REVIEW ARTICLE

A systematic review of the effects of airborne microplastic contamination on human lungs

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Abstract

Microplastics are the result of degradation of plastic waste in nature and contain various toxicological effects**.** It is estimated that humans inhale around 100,000 fine particles of plastic every day. The aim of this research is to determine whether exposure to microplastics in the air has an impact on human lungs. Data search in this study used four electronic databases, namely Scopus, Web of Science, Science Direct, and PubMed. 15 articles were included for analysis in this systematic review following a screening process of titles, abstract, and full texts that was based on clearly defined inclusion and exclusion criteria. Risk assessment to reduce data bias using the JBI Critical Appraisal Tool. Our findings from this systematic review show that airborne microplastic contamination has a negative effect on human lungs. It is recommended that government policies should be formed regarding the use of plastics so as to reduce airborne contamination. *(Afr J Reprod Health 2024; 28 [10s]: 430-448).*

Keywords: Microplastic; airborne; contamination; human lung

Résumé

Les microplastiques sont le résultat de la dégradation des déchets plastiques dans la nature et contiennent divers effets toxicologiques. On estime que les humains inhalent environ 100 000 fines particules de plastique chaque jour. L'objectif de cette recherche est de déterminer si l'exposition aux microplastiques dans l'air a un impact sur les poumons humains. La recherche de données dans cette étude a utilisé quatre bases de données électroniques, à savoir Scopus, Web of Science, Science Direct et PubMed. 15 articles ont été inclus pour analyse dans cette revue systématique après un processus de sélection des titres, des résumés et des textes intégraux basé sur des critères d'inclusion et d'exclusion clairement définis. Évaluation des risques pour réduire les biais de données à l'aide de l'outil d'évaluation critique du JBI. Nos résultats de cette revue systématique montrent que la contamination par les microplastiques en suspension dans l'air a un effet négatif sur les poumons humains. Il est recommandé que des politiques gouvernementales soient élaborées concernant l'utilisation des plastiques afin de réduire la contamination en suspension dans l'air. *(Afr J Reprod Health 2024; 28 [10s]: 430-448).*

Mots-clés: Microplastique; en suspension dans l'air; contamination; poumon humain

Introduction

Microplastics are plastic particles with a diameter of <5 mm, listed as the second major problem in global environmental science and ecology at the 2nd UN General Assembly in 2015. Rubber tires on transportation equipment that experience wear and tear are also a source of microplastic pollution in the environment in addition to pollutants in the form of thermoplastics including polyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP), and polyvinyl chloride (PVC)[1–3]. Globally research results have reported that the average emission of tire wear microplastic particles (TWMP) per person is equivalent to 0.81 kg/year, and the total amount of tire wear particles emittedin the world is around 5.9 million tonnes per year (approximately 1 .8% of total plastic production)[1].

Microplastics in the air are a source of pollution that is often found in land and air ecosystems[4]. Although most of the academic world focuses on the human health impact of microplastics

is in relation to the digestive system[5], atmospheric contamination by microplastics can also lead to different forms of lung damage. Microplastics in the atmospheric air also contribute to ecosystem contamination[6]. It is estimated that humans ingest around 100,000 fine plastic particles every day[7]. Most microplastics have lower gravity than sea air so they can be carried in the form of sea salt aerosols via sea air spray and wind to urban environments located near the coast[8]. Existing data shows that 7% of total MP contamination is estimated to occur due to airborne transmission from the sea[9]. Additionally, airborne MPs can arise from a variety of sources, with the main sources of microplastic pollution coming from synthetic textiles, erosion of synthetic rubber tires, and urban dust[8]. Growing research into microplastics has detected atmospheric impacts from cities[6]. Other sources of microplastic pollution come from human activities, including plastic clothing, furniture, buildings, traffic pollution, waste burning[10,11] and dry fertilizers made from polystyrene (PS) mud and peat in horticultural soil[12].

In recognising that there are several original studies regarding the effect of exposure to microplastics on lung health, the aim of this study is to carry out a systematic review to identify these effects. This was considered important because despite it being a critical part of public health, the researchers, to the best of their knowledge, could not find a high—quality systematic review that pooled together evidence in relation to the effect of airborne microplastic contamination on human lungs. This will help to provide the evidence base that can used to begin discussions, policy formation, and implementations on interventions to prevent airborne contamination with microplastics on national, regional, and global level. While also recognising that United Nations 3rd Sustainable Development Goal aims to ensure healthy lives for all people at all ages, with its 9th target (that is, SDG target 3.9) aimed at substantially reducing the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination by 2030.

Methods

Search strategy

This research study was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) checklist guidelines. The literature search was conducted on September 16, 2023 using several databases including SCOPUS, Web of Science, PubMed, and ScienceDirect. All literature used was published from 2000 to 2022 which was then filtered to find literature that was close to the research objectives. In order to search for related published literature, first, the title of this systematic review was broken down into searchable keywords by adapting the PICOS framework: participants/population/problem, interventions, comparisons, outcomes, and study design. In addition, in order to capture as much related literature as possible, different synonyms and Medical Subject Heading (MeSH) terms were included in the search expression. For example, synonyms for microplastic, which is the problem of this study using the PICOS framework, includenanoplastic, plastic microbeads, microplastic, plastic waste, plastic, fibrous microplastic. On the other hand, synonyms for the outcome of this study include lung, lung cancer, human exposure, interstitial lung disease, Pulmonary: Synonyms for airborne, which is also part of the problem of this study using the PICOS framework, include outdoor air quality, air pollution, and atmospheric. Furthermore, the research also used manual searches, including searching the reference lists of previously selected articles. The search strategy for database journals is presented in Table 1.

Inclusion and exclusion criteria

This study was selected based on the following inclusion criteria: (1) Problem research involving microplastic pollution in the air, (2) articles published within the selected timeframe, namely 2000 to 2022, (3) research aimed at analysing the

Table 1: Search strategy in selected databases

Database	Search Strategy	Filter	Record
SCOPUS	(Microplastic OR Nanoplastic OR "Microbeads Plastic" OR "plastic waste" OR macroplastic OR plastic OR "fibrous microplastic") AND (lungs OR "lungs cancer" OR "Interstitial lung disease" OR "human exposure" OR "health toxicity" OR "Pulmonary") AND ("Airborne" OR "outdoor air quality" OR "Air Pollution" OR "atmospheric")	2013-2023 Research, English, Journal	141
Web of Science	(Microplastic OR Nanoplastic OR "Microbeads Plastic" OR "plastic waste" OR macroplastic OR plastic OR "fibrous microplastic") AND (lungs OR "lungs cancer" OR "Interstitial lung disease" OR "human exposure" OR "health toxicity" OR "Pulmonary") AND ("Airborne" OR "outdoor air quality" OR "Air Pollution" OR "atmospheric")	2013-2023 Research, English, Journal	90
PubMed	#1: (("Microplastics/adverse effects"[Mesh] OR "Microplastics/analysis"[Mesh]) OR "Microplastics/chemistry"[Mesh]) OR "Microplastics/toxicity"[Mesh] #2 (((((("Lung Diseases, Fungal"[Mesh] OR "Lung Diseases, Obstructive"[Mesh]) OR "Lung Diseases"[Mesh]) OR "Lung Diseases, Interstitial"[Mesh]) OR "Carcinoma, Lewis Lung"[Mesh]) OR "Lung, Hyperlucent"[Mesh]) OR "Lung Injury"[Mesh]) OR "Acute Lung Injury"[Mesh]) OR "Lung"[Mesh] #3.(("Air Pollution"[Mesh] OR "Air Pollutants"[Mesh]) OR "Environmental Pollution"[Mesh]) OR "Environmental Restoration and Remediation"[Mesh]	2013-2023 Randomized control trial, English	9
ScienceDirect	(Microplastic OR "fibrous microplastic") AND (lungs OR "Interstitial lung disease" OR "human exposure" OR "health toxicity" OR "Pulmonary") AND ("Airborne" OR "atmospheric")	2013-2023, Research article	549

*represents "truncation", which is commonly used for article searching in several databases including WoS, PubMed, ProQuest (truncation can be used to avoid having to explicitly include all possible variants in the strategy); # represents the search number or search ID in PubMed databases. This is also common practice or strategy to use (for example, #1 OR #3 AND #3 to identify the previous search history).

Table 2: Methodological quality assessment of study

Author, year	1	2	3	4	5	6	7	8	9	Overall quality
Sajjad Abbasia, *et al* (2020)	Y	N	Y	Y	Y	Y	Y	NR	Y	Fair
Ieva Uogint˙, *et al* (2023)[13]	Y	N	Y	Y	Y	Y	Y	Y	Y	Fair
Yi-Chun Chen, *et al* (2023)[14]	Y	N	Y	Y	Y	Y	Y	NR	Y	Fair
Sheng Yang, *et al* (2023)[15]	Y	N	Y	Y	Y	Y	Y	NR	Y	Fair
Huajing Zhang, *et al* (2022)[16]	Y	N	Y	Y	Y	Y	Y	NR	Y	Fair
Mingkai Xu, *et al* (2019)[17]	Y	N	Y	Y	Y	Y	Y	NR	Y	Fair
Mohammad Alzaben, *et al* (2023)[18]	Y	N	Y	Y	Y	Y	Y	NR	Y	Fair
Sheng Yang, *et al* (2021)[19]	Y	N	Y	Y	Y	Y	Y	NR	Y	Fair
Antonio Laganà, *et al* (2023)[20]	Y	N	Y	Y	Y	Y	Y	NR	Y	Fair
Cheng-Di Dong, *et al* (2019)[21]	Y	N	Y	Y	Y	Y	Y	NR	Y	Fair
Luís Fernando Amato-Lourenço, *et al* (2021)[22]	Y	N	Y	Y	Y	Y	Y	NR	Y	Fair
Lauren C. Jenner, *et al* (2022)[23]	Y	N	Y	Y	Y	Y	Y	NR	Y	Fair
Rossella Bengalli, *et al* (2022)[24]	Y	N	Y	Y	Y	Y	Y	NR	Y	Fair
Chunzhao Chen, *et al* (2022)[25]	Y	N	Y	Y	Y	Y	Y	NR	Y	Fair
Qingying Shi, *et al* (2021)[26]	Y	N	Y	Y	Y	Y	Y	NR	Y	Fair
Cheng-Di Dong, *et al* (2019)[21]	Y	N	Y	Y	Y	Y	Y	NR	Y	Fair

Quality was rated as 0 for poor (0-3 out of 9 questions), i for fair (4-6 out of 9 questions), or ii for good (7-9 out of 9 questions); NA= not applicable; NR=not reported; Y=yes; N=No

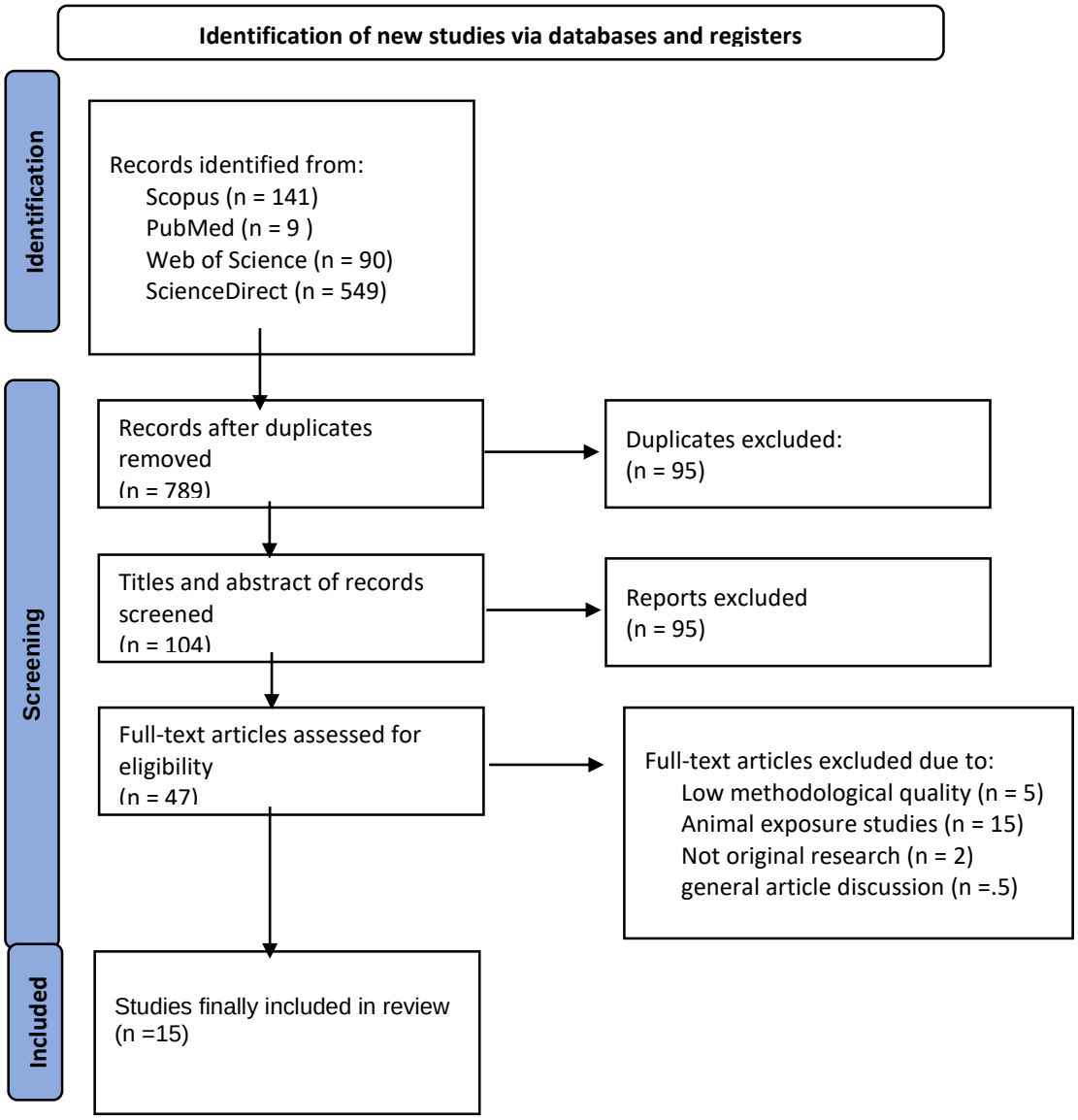

Figure 1: PRISMA flow diagram of the literature search and study selection for systematic review

incidence of lung damage, (4) open access, original research papers, (5) randomized controlled trial, and (8) report published in English. The exclusion criteria in this research are as follows: (1) air pollution other than microplastics, (2) outcomes only involving other areas of the human body other than the lungs, (3) non-experimental studies, and (4) articles not written in English. The selected studies underwent a risk of predisposition appraisal utilizing the JBI basic examination instrument.

Data extraction and data synthesis

All the data extraction steps starting from identification, archiving, screening, and eligibility checks were completed by PTN and checked by SK, LS, IKS, AH. Using the adaptation of the PICOS

framework, together with the synonyms and Medical Subject Heading (MeSH) terms, related articles from the different databases searched were identified. Duplicates based on the title of these already identified articles were then removed. Following this, the selected articles were then screened based on their titles and abstracts. Articles with titles and abstracts that do not fit the inclusion criteria were eliminated. Full text reviews of papers that satisfy the inclusion and exclusion criteria were conducted. The following information were then extracted to a Microsoft Excel spreadsheet: the citation information/authors, country/region of study, study design, participants, study duration, outcomes, result findings, study limitations and conclusion.

Bias assessment

There are 9 questions to reduce the risk of bias in the assessment. Among them:

1. Is it clear in the study what is the "cause" and what is the "effect" (i.e. there is no confusion about which variable came first)?
2. Is there a control group?
3. Are the participants included in the comparison similar?
4. Did the participants included in the comparison receive similar care/treatment, other than the exposure or intervention of interest?
5. Are there multiple outcome measures, both before and after the intervention/exposure?
6. Are the outcomes of the participants included in the comparison measured in the same way?
7. Are the outcomes measured in a reliable way?
8. Was follow-up complete and, if not, were differences between groups in terms of follow-up adequately described and analyzed?
9. Was appropriate statistical analysis used?

Included and excluded studies

The total number included in the systematic observation of this research was 789 taken from records after an extensive literature database search, there were 141 from Scopus, 9 articles from PubMed, 90 articles from Web of Science, and a total of 549 articles. comes from ScienceDirect. The same article was said to be a duplicate and 95 articles were deleted. After removing duplicates, the number of articles became 649, then the researchers recorded them and saved them for the next step, namely the first screening by checking the titles and abstracts. After the first screening was carried out, a second screening was carried out by viewing and broadcasting the full version of research studies so that there were 549 remaining articles. Then the third step was to look at studies that met the inclusion and exclusion criteria. The researchers found that the remaining 104 studies met the criteria for full text evaluation and 95 studies deleted from the database. From the results of evaluating the inclusion and exclusion criteria, there were 47 remaining research studies and the researcher re-screened the articles by observing those that best suited the research objectives, and in the end the researcher got 15 selected studies (as shown in Figure 1) to observe systematically.

Characteristics of included studies

A total of 15 studies included in this observation were original research. This study was taken from the publication of articles whose research came from various countries including Iran, Northern Europe, America, China, Denmark, Taiwan, Paulo. The study design used was a clinical study and an experimental study. The number of samples used in the study was different. But the samples used included research on the impact of microplastics on human alveolar epithelium, human BALF, human lung epithelial BEAS-2B cells, human lung carcinoma cells and human lung tissue.

Risk of bias assessment

Most of the results of the quality assessment in the study were able to answer all the questions asked in the assessment tool. The findings all used laboratory tests with reliable measuring instruments. Research for the control group was not described in the research article, in addition, the study did not explain the complete follow-up.

Results

The final findings of this study are that most of the microplastics exposed to humans either through air,

Table 3: General characteristics of the studies included in this study

No.	Author (Year)	Objective	country/region of study	Study Design	participants	Study Duration	Research findings	Study Limitations	conclusion
-	**a**	**C**	**c**	**d**	**e**	**f**	**g**	**h**	**i**
1	Sajjad Abbasia, *et al* (2020)[27]	Counting the particles that Collect, size and shape of microplastics in a group of adult men and women by various receptors (head hair, hands, face, and saliva) microscopically and polymer composition with Raman spectroscopy	Iran	clinical study	500 adults (250 males and 250 females and mostly working six to eight hours per day)	during the dry season (August 2019	The results of the study found 16,000 microplastic particles from the total number of samples. In the head hair sample, >7000 or >3.5 microplastic particles were found per individual per day and in saliva, 650 particles or 0.33 microplastics were found per individual per da	Samples taken to measure microplastic levels included the skin of the hands, face, scalp hair and saliva of respondents	MP exposure in humans is ubiquitous but heterogeneous in space and time, with the skin, mouth, and scalp hair all acting as important passive receptors
2	Ieva Uogint˙, *et al* (2023)[13]	identifying the presence of microplastic particles in human BALF samples from European residents using TEM-EDX methodology	Northern Europe	clinical study	10 outpatients undergoing standard fibrobronchoscopy procedure were randomly	NA	Microplastic levels were found in varying forms ranging from 0.14–12.8 particles per 100	Small sample amounts and the use of TEM-EDX microscopy for small particles is a powerful	research results show the presence of microplastics in the human respiratory tract

No.	Author (Year)	Objective	country/region of study	Study Design	participants	Study Duration	Research findings	Study Limitations	conclusion
					selected in a northern European population		ml BALF in all samples tested in fragmentation form.	technique, but cannot see the quantity of small nanoparticles	
3	Yi-Chun Chen, *et al* (2023) [14]	to identify the toxic effects of PSNP in a Transwell-based normal human bronchial epithelial cell (BEAS-2B) culture system improving methodological aspects for in vitro toxicity assessment of nanoplastics (NPs) and identifying polystyrene nanoplastics (PSNP) cytotoxicity effects on cellular uptake, oxidative stress, inflammation, and lung dysfunction.	Amerika	Experimental design	NA	PNSP exposure for 24 hours	studies have shown that PSNP may be harmful to human lung health even at very low concentrations.	In the study, the participants were not explained, the researchers used human bronchial epithelial cells (BEAS-2B)	inhalation of PSNPs, even at non-cytotoxic concentrations, has the potential to affect respiratory health in humans.
4	Sheng Yang, *et al* (2023) [15]	exploring the relationship between chronic obstructive pulmonary disease (COPD) and exposure to polystyrene nanoplastics	China	Experimental design	NA	exposure to polystyrene nanoplastics (PS-NPs) for 24 hours.	exposure to PS-NPs can result in oxidative stress, inflammatory responses and impaired AAT	not described Cultured human alveolar epithelial cells (HPAEpiC, ScienCell), human monocyte cells	The lung on a chip is made to reproduce the main structure of the alveolar-capillary barrier, and introduce the immune system to simulate the

No.	Author (Year)	Objective	country/region of study	Study Design	participants	Study Duration	Research findings	Study Limitations	conclusion
		(PS-NPs) monitored via a lung chip					function, as well as damage to the alveolar-capillary barrier for entry into the blood, thereby increasing the potential for COPD.	(THP-1, ATCC) and human endothelial cells (HUVEC, ATCC) were obtained	microenvironment in the body more realistically, enhancing the effect of immune response and sensitivity. After exposure, PS-NPs interact with cells to induce oxidative stress, inflammatory response, and impaired AAT function, and damage the alveolar-capillary barrier to enter the blood, which may increase the potential for developing COPD
5	Huajing Zhang, *et al* (2022) [16]	analyzing the impact of nano-PET toxicity at environmental concentrations on A549 cells in lung carcinoma cell	Amerika	Experimental design	NA	Exposure to nano-PET for 24 hour	There is an increase in reactive oxygen species caused by oxidative stress, resulting in a decrease in mitochondrial membrane potential	It is only explained that the A549 cells in lung carcinoma cells were obtained from America, there is no further explanation about the participants.	This study provides information on the toxicity of nano-PET at environmental concentrations in human lung cells, which helps to enrich the risk cognition of nanoplastics in the respiratory system.
6	Mingkai Xu, *et al* (2019)[17]	evaluated the effects of polystyrene nanoparticles with two	Amerika	Experimental design	NA	he uptake of PS-NPs by A549	The results showed that PSNP25 was	In vitro studies do not describe participants.	that exposure duration, diameter, and concentration are key

No.	Author (Year)	Objective	country/region of study	Study Design	participants	Study Duration	Research findings	Study Limitations	conclusion
		different sizes (PS-NP25: diameter 25 nm and PS-NP70: diameter 70 nm) on human alveolar epithelial cell line A549 including internalization, cell viability, cell cycle, apoptosis, and related gene transcription and protein expression.				cells was monitored using laser scanning confocal microscopy after 1 h of incubation	internalized more rapidly and efficiently into the cytoplasm of A549 than PS-NP70. PS-NP significantly affected cell viability, caused cell cycle S-phase arrest, activated inflammatory gene transcription, and altered the expression of pro-apoptotic and cell cycle-related proteins. PS-NPs induced significant upregulation of pro-inflammatory cytokines such as IL-8, NF-κB, and TNF-α, as well as pro-apoptotic		factors to evaluate the toxicological effects of PS-NPs on alveolar epithelial cells.

No.	Author (Year)	Objective	country/region of study	Study Design	participants	Study Duration	Research findings	Study Limitations	conclusion
							proteins such as DR5, caspase-3, caspase-8, caspase-9, and cytochrome c, suggesting that PS-NPs trigger the TNFα-related apoptotic pathway		
7	Mohammad Alzaben, *et al* (2023)[18]	identified a possible association between polyethylene terephthalate (PET) nanoplastic exposure and genotoxic responses in a human airway epithelial cell model (A549)	Denmark	Experimental design	NA	24-hour exposure to PET nanoplastics	there was a 30% increase in the production of reactive oxygen species in cells exposed to PET	do not describe participants.	this study showed that PET nanoplastic particles cause ROS production and DNA damage in A549 lung epithelial cells. The level of DNA damage was not significantly affected by challenge with redox-active compounds such as H_2O or buthionine sulfoximine (BSO). It is not known whether the observed effect is a result of the plastic particles themselves or chemicals leaching from them

No.	Author (Year)	Objective	country/region of study	Study Design	participants	Study Duration	Research findings	Study Limitations	conclusion
8	Sheng Yang, *et al* (2021)[19]	analyzed the relationship between lung injury and polystyrene nanoplastics (PS-NP) in two types of human lung epithelial cells (bronchial epithelium transformed with Ad12-SV40 2B, BEAS-2B) and (human lung alveolar epithelial cells, HPAEpiC)	America	Experimental design	NA	PS-NPs exposure on EAS-2B and HPAEpiC cells for 24 hours	Oxidative stress and inflammatory responses occur followed by cell death and weakening of the epithelial barrier, which can result in tissue damage and lung disease after prolonged exposure to nanoplastics.	do not describe participants.	nanoplastics can cause oxidative stress and inflammatory responses, followed by cell death and epithelial barrier damage, which can result in tissue damage and lung disease after prolonged exposure.
9	Antonio Laganà, *et al* (2023)[20]	To obtain a more realistic hazard assessment by studying the biological effects of aging microplastics and nanoplastics. In human alveolar epithelial cells (A549 cell line), the effects of polystyrene nanoplastics and microplastics oxidized at home (ox-nPS/mPS), with diameters of 0.1 and 1 μm, were compared	Virgin nPS (average size 100 nm) and mPS (average size 1 _m) were purchased from Sigma-Merck (Milan, Italy)	Experimental design	NA	nPs/MPs exposure on A549 cells for 24 hours	nPS/mPS has an effect on cell uptake on increased ROS, DNA damage, and mitochondrial disorders	There is no participant information and country where A549 cells were purchased	there is potential for negative impacts from inhalable plastic particle fractions on human health.

No.	Author (Year)	Objective	country/region of study	Study Design	participants	Study Duration	Research findings	Study Limitations	conclusion
		with fresh ones (v-nPS/mPS)							
10	Cheng-Di Dong, *et al* (2019)[21]	analyzed the relationship between lung toxicity and polystyrene microplastics (PS-MPs) in normal human lung epithelial cells BEAS-2B	Taiwan	Experimental design	NA	PS-MPs exposure on BEAS-2B Cells PS-MPs (1–1000 μg/cm3) for 24 and 48 h	PS-MP can cause cytotoxic and inflammatory effects on BEAS-2B cells by inducing the formation of reactive oxygen species. S-MP can decrease transepithelial electrical resistance by depleting zonula occludens protein. PS-MPs exposure increases the risk of chronic obstructive pulmonary disease	no participants and unknown sample size	inhaled PS-MP exposure has the potential to cause inflammatory and oxidative injury along with disruption of intercellular junction proteins in the lung, which may lead to PS-MP-induced lung barrier dysfunction and subsequent COPD
11	Luís Fernando Amato-	determined the presence of microplastics in human lung tissue from	São Paulo	Experimental design	From 20 nonsmoking adults who	This study was conducted	poor health conditions of patients are	Small sample size	The presence of microplastics in the lung has been found in human

No.	Author (Year)	Objective	country/region of study	Study Design	participants	Study Duration	Research findings	Study Limitations	conclusion
	Lourenço, *et al* (2021)[22]	twenty cases obtained at coronary autopsy and identified their characteristics, including size, format, color, and polymer matrix.			underwent routine coronary autopsy at the São Paulo City Death Verification Service of the University of São Paulo for cause of death verification	from August 2019 to March 2021	possible due to inhalation of contaminants with heterogeneous characteristics		lungs such as polypropylene and polyethylene
12	Lauren C. Jenner, *et al* (2022)[23]	to identify any MP particles present in digested human lung tissue samples, while also accounting for procedural and laboratory blank contamination	Castle Hill Hospital	Clinical Study	Lung tissue was obtained from 11 thoracic surgical patients at Castle Hill Hospital, Hull University Teaching Hospitals NHS	NA	39 MPs were identified within 11 of the 13 lung tissue samples with an average of 1.42 ± 1.50 MP/g of tissue. there are 12 types of polymers were identified in lung cells	It is not explained through the inclusion criteria how long the patient was exposed to microplastics in the environment.	microplastics were found in human lung tissue samples, using μFTIR spectroscopy
13	Rossella Bengalli, *et al* (2022)[24]	analyzed the toxic effects of MPs derived from inhaled plastic waste (wMPs) on an in vitro	American	Clinical Study	NA	The cytotoxicity of wMP on A549	The results obtained showed that, at high concentrations	No sample size, no oxplanation participants	There are moderate acute toxicity effects in vitro, with appreciable biological effects only after exposure

No.	Author (Year)	Objective	country/region of study	Study Design	participants	Study Duration	Research findings	Study Limitations	conclusion
		model of human lung epithelium, A549 cells.				cells for 24 hours	(100 μg/ml) and long exposure times (48 h), wMPs affected biological responses by inducing inflammation and genotoxicity, as a result of cell–wMP interactions, also including the uptake of smaller particles.		to high concentrations and long exposure times.
14	Chunzhao Chen, *et al* (2022)[25]	This study characterized the occurrence patterns of microplastics (MPs) in the bronchoalveolar lavage fluid (BALF) of children with pulmonary diseases	Tiongkok, China	Clinical Study	A total of 77 BALF samples were obtained from CAP and asthma patients in the Beijing Children's Hospital in 2022	1 year	Microplastics were present in 89.6% of BALF samples with a mean of 4.31 ± 2.77 items/10 mL, supporting the hypothesis that inhalation is a significant pathway of airborne	No study limitations	MP levels in BALF showed a negative correlation with children's age, possibly due to the preferred crawling and rolling activities in indoor environments and children's underdeveloped immune systems.

No.	Author (Year)	Objective	country/region of study	Study Design	participants	Study Duration	Research findings	Study Limitations	conclusion
							microplastic exposure to children's lungs.		
15	Qingying Shi, *et al* (2021)[26]	to test the hypothesis that human A549 lung epithelial cells exposed to NPs and various phthalate esters (PAEs) di-(2-ethyl hexyl) phthalate (DEHP) and dibutyl phthalate (DBP) may exhibit changes in cell viability, oxidative stress, and inflammatory reactions due to the interaction of NPs and PAEs, and these changes may vary depending on the concentration of NPs and PAEs and the nature of P	China	Experimental design	NA	The exposure of nPS on A549 cells for 24 hours	The mechanism of oxidative stress and inflammatory reactions occurs in the combined cytotoxicity of PAE and NP on A549 cells.	No sample size, no oxplanation participants	There is an effect of nPS on the cytotoxicity of PAE in A549 cells, which expands our knowledge on the potential risk assessment of NPs and combined pollution to human health.

(NA=not available)

hair, saliva, or through tissue culture cells were detected to have the presence of microplastics that cause toxicity to the lungs of the human respiratory system. Complete details of the research findings are explained in Table 3.

Discussion

The aim of this study was to determine the presence of microplastics in human lungs and the toxic effects on human lungs. This study is important to do because of the increasing number of research findings on the presence of microplastics in the environment, both in the air, water, sea and food. where when humans are exposed to microplastics it will have an impact on human. From the results of the literature review, all research results stated that there were cytotoxic effects on human lungs, both from direct exposure to microplastics to humans and samples taken from tissue culture cells. Microplastics are still considered an environmental pollution problem that is currently very important throughout the world which can cause have an impact on human health. World plastic production has recently reached more than 300 million tons[28]. Because plastic materials are resistant to degradation, they cause severe impacts on the environment[29].

Most plastics are released into the environment and degraded into microplastics (MPs) and nanoplastics (Nps) and their presence is widespread in the atmosphere[30]. Research Micro (nano) plastics have been identified in the air around the world[31–33]. Micro (nano) plastics suspended in the air can be inhaled by humans and then settle and accumulate in the lungs, potentially posing a health risk. The results of research on bird lungs revealed the presence of microplastics[34], in the lower respiratory tract and lungs of humans[22,35,36], as well as in the sputum of COPD patients. Medical studies reveal the onset of respiratory symptoms with exposure to microplastics in the workplace[37,38]. But research on the adverse effects of microplastics on the human respiratory system is still limited. Most research on the health risks of airborne micro(nano)plastics has focused on tissue cell culture models and in vivo animal models.[19,39]. For example, occupational observations, combined with 2D cell models, suggest that inhalation exposure to microplastics may increase the risk of COPD[21]. Therefore, more experimental research evidence is needed to clarify the role and mechanism of toxicity of micro(nano) plastics in the occurrence and development of COPD.

In this study, we conducted systematic observations to assess the impact of exposure to airborne microplastics on human lung health. A total of 15 research papers involved both pure experimental research and clinical research. The exposure period included in the systematic observation of each study is different, but what is emphasized here is that exposure to microplastics in the air can have a negative impact on human lungs. In research that looked at exposure to microplastics in children by looking at BALF there was no significant difference, but children in urban areas had a much greater impact on the health of workers in the respiratory system compared to rural areas[14]. Most studies on the effects of microplastic exposure on human lung cells have found that there is damage to DNA, increased ROS and oxidative stress, proving that over time microplastic exposure will have a negative impact on human respiratory and lung conditions[16–19].

The overall findings of the systematic review revealed that microplastics in the air will provide extensive exposure to humans and thus impact their health. Inhalation exposure provides a significantly higher increase in pulmonary disorders. According to research, higher exposure will have a big impact[24]. Abbasi, *et al*, also reported that with extensive exposure, inter- and intra-individual levels of microplastics are very heterogeneous[27]

In this study, the search selection of papers was based on damage to human lung cells as the primary outcome. However, the level of exposure to microplastics also has an impact on various health conditions including the respiratory system which will affect lung health [23]. There are still many health problems caused by microplastics that use tissue culture experiments with conditioned exposure doses. Most of the studies produced significant results regarding damage to human alveolar cells (A549).[16,17,20]

We also selected and used databases for searching research records which could result in bias in sampling due to inconsistency in data regarding hypotheses and lack of expected data. However, we used PRISMA guidelines in addition to inclusion and exclusion criteria aimed at minimizing risk bias and increasing confidence in the selected methods. It is hoped that the findings from several studies used in this systematic observation can be used for future research so that they can plan and develop new and effective research to prevent the impact of lung health on humans. In addition, the findings of this study can be considered in policy and practice creation by governments, public health authorities and other non-governmental organizations to design effective food interventions to prevent overall environmental pollution including microplastic pollution by replacing the use of plastic with organic materials. as one of the needs that humans use.

The strength of this study is that all studies were conducted using experimental and clinical study designs. where the samples tested have been adjusted to applicable standard procedures. The limitation of this study is that there are several articles that do not mention participants because the study used tissue culture cell samples.

Conclusion

Based on research findings, all the articles on microplastic exposure reviewed in this study have the potential to increase human lung disorders. However, the extent of this toxic effect on human lungs is based on the level of exposure, type of microplastic, size of microplastic, and type of research. greater concentrations of microplastics increase the toxicity of human lung cells. These findings can help to propel research regarding interventions that can be used to reduce airborne microplastic exposure. Policies regarding the use of plastic must thus receive full attention by the government. Furthermore more evidence is needed regarding similar studies looking at other health impacts.

Authors contribution

Prehatin Trirahayu Ningrum: conceptualized and designed the study, collected data and analyset the data
Soedjajadi Keman, Lilis Sulistyorini, I Ketut Sudiana, and Agus Hidayat: reviewed empirical studies
Hasrah Junaidi: designed the methodology
Abul Haris Suryo Negoro and Kustin: wrote the introduction and edited the paper.
All authors have approved this manuscript.

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