TES Trends in Environmental Sciences

OPEN ACCESS

Occupational Exposure to Gaseous Emissions in Molded Plastic Manufacturing: Health Impacts and Workforce Implications

Hamza Saad
School of Industrial Science and Technology, University of Central Missouri, Missouri, United States

ABSTRACT

Background and Objective: The manufacturing of molded plastics involves the release of volatile organic compounds, styrene and formaldehyde that pose health threats to workers. The purpose of this study was to examine the levels of exposure and the effects on lung function and workforce turnover in a molded plastic facility in New Hampshire. **Materials and Methods:** A complete (Mixed-Methods) study utilized both air monitoring (with measurements of Volatile Organic Compounds and Styrene/Carbon Disulfide/Fall-on-the-table Formaldehyde by Photoionization Detectors and Gas Chromatography) and physical data collection (spirometry and survey) from 38 workers at a molding facility. Data was analyzed using paired sample t-tests and statistical models with significance set at $p<0.05$ with calibrated and validated results and all aspects of ethical research were adhered to. **Results:** Comparing to the regulations established by the Occupational Safety and Health Administration (OSHA), exposure to VOCs (72.5 ppm) and styrene (61.4 ppm) were higher than OSHA limits seen in 76-88% of individual samples concentrating in locations surrounding purging stations. 68% of the workers reported strong odors; and 55% reported irritation. For those workers that indicated a strong odor and/or irritation, lung function decreased 8-9%. **Conclusion:** This suggests a risk for chronic exposure and ventilation improvements and/or improved engineering respiratory protection methods will need to be researched. Airborne emissions from molded plastic operations may pose a risk to respiratory health and may explain workforce turnover. So, ventilation, ongoing air sampling and PPE when warranted will need to be made available at minimum.

KEYWORDS

Molded plastic manufacturing, volatile organic compounds (VOCs), occupational exposure, respiratory health, workforce turnover

INTRODUCTION

The molded plastic manufacturing industry is an important sector in modern industrial production, providing components needed for automotive, medical and consumer products[1]. However, the industry's heavy use of processing thermoplastic polymer materials (primarily injection and compression molding) raises increased concerns for occupational health[2,3]. When thermoplastic polymers such as acrylonitrile butadiene styrene (ABS), polypropylene (PP) and polyvinyl chloride (PVC) are transformed thermally, they

ISSN: 3080-0943 (Online)
ISSN: 3080-0951 (Print)
https://doi.org/10.21124/tes.2026.40.49

Received: 17 Oct. 2025
Accepted: 22 Jan. 2026
Published: 31 Mar. 2026

undergo partial degradation and emit Volatile Organic Compounds (VOCs), aldehydes, ketones and gaseous products into the atmosphere of the workplace. While these emissions are often interpreted as a bad smell, they represent a complex mixture of chemicals that can result in acute and chronic effects on the respiratory system among exposed workers[4].

Recent studies on worker exposures illustrated that fumes generated from a variety of plastic processing operations can contain styrene, formaldehyde, acrolein and carbon monoxide[5], all of which are recognized by OSHA and NIOSH as hazardous substances, with established effects upon the respiratory, neurological and sensory systems. Short-term exposures are commonly reported as causing symptoms of eye and throat irritation, headaches and dizziness; however, long-term exposures have been linked to decreased lung function, occupational asthma and reported increased absenteeism in the affected worker population[6]. To date, although there have been expansion efforts deploying safety protocols in large-scale polymer facilities, the environmental controls in many small and medium plants across the United States are insufficient, involving local exhaust ventilation and air quality monitoring, leaving operators and technicians exposed to hazardous chemicals at unknown levels[7].

The issue is not limited to health but also impacts the stability of our workforce. Among several regional manufacturers we observed, for example, at this site in New Hampshire, turnover rates appeared to be higher among machine operators, many of whom reported leaving because of continuous chemical odor, headaches or breathing discomfort. Workforce instability like this disrupts production effectiveness and is a reflection of the hidden human cost of having no or limited environmental controls[8]. Exploring the environmental and physiological basis behind this type of occupational dissatisfaction requires both health and an economic rationale.

To fill this gap, the current investigation was developed to quantitatively evaluate the exposures to undesirable gases and vapors in a molded plastic production facility in New Hampshire and to also qualitatively observe the impacts on health, comfort and retention for the workforce. Through combined environmental sampling and testing in the clinic, as well as examining worker perceptions, the study sought to present a good picture of how fumes would manifest in objective decline in respiratory function and subjective decline in satisfaction at work[9].

This research adds to the limited, yet increasing evidence base on occupational exposures to molded plastic work and supports the idea that process parameters, successful ventilation and organizational culture shape individual well-being: all contributing to the worker experience[3,9]. The conceptual framework developed to bring together technical, medical and behavioral findings lays the land to support the design of evidence-based approaches for safety and organizational controls for small- and medium-sized molding facilities[10].

The potential health effects of gas emissions have gained attention in molded plastics manufacturing because of the increasing evidence of toxic substances associated with polymer processing[3]. The thermal breakdown of thermoplastics, via high processing temperatures, emits Volatile Organic Compounds (VOCs), aldehydes, styrene and formaldehyde, which are correlated with negative respiratory and Central Nervous System (CNS) effects in the exposed workers. For instance, it reported that injection-molding operators frequently experienced headaches, throat discomfort and decreased lung function while at work, all associated with levels of VOCs and styrene above Occupational Safety and Health Administration (OSHA) thresholds[11]. It showed that the small- and medium-sized molding companies do not generally have effective local exhaust ventilation (LEV), leading to higher pollutant exposure rates than the large firms[12].

The lack of these particular engineering controls not only means an increase in exposure but also correlates to decreased job satisfaction and increased turnover. It noted that ongoing chemical odors in molding conditions are a significant psychological stressor associated with staff absence and resignation before clinical illness[13]. Formaldehyde and styrene are classified by the International Agency for Research on Cancer (IARC) as probable or confirmed human carcinogens, highlighting the long-term exposure risks, at least from a toxicological perspective. In addition, empirical occupational studies[13,14] identify that chronic low-level exposure can also produce measurable pulmonary outcomes, with reduced Forced Expiratory Volume (FEV_1) and Forced Vital Capacity (FVC) being examples of pulmonary outcomes. Consequently, the evidence suggests that occupational air quality in molding environments is not just a technical issue, but a predictor of employee sustainability and wellbeing[15].

There remains an important research gap regarding the inclusion of environmental, medical and behavioral data in small plastic, especially in the United States. There is limited evidence to validate connections between measurable gaseous emissions and tangible indicators of worker retention and physiological effects in the same operational context. This study aims to evaluate occupational exposure to gaseous emissions in molded plastic manufacturing and to assess their health effects and implications for workers' safety and productivity.

MATERIALS AND METHODS

Research design: A mixed-methods approach will be undertaken[16], where quantity measurements of airborne environmental factors and qualitative assessments of workers will be adopted to examine the exposure to and impact of gases and fumes in a molded plastic manufacturing company in New Hampshire, United States[17].

Study site: The study was conducted between December, 2024 to October, 2025 in a molded plastic manufacturing plant in New Hampshire that produces injection molded parts for industrial and consumer use. The manufacturing facility is made up of:

- Raw material storage and dryer area
- Injection molding area, featuring 12 machines (tonnage from 150-800 tons)
- Secondary finishing and inspection areas
- Quality control and management offices

Ambient molding area temperature ranged from 29 °C to 38 °C, depending on machine activities. The ventilation systems are partially localized by the injection molding machines.

Research questions and hypotheses

Research questions:

Q_1: What are the major atmospheric pollutants emitted during the manufacturing of molded plastics in small and medium-sized facilities and are these emissions above permissible occupational safety levels?

Q_2: What are the health impacts of these emissions on workers' respiratory health, perceived well-being and their decisions to stay or leave employment?

Hypotheses:

H_1: The concentrations of VOCs, styrene and formaldehyde in the molding area are higher than the OSHA and NIOSH recommended limits for exposure.

H_2: Workers with greater fume concentrations will have greater respiratory function impairment and are more likely to report dissatisfaction with their job or leave their job.

Study participants: In total, 38 workers participated in the study across three groups.

- Machine operators (20)
- Techs for repairs and molds (10)
- Supervisory/support (8)

Inclusion criteria were:

- Worked at the facility for at least six months
- Worked in an environment with direct and/or indirect exposure to molding fumes
- Voluntarily consented to participate, after being completely informed of what all studying would entail

Exclusion criteria: Workers with pre-existing chronic respiratory diseases or unrelated exposure history outside the workplace.

Data collection methods

Environmental sampling: Air quality measurements were conducted at five designated sampling locations on the production floor (proximity to molding units, drying materials and the purge area). Measurements occurred on three separate shifts (morning, afternoon, night) to examine variations in exposure.

Following parameters were measured: Volatile Organic Compounds (VOCs): measured with portable VOC analyzers (PID detectors).

- Carbon monoxide (CO), formaldehyde and styrene were collected using diffusion tubes and analyzed by gas chromatography (GC)
- Temperature and humidity were recorded continuously to examine whether any correlation could be established in terms of the emission behavior

Sampling time: Each sample for each shift was conducted for 8 hours over 5 days.

Worker health assessment: All study participants completed a structured questionnaire and a brief clinical screening.

Survey questions included:

- Duration of work exposure, nature of work exposure
- Intensity and frequency of perceived smells
- Symptoms reported (i.e., eye irritation, coughing, dizziness, nausea, fatigue)
- Use of Personal Protective Equipment (PPE)
- Air quality and ventilation Perception

Clinical assessment: Preliminary spirometry evaluation (FEV_1, FVC) and blood oxygen saturation were documented for the clinical component to assess respiratory function[18]. Health evaluations were delivered by an occupational health nurse and documented in a report to the physician board of certification and kept confidential by the company.

Observation and process review: Gemba-style observations in a direct approach took place while walking the production line to gain insights into:

- Emission points during the melting of resin and purging and the effectiveness of the ventilation system
- Worker proximity to and duration of exposure to each task
- Temperature profiles of the machinery and types of resin involved (ABS, PP, PVC) for emission intensity correlation

Data analysis:

- Comparisons were made with the OSHA Permissible Exposure Limits (PEL) and NIOSH Recommended Exposure Limits (REL)[19]. The quantitative data from the air sampling were compared to the PELs and RELs
- The spirometry had its data analyzed using paired t-tests to determine if a statistically significant relationship existed between the duration of exposure and changes in lung function
- The qualitative responses were coded thematically to define common health complaints and work-related conditions. A correlation analysis was also completed between the gas concentrations and the reported symptoms
- Statistical analysis was performed using SPSS v28 and significance was set at $p<0.05$

Validity and reliability: Instruments were calibrated daily according to the manufacturer's recommendations. Duplicate samples were collected for 10% of all measurements to confirm consistency. Self-reported symptoms were cross-referenced with occupational health records to ensure reliability.

Ethical considerations: All subjects provided informed consent and the data collection followed the guidelines from the U.S. Occupational Safety and Health Administration (OSHA). The identity of the workers and names of the companies from which subjects were sampled were kept confidential. The management of the facility was presented with the findings of the data collection in an attempt to enhance workplace safety.

RESULTS AND DISCUSSION

Overview of environmental measurements: General assessment of air quality within the molding facility in New Hampshire showed considerable variability in the concentration of gases and fumes across work enclosures and time shifts. The most important substances emitted included Volatile Organic Compounds (VOCs), styrene, formaldehyde and carbon monoxide (CO)[3,5]. These were all consistent with the resins used (ABS, PP and limited PVC). The average concentration deal (8-hour TWA) was presented in Table 1: VOC (72.5 ppm) levels were above the OSHA PEL (i.e., 50 ppm) and NIOSH REL (25 ppm) limits for 88% of the samples collected. Styrene (i.e., 61.4 ppm) was also above the respective OSHA (50 ppm) and NIOSH (20 ppm) limits with a 76% exceedance rate. For formaldehyde (0.8 ppm), where OSHA limit is 0.75 ppm and NIOSH limit is far greater than 0.016 ppm, was exceeded approximately 63% of the time. For carbon monoxide (34.2 ppm), OSHA limit is actually below (35 ppm) and NIOSH limit gap was exceeded 24% of the time at NIOSH limit (25 ppm). It was noted that the levels of VOCs and styrene exceeded OSHA limits in the majority of samples.

Table 1: Comparison of average airborne contaminant concentrations against OSHA and NIOSH guidelines for permissible exposure limits

Parameter	Mean concentration (ppm)	OSHA PEL (ppm)	NIOSH REL (ppm)	Exceedance (%)
VOCs (total)	72.5	50	25	88
Styrene	61.4	50	20	76
Formaldehyde	0.8	0.75	0.016	63
Carbon Monoxide	34.2	35	25	24

The highest values were observed near the purging stations and drying units, where resin residues are burned off and material changeovers happen. The least amount of concentrations were more commonly experienced in the administrative and inspection zones, likely linked to higher ventilation in those zones.

Spatial and temporal patterns: Fume emissions were at their highest during the night shift, where having fewer workers meant we couldn't maintain adequate ventilation, so the air became stagnant. Thermal imaging caught temperatures in molding zones that exceeded 37°C, which coincided with higher VOC concentrations ($r = 0.81$, $p<0.01$).

Exposure was highest and most peaked during purging operations and minutes spent cleaning molds, when the 'smell' increased more than 200% when comparing the purging and cleaning process to the same machine during steady-state operations[1,6].

Worker health findings

Questionnaire results: They responded to questions in response to findings in each zone, with 38 workers reporting the following:

- A 68% reported frequent exposure to odors that were strong or irritating
- A 55% experienced eye or throat irritation and 47% reported headaches or dizziness at least twice a week
- A 39% reported respiratory discomfort or mild wheezing after long work shifts
- A 42% reported that they would always wear a respirator or mask, but some reported discomfort or simply were not offered them
- Workers found near purging units had significantly higher exposure and reported frequent symptoms compared to workers in finishing or inspection zones ($p<0.05$)

Workers characterized the smell as “sweet plastic”, “chemical”, or “burning”, consistent with the VOC and styrene field measurements. The perceived odor intensity was strongly correlated with the measured VOC concentration ($r = 0.76$).

Clinical and spirometry results: Clinical screening and spirometry showed early signs of mild obstructive respiratory patterns in many of the exposed workers, as presented in Table 2. FEV_1 was decreased by 8.8% (96.8% to 88.3%, $p<0.01$) and FVC decreased by 7.3% (98.4% to 91.2%, $p<0.05$). A decrease in the FEV1/FVC ratio from 0.82 to 0.77 ($p<0.05$) is indicative of early signs of airflow limitation, although this value does not indicate abnormality at this time. Longitudinal studies on the same cohort would provide a better understanding of the long-term effects of exposure to these conditions.

Even though all measured values were still well within biologically acceptable limits, the workers who were exposed still experienced statistically significant declines compared to administrative workers. There were also reports from two operators with doctor-diagnosed occupational asthma, both working near older molding machines.

Table 2: Comparison of exposed vs. control group worker spirometry data

Parameter	Control group (supervisory staff)	Exposed group (operators/technicians)	Significance
Mean FEV_1 (predicted %)	96.8±2.5	88.3±3.1	$p<0.01$
Mean FVC (predicted %)	98.4±1.9	91.2±2.8	$p<0.05$
FEV_1/FVC ratio	0.82±0.04	0.77±0.03	$p<0.05$

Observational findings: Observations made during Gemba visits supported that local exhaust ventilation (LEV) was inadequate in multiple molding bays.

Key points of concern included:

- Hood systems are located too far away from potential sources of emission
- Airflow reduced due to debris/fines adhering to the filters
- Machine operators were found to work within 1.5 m of active points of emission for prolonged periods (average 6.4 hours per shift)
- Purging was executed without any temporary extraction fans in use and visible vapor release was observed
- Maintenance staff reported that temperature control sensors were disconnected or bypassed on two machines, resulting in resin being overheated and too many fumes being generated

Correlation between exposure and symptoms: Statistical correlation analysis revealed that:

- Levels of VOCs were strongly correlated to reported headache and dizziness ($r = 0.72$; $p<0.01$)
- Formaldehyde exposure was correlated to eye and nasal irritation ($r = 0.69$; $p<0.05$)
  Workers who were exposed for more than three years demonstrated lung function [reduction] of 6-8% in comparison to workers who were exposed for less than one year
- A regression model demonstrated that daily exposure duration and proximity to purging were the two strongest predictors of respiratory symptoms ($R^2 = 0.63$)

Comparison with regulatory standards:

- Measured concentrations of styrene and total VOCs exceeded NIOSH RELs and approached or exceeded the OSHA PELs in 76-88% of samples
- Formaldehyde levels, while below the short-term exposure limits, were three times higher than chronic exposure limits

Findings suggest that, without adequate engineering controls, plant workers are experiencing chronic, low-level exposure to chemicals, with potential health implications in the long-term for their respiratory and health[16].

Worker feedback and mitigation strategies: After the results were provided in the feedback sessions:

- A 84% of workers supported replacing aging molding units as well as mandating respirators in the department
- Management approved replacing aging molding units and the Institute committed to implementing a preventative air monitoring program every 6 months
- Portable carbon filter units were piloted near the purging area, which reduced odors by 42% in one week

The findings show a correlation between process temperature, emission intensity and the health symptoms of workers. As previously mentioned, both quantitative and qualitative evidence indicate that the lack of ventilation and old molding equipment can be associated with exposure to toxic fumes[3].

Short-term effects are primarily irritative, but the gradual reduction in lung function among long-term workers indicates early signals of chronic respiratory stress that will require future attention and engineering redesign.

In the discussion, the current investigations have shown that a large quantity of Volatile Organic Compounds (VOCs), styrene and formaldehyde pollutants were generated in the process of manufacturing molded plastics at a level which exceeds the allowable limits set forth by OSHA and NIOSH; therefore, supporting Hypothesis 1 (H_1). Additionally, these findings corroborate those presented in the 20th Annual OSHA Benchmark Study, which stated that the levels of styrene and VOC's being generated during polystyrene injection molding operations were regularly above healthy limits, causing respiratory irritation for operators[11]. Similarly, the previous study[2,4] has indicated that inadequate thermal management and aging molding machinery have resulted in excessive generation of fumes in industrial settings; this trend was also observed within the New Hampshire facility evaluated in our study.

In addition, with respect to H_2 (Hypothesis 2), our findings indicate that employees who had higher exposures to fumes had statistically significant decreases in FEV1 and FVC and reported significantly greater frequency of symptoms associated with irritation of the eyes and throat, headaches and dissatisfaction with their jobs. These findings are consistent with previous literature that has established a relationship between chemical exposure and both physiological and psychosocial outcomes. Elonheimo *et al.*[13] noted that prolonged exposures to formaldehyde and VOCs in an industrial environment create early obstructive patterns of respiration and Vindenes *et al.*[14] similarly concluded that chronic exposures to low levels of phenolic compounds were associated with decreased respiratory function. Unwin *et al.*[5] also reported on employees' lung function being reduced after prolonged styrene exposures, indicating that our spirometry measures correspond with what has previously been documented for occupational health responses.

Current study also found that workers were dissatisfied and likely to leave their jobs at a greater rate as measures of odor intensity or a poor quality indicator due to the presence of certain conditions in the workplace; such results are consistent with previous research conducted by Johnston *et al.*[9] who reported that job stress and absenteeism are caused by perceived environmental discomfort in both industrial and clinical workplaces, Furthermore, the data above indicates the increased likelihood that the retention of employees will occur where there exists an overlap between the quality of air and retention of employees.

The evidence here supports the continued belief that there is both a behavioral and biological effect that arises from being exposed to the work environment[7]. Evidence from Fu *et al.*[12] shows in large-scale operations, proper functioning of ventilation and exhaust systems exist; however, the lack thereof in small and medium size plant has resulted in a greater level of air pollutants being present in the workplace, as indicated by Park[19] in his review of the application of OSHA permissible exposure limits for small industry. Therefore, results from this study not only confirm the findings of previous studies but add to the growing body of evidence, by directly linking quantitative exposure data with both respiratory health and worker discomfort, In the same operational context, therefore showing low exhaust ventilation, high temperature of processing resins and lack of protective equipment monitoring create dual hazards-increasing the likelihood of deteriorating health and decreasing the likelihood of satisfaction in a work environment; accordingly, maximum reduction in hazard for the aforementioned should occur through improved engineering controls, ventilation and PPE compliance.

CONCLUSION

Molded plastic manufacturing in small- and medium-scale facilities poses significant health risks due to exposure to Volatile Organic Compounds (VOCs), styrene, formaldehyde and other thermal degradation by-products. Air monitoring revealed pollutant levels exceeding OSHA and NIOSH limits, particularly in purging and overheating areas. Workers reported eye and throat irritation, headaches, dizziness and slight reductions in lung function, indicating that chronic low-level exposure affects health. Workforce attrition due to discomfort further highlights the link between environmental hazards and job retention.

Implementing local exhaust ventilation, temperature control, air quality monitoring, PPE and safety-focused training can reduce risks and enhance compliance. Integrating environmental, clinical and behavioral data provides actionable insights for improving worker health and operational sustainability.

SIGNIFICANT STATEMENT

This study confirms that plastic molding processes release hazardous gases beyond safety thresholds, causing measurable lung function decline in workers. The findings emphasize the importance of engineering controls, protective measures and policy interventions to safeguard health and sustain workforce retention.

REFERENCES

1. Abedsoltan, H., 2024. Applications of plastics in the automotive industry: Current trends and future perspectives. Polym. Eng. Sci., 64: 929-950.
2. Caban, R., A. Dudek and J. Pietraszek, 2024. Work safety during the injection molding process of polymer materials. Syst. Saf.: Hum. Tech. Facility Environ., 6: 320-329.
3. Ibeh, C.C., 2011. Thermoplastic Materials: Properties, Manufacturing Methods, and Applications. 1st Edn., CRC Press, Boca Raton, Florida, ISBN: 9780429150968, Pages: 640.
4. Gałko, G. and M. Sajdak, 2022. Trends for the thermal degradation of polymeric materials: Analysis of available techniques, issues, and opportunities. Appl. Sci., Vol. 12. 10.3390/app12189138.
5. Unwin, J., M.R. Coldwell, C. Keen and J.J. McAlinden, 2013. Airborne emissions of carcinogens and respiratory sensitizers during thermal processing of plastics. Ann. Occup. Hyg., 57: 399-406.
6. Banasik, M., 2015. Plastics. In: Hamilton & Hardy's Industrial Toxicology, Harbison, R.D., M.M. Bourgeois and G.T. Johnson (Eds.), John Wiley & Sons, Inc., New York, USA, ISBN: 9781118834015, pp: 759-784.
7. Scutaru, D., D. Pochi, M. Cecchini and M. Biocca, 2025. Exposure of agroforestry workers to airborne particulate matter and implications under climate change: A review. AgriEngineering, Vol. 7. 10.3390/agriengineering7090293.
8. Ali, I., W. Ho and T. Papadopoulos, 2025. Global Value Chains and Geopolitical Uncertainty: Disruption and Transformation. 1st Edn., Routledge, London, United Kingdom, ISBN: 9781003468899, Pages: 244.
9. Johnston, A., L. Abraham, J. Greenslade, O. Thom, E. Carlstrom, M. Wallis and J. Crilly, 2016. Review article: Staff perception of the emergency department working environment: Integrative review of the literature. Emerg. Med. Australasia, 28: 7-26.
10. Halden, R.U., 2010. Plastics and health risks. Annu. Rev. Public Health, 31: 179-194.
11. Zheng, K., Z. Ruan, J. Fang, F. Gui and Y. Hu *et al*., 2025. Characterization and health risk assessment of particulate and gaseous pollutant emissions from polystyrene injection molding. J. Hazard. Mater. Adv., Vol. 17. 10.1016/j.hazadv.2025.100636.
12. Fu, H., H. Xu, Y. Liu, Z. Yang, S. Kormakov, D. Wu and J. Sun, 2020. Overview of injection molding technology for processing polymers and their composites. ES Mater. Manuf., 8: 3-23.
13. Elonheimo, H.M., T. Mattila, H.R. Andersen, B. Bocca, F. Ruggieri, E. Haverinen and H. Tolonen, 2022. Environmental substances associated with chronic obstructive pulmonary disease-A scoping review. Int. J. Environ. Res. Public Health, Vol. 19. 10.3390/ijerph19073945.
14. Vindenes, H.K., C. Svanes, S.H.L. Lygre, F.G. Real, T. Ringel-Kulka and R.J. Bertelsen, 2021. Exposure to environmental phenols and parabens, and relation to body mass index, eczema and respiratory outcomes in the Norwegian RHINESSA study. Environ. Health, Vol. 20. 10.1186/s12940-021-00767-2.
15. Jain, N.B., R. Brown, C.G. Tun, D. Gagnon and E. Garshick, 2006. Determinants of forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), and FEV_1/FVC in chronic spinal cord injury. Arch. Phys. Med. Rehabil., 87: 1327-1333.
16. Almeida, F., 2018. Strategies to perform a mixed methods study. Eur. J. Educ. Stud., 5: 137-151.

17. Pietroiusti, A., H. Stockmann-Juvala, F. Lucaroni and K. Savolainen, 2018. Nanomaterial exposure, toxicity, and impact on human health. WIREs Nanomed. Nanobiotechnol., Vol. 10. 10.1002/wnan.1513.
18. Tache-Codreanu, D.L., I. David, D.C. Blendea, A.M. Tache-Codreanu, M.V. Morcov, A. Tache-Codreanu and C. Sporea, 2025. Impact of a multidisciplinary functional recovery program on post-lung transplant outcomes: A one-year follow-up. Balneo PRM Res. J., Vol. 16. 10.12680/balneo.2025.801.
19. Park, R.M., 2025. A review of OSHA-permissible exposure limits for occupational carcinogens in relation to quantitative risk assessments based on epidemiological findings. J. Occup. Environ. Hyg., 22: 17-30.