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Occupational and Environmental Exposures: Trends in Publications, Diseases, and Experimental Models

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INTRODUCTION: Environmental exposures such as silica dust, microplastics, and general dust have significant health impacts. We performed a PubMed-based analysis (2000-2025) of research trends on these exposures, associated diseases, and experimental models. Pulmonary fibrosis was the most studied disease, while animal models and conventional *in vitro* systems dominated experimental approaches. Organ-on-chip platforms remain scarcely used. The results highlight growing research interest and the need for advanced human-relevant models to study exposure effects on respiratory and systemic health. Diverse environmental agents (particulates, gases, volatile organic compounds, biological agents, and nanomaterials) disseminate through the atmosphere, water, and soil, resulting in human exposure via numerous pathways. The result of exposure is influenced by the physicochemical characteristics of the substance (dimensions, morphology, surface chemistry), the exposure dosage, the duration of exposure, and the exposure pathway.¹ Especially, fine-ultrafine particles in the atmosphere can penetrate through the upper and lower respiratory pathways due to their aerodynamic features; PM 2.5² or smaller particles can directly interact with epithelial cells at the alveolar level. The airway epithelium serves as the main defense mechanism against inhaled substances. Also orchestrate the homeostasis via physical and immunological defense mechanisms. To form the epithelial barrier, epithelial cells are connected to each other by cell-cell junctions (tight, gap, and adherents).³ Due to the inhalation of 6-12 liters of air per minute, this tissue is subjected to a significant quantity of deleterious substances and pathogenic organisms.⁴ Because of the lack of early diagnosis methods and the gaps that need to be addressed, particularly in studies conducted with animal models, the number of studies observing the effects of exosomes on the lungs and other organs is increasing. For example, pneumoconiosis, one of the world's most common occupational diseases, or silicosis, considered an occupational lung disease, is characterized by the inhalation of crystalline silica dust, inflammation, and progressive fibrosis.⁵ On the other hand, physiological and anatomical mimicry models of the respiratory system have been proven to be essential for drug development and elucidating the pathophysiological mechanisms of diseases triggered by epigenetics and hereditary genetic factors. Lung epithelial models can be organized as monoculture/multicultural cells with supporting scaffolds such as trans-wells and bio-gels. Notably, as a novel study niche, organ-on-a-chips provide controllable physiological conditions that recapitulate tissue specific features.

MATERIAL AND METHODS: We performed a PubMed search (2000-2025) to quantify publications on occupational exposures (silica, coal dust, microplastics, dust), related diseases [asthma, chronic obstructive pulmonary disease (COPD), lung cancer, pulmonary fibrosis, cardiovascular disease], and experimental models (transwell, organ-on-a-chip, *in vitro*, *ex vivo*, animal). Counts were retrieved using the PubMed API, either annually or as total sums, with

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optional epithelial-focused filtering. Data were compiled and visualized in Python using trend plots, bar charts, and heatmaps of exposure-disease and exposure-model relationships.

RESULTS: Annual publication trends for silica dust, microplastic, dust, and coal dust showed an overall increase from 2000 to 2025, with silica dust and dust exhibiting steady growth and microplastic-related publications rising sharply after 2016. Total publications were highest for silica dust and dust, while coal dust and microplastic were less studied. Exposure-disease analysis revealed pulmonary fibrosis as the primary outcome associated with silica dust (619 publications) and dust (373), whereas asthma and COPD were less frequently studied; microplastic and coal dust publications were comparatively few. Experimental model usage indicated a clear predominance of animal models and *in vitro* studies across all exposures, with transwell systems used sporadically and organ-on-chip platforms largely unexplored (Figure 1).

CONCLUSION: The observed trends reflect increasing research focus on occupational and environmental exposures, particularly for silica dust and microplastics, with pulmonary fibrosis as the most frequently studied disease outcome. The predominant use on animal and conventional *in vitro* models underscores a gap in physiologically relevant human-based experimental systems. Organ-on-chip technology, despite its potential to recapitulate human epithelial barriers and tissue-specific responses, remains minimally utilized, highlighting a clear opportunity for future mechanistic studies. These findings emphasize the need for innovative experimental models to better understand exposure-related pathophysiology and to bridge the translational gap between *in vitro* and *in vivo* studies.

KEYWORDS: Environmental exposures, silica dust, microplastics, pulmonary fibrosis, organ-on-chip, *in vitro* models, bibliometric analysis

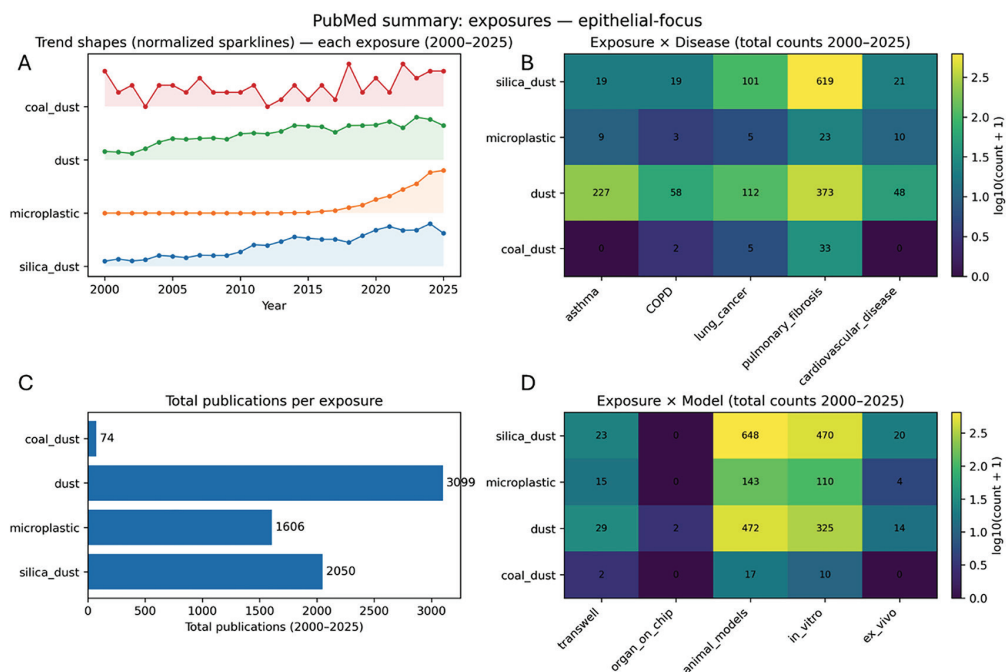


Figure 1. PubMed publication trends and experimental model usage for selected environmental exposures (2000–2025). A) Normalized annual publication trends for silica dust, microplastic, dust, and coal dust. B) Total publications per exposure across 2000–2025. C) Heatmap of total publications for each exposure-disease pair. D) Heatmap of total publications for each exposure-model combination

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REFERENCES

1. Bhardwaj G, Abdulkadhim M, Joshi K, Wankhede L, Das RK, Brar SK. Exposure pathways, systemic distribution, and health implications of micro-and nanoplastics in humans. *Applied Sciences*. 2025;15(16):8813. [\[Crossref\]](#)
2. Goksel O, Sipahi MI, Yanasik S, et al. Development of a biomimetic human airway epithelial barrier-on-a-chip and *ex vivo* human airway model: tools for evaluating silica PM 2.5 particle exposure. *Allergy*. 2024;79(11):2953-2965. [\[Crossref\]](#)
3. Kaya B, Yesil-Celiktas O. Ionic liquid-based transparent membrane-coupled human lung epithelium-on-a-chip demonstrating PM0.5 pollution effect under breathing mechanostress. *Bio Des Manuf*. 2024;7(5):624-636. [\[Crossref\]](#)
4. Hiemstra PS, McCray PB Jr, Bals R. The innate immune function of airway epithelial cells in inflammatory lung disease. *Eur Respir J*. 2015;45(4):1150-1162. [\[Crossref\]](#)
5. Pleil JD, Ariel Geer Wallace M, Davis MD, Matty CM. The physics of human breathing: flow, timing, volume, and pressure parameters for normal, on-demand, and ventilator respiration. *J Breath Res*. 2021;15(4). [\[Crossref\]](#)
6. Austin EK, James C, Tessier J. Early Detection Methods for Silicosis in Australia and Internationally: a review of the literature. *Int J Environ Res Public Health*. 2021;18(15):8123. [\[Crossref\]](#)