (2021). Assessment of the prevalence and risk factors of low back pain in operating room health workers: An observational study in italy. South Eastern European Journal of Public Health, 16, 1-13. doi:10.11576/seejph-4240

Button, M., Dalstrom, M., Doughty, A., Lizer, S., & Messer, B. (2022). Return to work self-efficacy (RTWSE-19) assessment for patients with acute work-related low back pain. Journal for Nurse Practitioners, 18(6), 660-662. doi:10.1016/j.nurpra.2022.02.024

De Oliveira Santos, T. J., Tavares, C. E., Viana, F. P., & Fagundes, R. R. (2020). Quality of life of brazilian industrial workers: A review article. Revista Brasileira De Medicina do Trabalho, 18(2), 223-231. doi:10.47626/1679-4435-2020-562

Fujii, R., Imai, R., Shigetoh, H., Tanaka, S., & Morioka, S. (2022). Changes in task-specific fear of movement and impaired trunk motor control by pain neuroscience education and exercise: A preliminary single-case study of a worker with low back pain. SAGE Open Medical Case Reports, 10 doi:10.1177/2050313X221131162

Graves, J. M., Fulton-Kehoe, D., Jarvik, J. G., & Franklin, G. M. (2014). Health care utilization and costs associated with adherence to clinical practice guidelines for early magnetic resonance imaging among workers with acute occupational low back pain. Health Services Research, 49(2), 645-665. doi:10.1111/1475-6773.12098

Guo, F., Liu, L., Lv, W., Li, F., & Duffy, V. G. (2022). A bibliometric analysis of occupational low back pain studies from 2000 to 2020. Archives of Environmental and Occupational Health, 77(5), 362-371. doi:10.1080/19338244.2021.1893634

Itoh, H., Kitamura, F., & Yokoyama, K. (2013). Estimates of annual medical costs of work-related low back pain in japan. Industrial Health, 51(5), 524-529. doi:10.2486/indhealth.2013-0042

Iwakiri, K., Sotoyama, M., Takahashi, M., Liu, X., Koda, S., & Ichikawa, K. (2018). Effectiveness of re-education based on appropriate care methods using welfare equipment on the prevention of low back pain among care workers: A 1.5 year follow-up study. Industrial Health, 56(5), 419-426. doi:10.2486/indhealth.2017-0175

Iwakiri, K., Takahashi, M., Sotoyama, M., Liu, X., & Koda, S. (2019). Priority approaches of occupational safety and health activities for preventing low back pain among caregivers. Journal of Occupational Health, 61(5), 339-348. doi:10.1002/1348-9585.12055

Jeong, H., & Ohno, Y. (2017). Symmetric lifting posture recognition of skilled experts with linear discriminant analysis by center-of-pressure velocity. Intelligent Service Robotics, 10(4), 323-332. doi:10.1007/s11370-017-0227-8

Kazemi, S. -., Tavafian, S. -., Hidarnia, A., & Montazeri, A. (2020). Development and validation of an instrument of occupational low back pain prevention behaviours of nurse. Journal of Advanced Nursing, 76(10), 2747-2756. doi:10.1111/jan.14459

Kazemi, S. -., Tavafian, S. -., Hiller, C. E., Hidarnia, A., & Montazeri, A. (2021). The effectiveness of social media and in-person interventions for low back pain conditions in nursing personnel (SMILE). Nursing Open, 8(3), 1220-1231. doi:10.1002/nop2.738

Lee, S. S., Choi, Y., & Pransky, G. S. (2016). Extent and impact of opioid prescribing for acute occupational low back pain in the emergency department. Journal of Emergency Medicine, 50(3), 376-384.e2. doi:10.1016/j.jemermed.2015.10.015

Melloh, M., Elfering, A., Stanton, T. R., Käser, A., Salathé, C. R., Barz, T., . . . Theis, J. -. (2013). Who is likely to develop persistent low back pain? A longitudinal analysis of prognostic occupational factors. Work, 46(3), 297-311. doi:10.3233/WOR-131672

Mohseni Bandpei, M. A., Ehsani, F., Behtash, H., & Ghanipour, M. (2014). Occupational low back pain in primary and high school teachers: Prevalence and associated factors. Journal of Manipulative and Physiological Therapeutics, 37(9), 702-708. doi:10.1016/j.jmpt.2014.09.006

Myung, E., Neto, J. D., Murta, G. A., Vieira, A., Gomes de Lima, P. R., Lessa, L., & Bernardo, W. M. (2018). ANAMT technical guideline (DT 05): Prevention of occupational low back pain through back belts, lumbar support or braces. Revista Brasileira De Medicina do Trabalho, 16(4), 524-531. doi:10.5327/Z1679443520180334

Omidianidost, A., Hosseini, S. Y., Jabari, M., Poursadeghiyan, M., Dabirian, M., Charganeh, S. S., & Yarmohammadi, H. (2016). The relationship between individual, occupational factors and LBP (low back pain) in one of the auto parts manufacturing workshops of tehran in 2015. Journal of Engineering and Applied Sciences, 11(5), 1074-1077. doi:10.3923/jeasci.2016.1074.1077

Saengdao, O., Surasak, B., & Jayanton, P. (2021). A diagnostic assistant tool for work-related low back pain in hospital workers. Indian Journal of Occupational and Environmental Medicine, 25(1), 11-16. doi:10.4103/ijoem.IJOEM_153_19

Shojaei, I., Vazirian, M., Croft, E., Nussbaum, M. A., & Bazrgari, B. (2016). Age related differences in mechanical demands imposed on the lower back by manual material handling tasks. Journal of Biomechanics, 49(6), 896-903. doi:10.1016/j.jbiomech.2015.10.037

Shorthouse, F. M., Roffi, V., & Tack, C. (2016). Effectiveness of educational materials to prevent occupational low back pain. Occupational Medicine, 66(8), 623-629. doi:10.1093/occmed/kqw072

Shraim, M., Cifuentes, M., Willetts, J. L., Marucci-Wellman, H. R., & Pransky, G. (2017). Regional socioeconomic disparities in outcomes for workers with low back pain in the united states. American Journal of Industrial Medicine, 60(5), 472-483. doi:10.1002/ajim.22712

Song, J., Qu, X., & Chen, C. -. (2016). Simulation of lifting motions using a novel multi-objective optimization approach. International Journal of Industrial Ergonomics, 53, 37-47. doi:10.1016/j.ergon.2015.10.002

Tam, J. Z., Mohamed, Z., Puteh, S. E. W., & Ismail, N. H. (2019). A systematic review on identifying associated factors in deciding work- relatedness of chronic back pain among employees at work. Malaysian Journal of Public Health Medicine, 19(1), 1-14. Retrieved from www.scopus.com

Tam, J. Z., Mohamed, Z., Puteh, S. E. W., & Ismail, N. H. (2019). Backs tool: A study in identifying associated factors of occupational chronic low back pain in a developing country. Malaysian Journal of Public Health Medicine, 19(2), 1-10. Retrieved from www.scopus.com

Wartski, M., Williams, C. M., Broughton, N. S., & Bowles, K. -. (2019). Quantifying the lumbar spine movements of surgeons during surgical lists in a teaching hospital. ANZ Journal of Surgery, 89(3), 153-158. doi:10.1111/ans.14812

Yang, Y., Liu, S., Ling, M., & Ye, C. (2022). Prevalence and potential risk factors for occupational low back pain among male military pilots: A study based on questionnaire and physical function assessment. Frontiers in Public Health, 9 doi:10.3389/fpubh.2021.744601

Zanatelli, M. M., Guimarães, A. V., Storte, G. R., Velloso, N., Emidio, M. V., Peruzzetto, M. C., & de Santis Bastos, P. A. (2021). Prevalence of low back pain in port of santos workers. [Prevalência de lombalgia em trabalhadores do Porto de Santos] Revista Brasileira De Medicina do Trabalho, 19(2), 173-180. doi:10.47626/1679-4435-2021-580

Zhang, C., Yang, Z., & Zhang, H. (2022). Psychometric evaluation of the chinese version of occupational LowBack pain prevention behaviors questionnaire among clinical nurses: A validation study. Frontiers in Public Health, 10 doi:10.3389/fpubh.2022.827604

Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

Diagnostic Perspectives in Low Back Pain: A Short Systematic Review

Pedro Carretas[1]

1 Faculty of Engineering, University of Porto, PT (up201910164@edu.med.up.pt)

Abstract

Introduction: Low back pain (LBP) is highly prevalent and can cause disability, being a major topic in occupational health. Loss of work due to LBP has substantial social, economic, and personal consequences. The misdiagnosis and mismanagement of LBP results in a rise in pain disorders and health costs and contribute to the opioid crisis. LBP can be divided by duration (acute, sub-acute or chronic) and by origin (specific or non-specific). Non-specific LBP does not have an attributable known cause and counts for the majority of cases of LBP overall. This systematic review aimed to find evidence, in the literature, of the methods and criteria used to diagnose LBP.

Methodology: This work was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement methodology. The search focused on studies that presented a diagnostic approach or the criteria used to establish the diagnosis of LBP. The electronic database searched was Scopus. In the database, the used filters were the year of publication (2013 to 2023), type of document (articles), type of source (journals and scientific publications), and language (English). The research was carried out from September 2022 to May 2023.

Results and Discussion: According to PRISMA guidelines, 74 items were initially found in the database. After applied filters date, document type and language remained 37 articles for eligibility. Then 22 articles were excluded because the subject was not related to the scope of the review. So, it was possible to identify 15 relevant publications. From these articles, 5 present examples of medical questionnaires validated that are used in LBP diagnostic. The use of imaging studies was described in 4 papers, and the need to involve other professionals like physical therapists was described in 2 studies.

Conclusions: The analysis of the selected studies suggests that LBP diagnosis is complex and that are available some medical questionnaires that could guide and help doctors. There is some evidence that physical therapists could also have an important role in LBP diagnostics and that medical education is beneficial for these professionals. The use of imaging studies on a routine basis is not recommended, and it should be used only after a complete medical history and examination.

Author Keywords: low back pain, diagnostic, criteria, screening

References

Oliveira CB, Maher CG, Pinto RZ, et al. Clinical practice guidelines for the management of non-specific low back pain in primary care: an updated overview. Eur Spine J. 2018;27(11):2791-2803. doi:10.1007/s00586-018-5673-2

Korogod N, Steyaert A, Nonclercq O, Opsommer E, Berquin A. Can the French version of the short Örebro Musculoskeletal Pain Screening Questionnaire or its subsets predict the evolution of patients with acute, (sub) acute and chronic pain?. BMC Musculoskelet Disord. 2022;23(1):311. Published 2022 Apr 1. doi:10.1186/s12891-021-04944-9

Doll J, Kreikemeier M, Maddigan C, Marshall N, Young M. Analyzing Unnecessary Imaging for Low Back Pain in Nebraska from a Statewide Health Information Exchange. J Med Syst. 2022;46(7):51. Published 2022 Jun 9. doi:10.1007/s10916-022-01838-8

Deodhar A, Kiwalkar S, Mehendale T, Bhalerao S. Axial Spondyloarthritis in the Chiropractic Care Setting: A Systematic Literature Review. J Clin Rheumatol. 2022;28(2):e589-e595. doi:10.1097/RHU.0000000000001776

Steen E, McCrum C, Cairns M. A UK survey evaluation of First Contact Practitioners' and musculoskeletal physiotherapists' confidence, recognition, and referral of suspected axial spondyloarthritis [published online ahead of print, 2022 Nov 21]. Musculoskeletal Care. 2022;10.1002/msc.1706. doi:10.1002/msc.1706

Leungbootnak A, Puntumetakul R, Kanpittaya J, Chatprem T, Boucaut R. Validity of a Screening Tool for Patients with a Sub-Threshold Level of Lumbar Instability: A Cross-Sectional Study. Int J Environ Res Public Health. 2021;18(22):12151. Published 2021 Nov 19. doi:10.3390/ijerph182212151

Glechner A, Rabady S, Bachler H, et al. A Choosing Wisely top-5 list to support general practitioners in Austria. Eine Choosing Wisely Top-5-Liste zur Unterstützung von Allgemeinmedizinern in Österreich. Wien Med Wochenschr. 2021;171(13-14):293-300. doi:10.1007/s10354-021-00846-6

Chatprem T, Puntumetakul R, Boucaut R, Wanpen S, Chatchawan U. A Screening Tool for Patients With Lumbar Instability: A Criteria-related Validity of Thai Version. Spine (Phila Pa 1976). 2020;45(21):E1431-E1438. doi:10.1097/BRS.0000000000003606

Sedrez JA, Mesquita PV, Gelain GM, Candotti CT. Kinematic Characteristics of Sit-to-Stand Movements in Patients With Low Back Pain: A Systematic Review. J Manipulative Physiol Ther. 2019;42(7):532-540. doi:10.1016/j.jmpt.2018.12.004

Oliveira CB, Maher CG, Pinto RZ, et al. Clinical practice guidelines for the management of non-specific low back pain in primary care: an updated overview. Eur Spine J. 2018;27(11):2791-2803. doi:10.1007/s00586-018-5673-2

Teboul-Coré S, Roux C, Borderie D, et al. Bone mineral density and bone remodeling markers in chronic low back pain patients with active discopathy: A case-control exploratory study. PLoS One. 2018;13(6):e0196536. Published 2018 Jun 29. doi:10.1371/journal.pone.0196536

Taghipour-Darzi, M., Ebrahimi-Takamjani, E., Salavati, M., Mobini, B., Zekavat, H., & Beneck, G. J. (2015). Construct validity of center of rotation in differentiating of lumbar segmental instability patients. Journal of Back and Musculoskeletal Rehabilitation, 28(4), 675-680. doi:10.3233/BMR-140565

Cuesta-Vargas, A. I., & González-Sánchez, M. (2014). Spanish version of the screening örebro musculoskeletal pain questionnaire: A cross-cultural adaptation and validation. Health and Quality of Life Outcomes, 12(1) doi:10.1186/s12955-014-0157-5

Downie, A., Williams, C. M., Henschke, N., Hancock, M. J., Ostelo, R. W. J. G., De Vet, H. C. W., . . . Maher, C. G. (2013). Red flags to screen for malignancy and fracture in patients with low back pain: Systematic review. BMJ (Online), 347 doi:10.1136/bmj.f7095

Hilal, K., Sajjad, Z., Sayani, R., & Khan, D. (2013). Utility of limited protocol magnetic resonance imaging lumbar spine for nerve root compression in a developing country, is it accurate and cost effective? Asian Spine Journal, 7(3), 184-189. doi:10.4184/asj.2013.7.3.184

Firefighters' Respiratory Health

S. Lavandeira[1,2], M. Oliveira[1], M. J. Alves[2,3] and S. Morais[1*]

1 REQUIMTE/LAQV, ISEP, Polytechnic of Porto, Porto, Portugal

2 AquaValor – Center for Valorization and Transfer of Water Technology, Chaves, Portugal

3 CIMO, Polytechnic of Bragança, Bragança, Portugal;

*E-mail: sbm@isep.ipp.pt

Abstract

Introduction: Working as a firefighter encompasses regular exposure to several health-hazardous pollutants released during firefighting. Despite the use of adequate personal protective equipment and preventive measures, the respiratory health of firefighters can be compromised/aggravated, in the short or long term. Thus, the objective of this study is to characterize the main respiratory disorders of firefighters.

Methodology: A PRISMA-based systematic review search was carried out in Scopus, Medline (PubMed) and Web of Science databases, through the combination of the following keywords utilizing the operator “AND": "firefighters", respiratory diseases", "airways diseases", "lung diseases" and "respiratory health".

Results and Discussion: Several studies associate occupational exposure during firefighting activities with short-term consequences for the respiratory health of firefighters, such as decreased lung function, inflammation and allergic sensitization of the airways. Other studies found an increased incidence of asthma, bronchitis, emphysema, and chronic rhinosinusitis in some New York firefighters exposed to the dust and by-products of combustion resulting from the collapse of the twin towers. Nevertheless, there is a lack of information for clarifying the long-term effects on the respiratory health of firefighters, resulting from firefighting activities. The current data show that firefighting can result in an increased risk of death from mesothelioma cancer and cardiorespiratory diseases.

Conclusions: This work highlights the prevalence of some respiratory diseases in firefighters, emphasizing the need to understand the long-term effects of repeated smoke exposure on the respiratory health of these workers, to better promote their health and quality of life.

Author Keywords: firefighters, respiratory diseases, airways diseases, lung diseases and respiratory health.

References

Soteriades, E.S., Smith, D.L., Tsismenakis, A.J., Baur, D.M., Kales, S.N., 2011. Cardiovascular disease in US firefighters: A systematic review. Cardiol. Rev. 19, 202–215. Available from: https://doi.org/10.1097/CRD.0b013e318215c105.

Gianniou, N., Katsaounou, P., Dima, E., Giannakopoulou, C.E., Kardara, M., et al., 2016. Prolonged occupational exposure leads to allergic airway sensitization and chronic airway and systemic inflammation in professional firefighters. Respir. Med. 118, 7–14. Available from: https://doi.org/10.1016/j.rmed.2016.07.006.

Niles, J.K., et al., The Respiratory Pyramid: From Symptoms to Disease in World Trade Center Exposed Firefighters. American Journal of Industrial Medicine, 2013. 56(8): p. 870-880.

Laroche, E. and S. L'Esperance, Cancer Incidence and Mortality among Firefighters: An Overview of Epidemiologic Systematic Reviews. International Journal of Environmental Research and Public Health, 2021. 18(5).

Funding

This work was financially supported by the project PCIF/SSO/0017/2018 by the Fundação para a Ciência e Tecnologia (FCT) and Ministério da Ciência, Tecnologia e Ensino Superior (MCTES) through national funds.

Acknowledgements

This work received support from UIDB/50006/2020, UIDP/50006/2020, LA/P/0008/2020, PCIF/SSO/0090/2019, and 2022.05381.PTDC by FCT-MCTES. M. Oliveira and S. Lavandeira would like to thank, respectively, the Individual Program Agreement CEECIND/03666/2017 and the PhD grant (2022.12979.BDANA), funded by the Fundação para a Ciência e Tecnologia.

Surface Contamination by Antineoplastic Drugs in Three Portuguese Hospitals

Maria Francisca Portilha-Cunha[1,2], Arminda Alves[1,2], Ana R. L. Ribeiro[2,3], Adrián M. T. Silva[2,3], Mónica S. F. Santos[1,2,4,5]

1 LEPABE, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up201404145@edu.fe.up.pt; aalves@fe.up.pt) ORCID 0000-0001-7069-0500; 0000-0002-5090-621X

2 ALiCE, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

3 LSRE–LCM, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (ritalado@fe.up.pt; adrian@fe.up.pt) ORCID 0000-0002-4445-5379; 0000-0001-8551-6353

4 EPIUnit, Institute of Public Health, University of Porto, Rua das Taipas 135, 4050-600 Porto, Portugal (monica.santos@ispup.up.pt) ORCID 0000-0001-8684-0147

5 ITR, University of Porto, Rua das Taipas 135, 4050-600 Porto, Portugal

Abstract

Introduction: Antineoplastic drugs (ADs) are considered hazardous medicinal products for being potentially carcinogenic, mutagenic, and/or teratogenic to humans. No occupational exposure limits exist for ADs, thus the "as low as reasonably achievable" (ALARA) precautionary principle remains the best standard to reduce occupational exposure – and assessing environmental contamination in oncological healthcare settings is fundamental to do so. Since dermal absorption is the primary exposure route1, surface contamination is the preferred indicator of exposure risk and is essential to take corrective measures2. In Portugal, no organized medical surveillance exists for ADs and compliance with the International Society of Oncology Pharmacy Practitioners (ISOPP) standards is voluntary3.

Materials and Methods: The most potentially contaminated and/or more frequently handled/touched surfaces (between 16 and 24 comparable locations) from the pharmacy (preparation unit) and day-care hospital (administration unit) of three Portuguese hospitals were sampled at the end of a working day and before general cleaning, thus considering a worst-case scenario. The presence of 13 pharmaceuticals was analysed by wipe sampling, extraction and liquid chromatography–tandem mass spectrometry4; 100 pg/cm2 was considered a guidance value for relevant surface contamination with ADs. A preliminary occupational exposure risk assessment to ADs was based on guidelines from Direção-Geral da Saúde5.

Results and Discussion: A consistent widespread presence of cyclophosphamide and ifosfamide at relevant concentrations was observed in hospital A. Its healthcare workers are potentially at some relevant health risks, since the occupational risk associated with cyclophosphamide (carcinogenic to humans) and ifosfamide will never be low, independently of the exposure level, based on a preliminary occupational exposure risk assessment, considering the relevant contamination found on work surfaces. No concentrations above the guidance value were found in hospital B and only in one place in hospital C; this may be related to good cleaning but also to a low manipulation of the target ADs in the days before sampling.

Conclusions: This study highlights that results from a given occupational context cannot be generalized and that implemented procedures might need revision, namely the efficacy of the cleaning protocols, cleaning schedule/strategy, and sanitation products. With the aim of taking proper corrective measures and reducing contamination levels, it is advised to expand the environmental assessment performed, as a thorough risk assessment and discussion should be supported by an enlarged, regular monitoring program.

Author Keywords: Cytotoxics, environmental monitoring, occupational exposure, healthcare workers, risk assessment.

References

Turci, R., Sottani, C., Spagnoli, G., Minoia, C. (2003). Biological and environmental monitoring of hospital personnel exposed to antineoplastic agents: a review of analytical methods. doi.org/10.1016/S1570-0232(03)00100-4

Petit, M., Curti, C., Roche, M., Montana, M., Bornet, C., Vanelle, P. (2017). Environmental monitoring by surface sampling for cytotoxics: a review. doi.org/10.1007/s10661-016-5762-9

Mathias, P. I., Mackenzie, B. A., Toennis, C. A., Connor, T. H. (2019). Survey of guidelines and current practices for safe handling of antineoplastic and other hazardous drugs used in 24 countries. doi.org/10.1177/1078155217726160

Portilha-Cunha, M. F., Ramos, S., Silva, A. M. T., Norton, P., Alves, A., Santos, M. S. F. (2021). An improved LC–MS/MS method for the analysis of thirteen cytostatics in workplace surfaces. doi.org/10.3390/ph14080754

DGS (2018). Guia Técnico nº 2: Vigilância da saúde dos trabalhadores expostos a agentes químicos cancerígenos, mutagénicos ou tóxicos para a reprodução. https://www.dgs.pt/saude-ocupacional/referenciais-tecnicos-e-normativos/guias-tecnicos/guia-tecnico-n-2-pdf1.aspx

Acknowledgements

This research was financially supported by: Project POCI-01-0145-FEDER-031297 (CytoStraTech)—funded by FEDER funds through COMPETE2020—Programa Operacional Competitividade e Internacionalização (POCI) and by national funds (PIDDAC) through FCT/MCTES; LA/P/0045/2020 (ALiCE), UIDB/00511/2020 and UIDP/00511/2020 (LEPABE), UIDB/50020/2020 and UIDP/50020/2020 (LSRE-LCM)—funded by national funds through FCT/MCTES (PIDDAC); Project NORTE-01-0145-FEDER-000069 (HealthyWaters)—supported by Norte Portugal Regional Operational Programme (NORTE 2020), under the PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund (ERDF); and UIDB/04750/2020 (EPIUnit) and LA/P/0064/2020 (ITR), funded by national funds through the FCT - Foundation for Science and Technology, I.P. Maria Francisca Portilha-Cunha is grateful to the Portuguese Foundation for Science and Technology (FCT) for her Ph.D. grant (2021.05219.BD). The authors thank the availability and collaboration of the hospitals involved in this study.

Index of authors

ISBN: 978-972-752-310-8

www.fe.up.pt/dce
dce@fe.up.pt