Dean&Francis

ISSN 2959-6149

Impact of Microplastics in the Environment on Human Health and Its Policy Analysis: A Case Study on China

Yixin Zhou[1*,#],

Zhengye Guo[2,#],

Victoria Xiangyi Woo[3,#],

Zefan Cheng[4,#],

IVAN YU[5,#]

[1]*College of International Law and Sociology, Sichuan International Studies University, Chongqing, 400031, China, 3230677122@qq.com*
[2]*College of Medicine and Veterinary Medicine, The University of Edinburgh, Edinburgh, EH8 9YL, United Kingdom, guozhengye2000@163.com*
[3]*Lexington High School, Lexington, 02420, United States, victoria.x.woo@gmail.com*
[4]*School of medicine, Jianghan University, Wuhan, 430056, China, 2328431091@qq.com*
[5]*Guangzhou Zhixin High School, Guangzhou, 510105, China, i243658r@qq.com*
** Corresponding author*
#co-first authors

Abstract:

Microplastics, as a new type of pollutant, have received extensive attention from scholars in recent years. This paper explores the impact of microplastics on human health from the interdisciplinary perspective of health economics and public policy in China. The paper finds that plastic wastes are influencing factors of the increasing demand for respiratory medicines, probably owing to the release of airborne microplastics. Additionally, this paper focuses on the development of microplastics policy in China and other countries, drawing on the experience of microplastics pollution control worldwide. The paper puts forward recommendations in the following four aspects: 1.Introduce targeted policies and increase monitoring of microplastics. 2.Clarify the responsibilities of each department and promote cross-sectoral collaboration. 3.Strengthen international exchanges and establish multi-platform cooperation. 4.Enhance the dissemination of knowledge about microplastics and raise citizens' environmental awareness in China.

Keywords: Microplastics, Public health, Economic impact, Policy

ISSN 2959-6149

1. Introduction

Air pollution as defined by the World Health Organization (WHO) is the "contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere." Categorized as air pollution, airborne microplasticss and their harmful effects have been increasingly studied in recent research as plastics have become widely used around the world. This paper aims to examine airborne microplastics concentrations in China and demonstrate the medical costs that arise from resulting respiratory diseases. We will also analyze previous plastics policies in order to provide the foundations for a future effective policy on microplasticss.

Microplasticss are small pieces of plastic less than 5 mm in diameter, including nanosized plastics less than 1 μm [1]. They are classified by their shape into fibers, fragments, and pellets. Fibers have a length to width ratio greater than 3, pellets are approximately spherical in shape, and the remaining microplasticss are termed fragments [7]. Based on the length of their longest dimension, microplasticss are also categorized into groups of 5−30, 30−100, 100−300, 300−1000, and 1000− 5000 μm [7].

There is a distinction between microplasticss according to their method of creation. Primary microplasticss are specially manufactured to be small, and are often used for abrasion on the skin [7]. These include personal care products such as facial cleansers and cosmetics [4]. Meanwhile, secondary microplasticss originate from the degradation of larger plastics through mechanical weathering, photooxidation degradation, and biodegradation [7]. In particular, when plastics enter the air, they undergo degradation and erosion processes that change their morphology and surface characteristics. It is of note that industrial production produces many secondary microplasticss through industries such as the synthetic textile industry, the flocking industry, and the plastics industry [4].

Microplasticss have been found in human lungs, placenta, and stool through means of ingestion, skin contact, and inhalation [4]. Including inhalation of airborne microplasticss, humans may consume 74000-121000 microplastics particles a year [3]. The toxic effects of microplasticss in experimental models of cells, organoids, and animals include oxidative stress, DNA damage, organ dysfunction, metabolic disorder, immune response, neurotoxicity, and reproductive and developmental toxicity [4]. Furthermore, high exposure to airborne microplasticss has caused coughing, dyspnea, occupational asthma, and interstitial lung disease – all respiratory health issues [1]. However, little research has been done about low exposure situations, which is cause for alarm because most people are exposed to low microplastics concentrations. Further affecting humans, atmospheric microplasticss may also transfer toxicants, such as heavy metals and organic chemicals, in the air [1].

This paper focuses on microplasticss in China because China is the world's largest producer and consumer of plastics. China generated around 26.74 million tons of plastic waste in 2019 [5], and although the country has implemented several policies to address plastic waste emissions, the policies do not appear to reach maximum effectiveness. As of 2020, current policies were predicted to reduce plastic waste emissions to 13.49 million tons by 2035, while target policies could have minimized emissions to 2.63 million tons under the same time frame [5].

In fact, China does not have a widely known reference for all of its plastic policies, even though analysis of policy is crucial to understanding previous attempts to reduce pollution. Moreover, comparison of domestic and foreign plastic policies could allow conclusions to be drawn about which policies are more effective in reducing plastics and their associated health effects. To enable the proposal of new policies which are efficient in dealing with plastics, especially microplasticss, this paper includes a section on policy analysis.

We further observed that the focus of air pollution research in China has been primarily on particulate matter (PM), rather than microplasticss – especially those which are airborne. More research needs to be done on the complicated health effects of airborne microplasticss. In particular, because the health effects of airborne microplasticss are relatively unstudied, it is difficult to analyze the resulting consequences in the health sector – such as the quantity of money or years of life which are lost due to atmospheric microplastics exposure.

More generally, fewer than 1% of China's 500 largest cities meet the air quality standards suggested by WHO [6]. Also, 99.6% of the Chinese population reside in areas with fine particle (PM2.5) concentrations above the WHO guideline of 10 μg/m3 in 2003 [2]. This paper was conducted with the consideration that air quality in China is fairly poor, and that atmospheric microplasticss especially have rarely been studied in the country. Thus, we conducted research on atmospheric microplasticss in China to help the country better its air pollution situation.

Ultimately, this paper approaches atmospheric microplasticss from the unique interdisciplinary perspective of health economics and public policy. We explore airborne microplasticss and their impact on human health and health costs, as well as previous plastics policies around the world. We aim to draw attention to airborne microplasticss as a significant source of air pollution harming humans, and also provide an accessible reference for plastic policies. By suggesting the medical costs associated with atmospheric microplastics exposure, we begin to analyze how exposure affects the health industry, and set the stage for future cost-effective policy analysis.

The rest of the paper is formatted as follows: first we will give a literature review of previous papers on microplasticss inside and outside of China; then, we will describe our methodology and data findings; after, we will analyze microplastics policies; and finally we will conclude.

2. Literature review

2.1 China's Current Status in the Field of Microplasticss Research

In recent years, China has made certain achievements in microplastics research, attracting the interest of many experts. Research on microplasticss in China includes the sources, distribution, and migration of microplasticss, and their effects on the natural environment and potential implications for human health. The research will summarize studies undertaken by both domestic and international experts on microplasticss from various research viewpoints.

2.2 Environment Science and Ecology

The pollution features of microplasticss in environment is currently a main focus in microplasticss research. Zhang et al. report that microplasticss can be found in the atmospheric deposition of urban, rural, and remote regions. Moreover, the microplasticss exhibit considerable potential of long-distance migration, so they can impact locations distant from pollution sources[8]. Wind, snowfall, and weathering greatly contribute to dispersal of microplasticss from their origins to terrestrial and marine environment[8]. Moreover, microplasticss occur frequently in soil as well. Zhang et al. analyzed the sources of microplasticss in soil (mulch film application, sewage irrigation, organic membrane usage, and atmospheric deposition.), and their detrimental effects on human health through interactions with crops (damage to soil health, structure, physical and chemical properties, and microorganisms)[9]. The survey by Sun et al. indicates that the primary sources of microplasticss in the ocean involve degradation of plastic waste, the entry of terrestrial plastic waste, disposal by vessels, and pollutants from the aquaculture industry[10]. The pollutants that are inherent to the microplasticss and accumulate on their surface can influence worldwide distribution of pollutants and exert a cumulative harmful impact on marine organisms[10].

2.3 Public Health

Microplasticss are widespread in the human diet because of their unique physical and chemical properties, so they can be exposed among all age populations.[11] In terrestrial ecosystem, soil is a potential route for plant exposure to microplasticss, which may subsequently affect crops and transfer to human through the food chain. Aquatic organisms, after ingesting polybrominated diphenyl ethers(PBDEs), can also pose potential health risks to humans through the food web[11]. Microplasticss can translocate through various routes in the food chain, including drinking water, food consumption, placental transfer in pregnant women, and breastfeeding[11].

Microplasticss can disperse through the atmosphere, mixing with the particles inhaled by humans on a daily basis. They can travel from marine environment to the sky. Airborne microplasticss can potentially enter the human body via respiration. Although it is commonly believed that only fibers with a diameter less than 10μm may enter the body, research has revealed that the existence of 250μm-long fibers within lung tissues. This presence may result from the fibers' reduced size, typically ranging from a few to twenty micrometers, which can inadvertently infiltrate further into the respiratory system[15]. According to Zhang and Li's research, a significant quantity of microplasticss is inhaled each year, with this pathway constituting around fifty percent of total exposure[13].

2.4 Microplasticss and Economic activities

Liu et al. investigated economic activities in 17 mega-cities in northern China to analyze the relationship between atmospheric microplastics deposition flux, GDP, and industrial structure. [14]The findings indicate that GDP growth, population, and tertiary service sector expansion are significant factors affecting microplastics contamination. The rapid growth of economic and population greatly exacerbates microplastics contamination. The extent of microplastics contamination is apparently positively associated with urban population and GDP: higher population density and economic development correspond to increased microplastics pollution. (Liu et al., 2024) This study raises awareness of microplasticss, advocating environmental conservation and reducing plastic use and waste. It also offers data assistance to governments in developing more effective control and prevention measures for microplastics pollution.[14]

2.5 Conclusion

Improper disposal of plastic waste or production and use of plastics might result in the generation of microplasticss. Upon entering the environment, microplasticss can depos-

ISSN 2959-6149

it in several mediums, including soil, aquatic systems, and atmosphere, thereby impacting ecosystem structure and function. They can infiltrate the human body via several routes, posing a threat to human health. Contemporary research on the attributes of microplastics contamination in the atmosphere is comparatively underdeveloped and limited in contrast to studies conducted in aquatic and terrestrial settings. This may result from the absence of defined research methodologies for airborne microplasticss and a general dearth of data concerning air pollution.

The current comprehension of the possible health concerns posed by microplasticss to humans remains inadequate, likely due to the scarcity of data regarding their precise toxicological effects and associated risks[12]. Further research is required for a thorough evaluation of microplasticss' toxicity, which is essential for developing appropriate strategies to mitigate environmental pollution and health risks associated with microplasticss. Moreover, comprehensive analyses regarding the correlation between microplasticss and human respiratory health in China, alongside investigations into China's microplastics regulations, remain relatively insufficient. This study employs an interdisciplinary approach, integrating health economics and public policy, to examine the relationship between microplasticss and human health. This analysis compares microplastics policies in China with those of other nations and offers recommendations for future microplastics policies in China.

3. Data and Methodology

3.1 Data collection

To investigate the economic impact of microplasticss on public health in China, data was collected for the period from 2015 to 2019. Due to limitations in the existing measurement of airborne microplasticss, data on plastic waste was used as a proxy, since it is the source of airborne microplasticss[17]. Given that plastic waste is difficult to decompose naturally, it is often disposed of through burning and landfilling[18]. These disposal methods can release microplasticss and other harmful gases into the environment[19]. Consequently, data on plastic waste was sourced from the "Global Plastics Outlook: Economic Drivers"[20]. Released microplasticss can penetrate deep into people's lungs and can trigger or exacerbate respiratory diseases[21]. With the rising incidence of such diseases, there is an increasing demand for respiratory medications, which subsequently drives up healthcare expenditures.

The economic factor representing the impact on public health is the market size of respiratory medication. This market size is measured in Chinese currency, and data were gathered from a national report on respiratory medications (https://www.chinabaogao.com/), reflecting the expenditures associated with these medications. This serves as a direct reflection of the prevalence and economic burden of respiratory diseases[22].

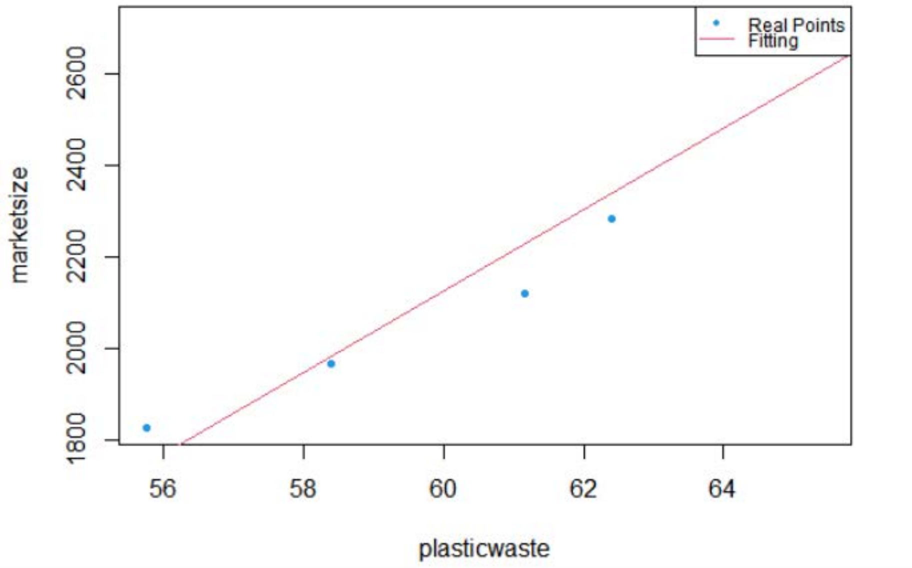
Two control variables were taken into consideration, as they influence the market size of respiratory medications: domestic general government health expenditure (as a percentage of GDP) and GDP growth (annual percentage). Domestic general government health expenditure represents government investment in public health[23], while GDP growth (annual percentage) reflects the purchasing power of the population[24]. Data for both control variables were collected from the World Bank (https://data.worldbank.org.cn/).

3.2 Method

The linear regression model[25] was utilized as the econometric framework to identify the relationship between plastic waste and spending on respiratory medications. Data analysis was conducted using R version 4.2.2[26]. Three linear regression models were generated. The first model included only plastic waste as the independent variable and the market size of respiratory medications as the dependent variable: model1 <-lm(market size of respiratory medications ~ plastic waste). The second model introduces domestic general government health expenditure (percentage of GDP) as a control variable to the first model: model2 <-lm(market size of respiratory medications~plastic waste+domestic general government health expenditure). The third model incorporated GDP growth as an additional control variable: model3 <-lm(market size of respiratory medications~plastic waste+domestic general government health expenditure+GDP growth).

3.3 Results

The first model only included plastic waste as the independent variable to assess its contribution to expenditures. The R-squared value is 0.9319, and the adjusted R-squared is 0.9092, indicating that variations in plastic waste significantly explain variations in the market size of respiratory medications. The relationship observed is unlikely to be due to chance. The significance of coefficient reveals that the coefficient for plastic waste is statistically significant (p-value = 0.0077), providing strong evidence for the existence of the existence of this relationship. This suggests a significant linear correlation between the amount of plastic waste and the market size for medications related to respiratory diseases, as illustrated in the graph below. However, the relatively large range of residuals indicates that this model may not fully capture the variability present in some data.



Graph.1 Linear Correlation Between Plastic Waste and the Market Size of Respiratory Medication

The second model introduced domestic general government health expenditure as a control variable. The R-squared value increased to 0.9945, and the adjusted R-squared is 0.9889. The enhancement indicates a substantial improvement in the model's ability to explain and account for variations in the data. The significance of the coefficients for both variables is notable with p-values of 0.00352 and 0.04149, respectively, indicating that both factors impact the market size of respiratory medications. Additionally, the range of residuals is significantly reduced, suggesting a better alignment between the model and the observed data.

The third model incorporates GDP growth as an additional control variable. Both the R-squared and adjusted R-squared values approach 1. This suggests that this model almost completely explains the variability of dependent variable. The statistical significance of all coefficients for all three variables—plastic waste (p-value= 0.0125), domestic general government health expenditure (p-value= 0.0495), and GDP growth (p-value= 0.0417)—indicates that each of these factors significantly influences the market size of respiratory medications in China.

3.4 Analysis

3.4.1 Plastic waste

In all three models, the significant coefficients of plastics waste indicate a strong linear correlation between plastic waste and the market size of respiratory medications. This suggests that an increase in plastic waste might be a contribution to larger expenditures on respiratory medications. Airborne plastics, as an intermediate link, come from plastic waste ,especially landfill plastic waste[18]. They then act on human respiratory system[21], thereby explaining the correlation between plastic waste and expenditures on respiratory medications.

The result from the models highlights the negative impact of plastic waste and microplasticss on economic and public health, which is a growing concern in China and worldwide[27-28]. Therefore, it is important to implement measures to control plastic waste and microplasticss to reduce their negative effects.

3.4.2 Domestic General government health expenditure

In the second and the third model, domestic general government health expenditure, as a control variable, shows a significant positive correlation with the market size of respiratory medications. This indicates that government investment in health can stimulate the growth of the respiratory medication market.

Domestic general government health expenditure reflects government intervention in public health, which plays an important role in the pharmaceutical market[29]. As health expenditure increases, assess to medicines improves, enabling more efficient healthcare delivery[29]. This, in turn, stimulates the consumption of medical care, including medications. Furthermore, increased health expenditure fosters capital accumulation, attracting more pharmaceutical enterprises and expanding the overall size of medication market[30].

ISSN 2959-6149

3.4.3 GDP growth

In the third model, the significantly negative coefficient of GDP growth rate appears somewhat counter-intuitive, as economic growth typically drives growth in the healthcare market. Normally, an increase in GDP reflects a rise in society wealth and resident's income, which can lead to higher medical expenditure and an expanded medication market[25]. There might be several explanations for this negative correlation: Economic growth has provided a solid foundation for the medical and health industry, allowing the resources in the medical field to have a more reasonable allocation[31]. Therefore, unnecessary medication usage is reduced. At the same time, with the increase in residents' income, people's health awareness may enhance and the incidence of having respiratory diseases might decrease[32].

3.5 Limitations

In discussing the economic impact of microplasticss, we use plastic waste as a proxy for microplastics emissions, as plastic waste is one of the primary sources of microplasticss and there is a lack of specific data on microplasticss. Consequently, the model may not provide robust evidence of the economic impact of microplasticss.

Additionally, caution is needed regarding the risk of over-fitting. In practical applications, especially with a limited number of data points (such as the five data points used in this analysis), the model may become overly complex, resulting in poor predictive ability for new data.

It is also important to note that the medical market can be affected by various factors, such as policies[33], systems[34], and culture aspects[35].Therefore these factors should also be taken in into consideration in future modelling efforts.

4. Policy analysis

In recent years, with the acceleration of China's industrialization and the massive use of chemicals, the sources of pollution in the environment have been increasing, bringing great impacts on the natural ecological environment and human health. Microplasticss, as a new pollutant, have received widespread attention at the international level. Based on the global perspective, our research team will analyze the microplastics policies in China and other countries, and discuss the future development direction of China's microplastics policy by analyzing and comparing the policies of different countries, to provide new ideas for both microplastics pollution prevention and control in China.

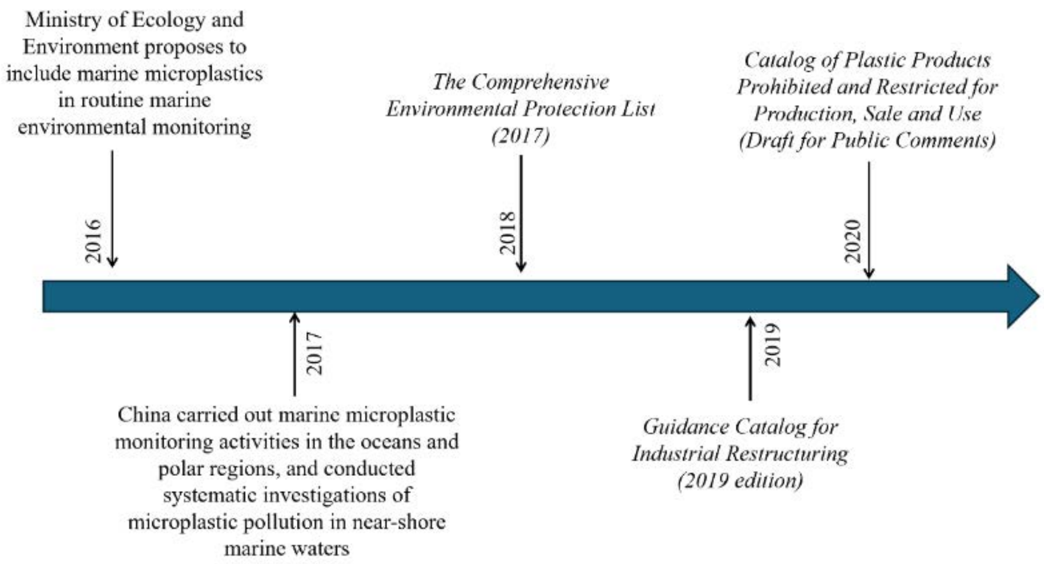
4.1 The microplastics policies in China

China's policy on microplastics started late, dating as far back as 2016, when Huo, deputy director of China's Ministry of Ecology and Environment, proposed at a press conference the inclusion of marine microplastics within the scope of routine environmental monitoring of the oceans[36]. This is the first time that China has proposed actions on microplastics prevention and control at the national level, and it marks the beginning of microplastics control in China[37]. In 2017, China carried out marine microplastics monitoring activities for the first time in the oceans and polar regions to systematically investigate microplastics pollution in near-shore marine waters, which focused on marine microplastics transport pathways and promoted research on marine microplastics monitoring technologies and risk assessment methods[38]. Although the issue of marine microplastics in China received attention in 2016, this is only a proposal for a solution to a hotspot problem, so it has its limitations in terms of legal effect.

In February 2018, *the Comprehensive List of Environmental Protection (2017)* issued by the former Ministry of Environmental Protection (now the Ministry of Ecological Environment) included "cosmetics and cleaning supplies with plastic microbeads" and "plastic microbead additives" in the list of "high pollution and high environmental danger" products[39], but the list did not put forward corresponding restrictions on their use. In 2019, China's National Development and Reform Commission (NDRC) issued the *Guidance Catalogue for Industrial Structure Adjustment (2019 edition)*, which phases out daily chemicals containing plastic microbeads, ultra-thin plastic bags with a thickness of less than 0.025 mm, and polyethylene agricultural land film with a thickness of less than 0.01 mm[40], and it also marked a detailed ban on the time of the generation and sale of daily chemicals containing plastic microbeads. Plastic beads, as plastic particles with a diameter of less than 2 millimeters, are widely found in people's daily use of personal care products, and these daily use products containing plastic beads are difficult to filter in the process of flowing into the sewage treatment plant after use, and are eventually discharged into the rivers and oceans, resulting in serious marine pollution. The promulgation of this policy provides effective control over a major source of microplastics production, which is of positive significance to China's microplastics prevention and control actions.

In 2020, China's National Development and Reform Commission (NDRC) also drafted *the Catalog of Plastic Products Prohibited, Restricted for Production, Sale and Use (Draft for Public Comments)*[41], and made it available for public consultation. All of these policies can be seen that the Chinese government attaches great importance to the issue of plastics and the prevention of microplasticss.

Tab.1 The Development of Microplastics Policy in China



4.2 The microplastics policies in other countries

The management of marine microplastics in the European Union, the United States, Canada, and other countries and regions first originated in the late 20th century. In 1992, the Convention for *the Convention for the Protection of the Marine Environment of the North-East Atlantic* (*the OSPAR Convention*), issued by the European Union, included microplastics abundance in the stomachs of seabirds as a marine ecological indicator. On June 23, 2014, the first United Nations Environment Assembly released *the United Nations Environment Programme Yearbook 2014* and *Assessing the Value of Plastics*, both of which specifically addressed the issue of microplastics, pointing out its' damage to marine ecosystems as well as fisheries and tourism, which has sparked widespread concern among countries.

The United States was the first country to restrict the production of primary microplastics. In December 2015, the U.S. signed into law the *Microbead-Free Waters Act of 2015*, a national law explicitly states that personal care manufacturers are no longer allowed to produce personal care products that contain plastic microbeads. Besides, the sale of such products will be banned completely from July 2018 onwards. Countries such as the Netherlands, the United Kingdom, Canada, Germany, and others have also introduced relevant legislation and developed a series of regulatory programs on the risks posed by microplasticss to the environment, as well as on the production and distribution of microplasticss.

The growing problem of microplastics and the increasing prominence of environmental pollution have gradually brought it into the public eye and attracted the attention of countries around the world. At the sixth plenary meeting of the United Nations in May 2016, microplasticss were formally consulted as an important environmental issue, and the General Assembly also urged States that had not yet done so to cooperate across international and sectoral boundaries to combat the problem of marine litter and microplastics. Finally, at the fifth United Nations Environment Assembly in 2022, participating countries unanimously adopted a historic resolution on a global end to plastic pollution.

In September 2023, the United Nations, and the European Commission adopted the *COMMISSION REGULATION (EU) to 2023/to 2055*. This policy is a formal microplastics restriction that restricts the release of microplastics and its associated products within the EU by amending *Annex XVII of REACH* in the hope of achieving a reduction in the polluting nature of microplastics[42]. The regulation has not yet been introduced for one year, and its implementation in the European Union has not yet been well verified. However, from the decree, we can still see that the European Union attaches importance to the problem of microplastics pollution.

The policies above focus on three aspects of the content: First, control the source of plastic pollution; second, prohibit the use of plastic beads; the third is the production of

ISSN 2959-6149

plastics, the use of recycling management, so as to reduce the use of plastics brought about by pollution.

Tab.2 Summary of Microplastics Policies in Selected Countries

time	Country/Organization	Microplastics policy
1992	European Union (EU)	*OSPAR Convention* Microplastic abundance in seabird stomachs as a marine ecological indicator
2014	United Nations (UN)	*UNEP 2014 Annual Report&Assessing the value of plastics* Pointing out the damage caused by microplastics to marine ecosystems, as well as to fisheries and tourism
2015	United States	*Microbead-Free Waters Act of 2015* Personal care product manufacturers are expressly prohibited from producing personal care products containing plastic microbeads.
2023	United Nations (UN)&European Union (EU)	*COMMISSION REGULATION (EU) to 2023/to 2055* Restrictions on the placement of microplastics themselves and their associated products within the EU

4.3 Policy recommendations on microplastics in China

Though from a global perspective, the issue of microplastics has only a history of more than 30 to 40 years since its discovery to be emphasized, and the policies enacted by various countries are still deficient in some aspects. However, there are still many experiences worth learning for China, and our research group has some reference suggestions for the development of microplasticss in China.

4.3.1 Introducing targeted policies, and increasing monitoring of microplastics

At present, China has not issued a targeted policy on microplastics, and policies in place are mostly from a plastics control perspective, but actually, the introduction of targeted policies can make post-regulation easier. For example, the European Union has introduced a restriction bill on microplastics, which defines the categories of microplastics in detail and gives specific treatment programs, which makes the various departments of the European Union countries deal with the issue of microplastics with clearer thinking and higher efficiency.

4.3.2 Clarifying the responsibilities of each department, and taking action on cross-sectoral collaboration

The problem of microplastics pollution involves a large number of departments, and there are cross-functional phenomena in various departments, it is inevitable that when dealing with the problem, the scope of responsibilities is not clear, which leads to the problem of unresolved pollution control. Therefore, China can learn from Sweden's experience and set up a special department to coordinate the responsibilities of the National Development and Reform Commission, the State Ministry of Ecology and Environment, and other departments, so as to realize cross-sectoral collaboration and cooperation, and ultimately realize the efficient treatment of microplastics environmental management.

4.3.3 Strengthening international exchanges, and forming multi-platform cooperation

As a big country in plastic production and consumption, China should be based on the international vision, actively communicate with various countries, and conduct in-depth discussions on the experience of microplastics prevention and control. What's more, China can also further cooperate with domestic and foreign environmental protection organizations to jointly introduce relevant prevention and control policies, so as to promote the development of microplastics prevention and control.

4.3.4 Increasing the popularization of microplastics knowledge, and enhancing citizens' environmental awareness

We also observed that while there is awareness of the environmental protection of plastics in Chinese society today, there is still a lack of knowledge about specific categories of plastic products such as microplastics. From the introduction of a policy to its implementation, extensive citizen participation is indispensable. Therefore, we hold the view that the Chinese government should also actively introduce appropriate policies to let the relevant publicity departments increase the popularization of microplasticss, so as to deepen citizens' understanding of such pollutants. Eventually, awareness of microplastics prevention will be created throughout Chinese society.

5. Conclusion

While microplasticss have been considered a relatively recent pollutant, due to the widespread use of plastics, normal ecological balance, and human health have suffered from disastrous damage. Policies on microplasticss are, therefore, being developed worldwide. Within such initiatives, China is at the core, as one of the leading manufacturing and consuming nations. This paper undertakes an in-depth analysis of the policies of China concerning microplasticss, comparative analysis with international practices, and infers recommendations for policy development in the future.

Data collected on the economic impact of microplasticss on public health due to respiratory diseases in China yields strong evidence for a correlation between plastic waste and health expenditure. Since specific data concerning microplasticss up in the air is not available, the study used plastic waste as an indicator in the analysis. Key findings of this study showed that plastic wastes are an influencing factor of the increasing respiratory medicines demand, probably owing to the release of airborne microplastics in the course of plastic wastes disposed of through landfills and burning processes.

Three regression models were employed in studying the relationship between plastic waste and healthcare expenditure.

The first model, with plastic waste being the only independent variable, was a very significant model in terms of plastic waste on respiratory medication expenditures. Adding domestic government health expenditures and GDP growth as control variables developed this relationship in subsequent models. But more interestingly, the inclusion of government health expenditure as a control variable increased the predictive power of the model, hence indicating the key role of government intervention in health outcomes.

These results suggest plastic waste, being an origin of airborne microplasticss, represents a crucial economic load to public health in China. However, these findings are needed with caution in drawing any definite conclusion, taking into consideration the shortcomings of the models used, including plastic waste as an indirect variable for microplasticss and possible overfitting. This result indicates an urgent need to cut down on plastic waste and microplasticss in order to alleviate public health costs.

Comparative Policy Analysis While China is acting on ways of tackling microplasticss, it may be behind many Western countries in doing so. On the other side, Western countries started solving this area of emergency long ago. China has indeed taken some steps towards recognizing the menace of microplasticss and laid down preliminary policies, but effective manned combat with microplastics pollution still has a long way to go. Based on the experiences of other countries, such as the United States and Europe, this can be promoted through targeted policy promotion and enhancement in cross-sector collaboration, fostering public awareness that reduces microplastics pollution by a great margin. Considering its size, volume of industrial output, and role in the modern world, anything it does in this respect will help not only its own citizens but also help to mitigate global environmental degradation.

Acknowledgement

The authors express profound gratitude to Professor Antonio Trujillo for his insightful guidance and valuable suggestions on this work. They are also thankful to Teaching Assistant Tong Li for his expert advice on data processing. Additionally, the authors acknowledge the equal contributions of Yixin Zhou, Zhengye Guo, Victoria Xiangyi Woo, Zefan Cheng, and IVAN YU, who are recognized as co-first authors.

References

[1] Cao, Guodong, and Zongwei Cai. «Getting health hazards of inhaled nano/microplastics into focus: Expectations and challenges.» Environmental Science & Technology 57.9 (2023): 3461-3463.

[2] Chen, Shuo, et al. «Gone with the wind? Emissions of neighboring coal-fired power plants and local public health in China.» China Economic Review 69 (2021): 101660.

[3] Cox, Kieran D., et al. «Human consumption of microplastics.» Environmental science & technology 53.12 (2019): 7068-7074.

[4] Li, Yue, et al. «Potential health impact of microplastics: a review of environmental distribution, human exposure, and toxic effects.» Environment & Health 1.4 (2023): 249-257.

[5] Sun, Ying, et al. «China's roadmap to plastic waste management and associated economic costs.» Journal of Environmental Management 309 (2022): 114686.

[6] Zhang, Qingfeng, and Robert Crooks. Toward an environmentally sustainable future: Country environmental analysis of the People's Republic of China. Asian Development Bank, 2012.

[7] Zhu, Xuan, et al. «Airborne microplastic concentrations in five megacities of northern and southeast China.»Environmental science & technology 55.19 (2021): 12871-12881.

[8] Atmospheric microplastics: A review on current status and perspectives Yulan Zhanga,b,⁎ , Shichang Kanga,b,f , Steve Allenc,⁎⁎, Deonie Allenc , Tanguang Gaod , Mika Sillanpääe

ISSN 2959-6149

a State Key Laboratory of Cryospheric Sciences, Northwest Institute of
[9] Zhang Yongjiang, Chen Hongmin, Wu Lijun, etc. Soil microplastic pollution and agricultural safety : sources, impacts and removal [J]. Journal of Guizhou Normal University (Natural Science Edition), 2024,42 (04) : 31-43.DOI : 10.16614 / j.gznuj.zrb.2024.04.004.
[10] Sun Chengjun, Jiang Fenghua, Li Jingxi, et al. Research progress on the source, distribution and ecological environment impact of microplastics in the ocean [J]. Advances in marine science, 2016,34 (04) : 449-461.
[11] HORE M, BHATTACHARYYA S, ROY S, et al. Human Exposure to Dietary Microplastics and Health Risk: A Comprehensive Review[J].
[12] ZHAO B, REHATI P, YANG Z, et al. The potential toxicity of microplastics on human health[J].
[13] Li Y, Chen L, Zhou N, Chen Y, Ling Z, Xiang P. Microplastics in the human body: A comprehensive review of exposure, distribution, migration mechanisms, and toxicity. Sci Total Environ. 2024 Oct 10;946:174215. doi: 10.1016/j.scitotenv.2024.174215. Epub 2024 Jun 22. PMID: 38914339.
[14] Liu, P., Shao, L., Zhang, Y., Silvonen, V., Oswin, H., Cao, Y., ... & Morawska, L. (2024). Atmospheric microplastic deposition associated with GDP and population growth: Insights from megacities in northern China. Journal of Hazardous Materials, 469, 134024
[15] LIM D, JEONG J, SONG K S, et al. Inhalation toxicity of polystyrene micro(nano)plastics using modified OECD TG 412[J/OL]. Chemosphere, 2021: 128330.http://dx.doi.org/10.1016/j.chemosphere.2020.128330.
[16] Zhang Qun. Study on the pollution characteristics of microplastics in air deposition in human settlements [D].East China Normal University, 2022.DOI : 10.27149 / d.cnki.ghdsu.2022.000648.
[17] Wojnowska-Baryła I, Bernat K, Zaborowska M. Plastic waste degradation in landfill conditions: the problem with microplastics, and their direct and indirect environmental effects[J]. International Journal of Environmental Research and Public Health, 2022, 19(20): 13223.
[18] Golwala H, Zhang X, Iskander S M, et al. Solid waste: An overlooked source of microplastics to the environment[J]. Science of the Total Environment, 2021, 769: 144581.
[19] Dey S, Veerendra G T N, Babu P S S A, et al. Degradation of plastics waste and its effects on biological ecosystems: A scientific analysis and comprehensive review[J]. Biomedical Materials & Devices, 2024, 2(1): 70-112.
[20] OECD (2022), Global Plastics Outlook: Economic Drivers, Environmental Impacts and Policy Options, OECD Publishing, Paris, https://doi.org/10.1787/de747aef-en.
[21] Amato-Lourenço L F, dos Santos Galvão L, de Weger L A, et al. An emerging class of air pollutants: potential effects of microplastics to respiratory human health?[J]. Science of the total environment, 2020, 749: 141676.
[22] Dubois P, De Mouzon O, Scott-Morton F, et al. Market size and pharmaceutical innovation[J]. The RAND Journal of Economics, 2015, 46(4): 844-871.
[23] Kim T K, Lane S R. Government health expenditure and public health outcomes: A comparative study among 17 countries and implications for US health care reform[J]. American International Journal of Contemporary Research, 2013, 3(9): 8-13.
[24] Hoffmann J P. Linear regression models: applications in R[M]. Chapman and Hall/CRC, 2021.
[25] Stepovic M. GDP growth and health care expenditures worldwide[J]. The Open Pharmacoeconomics & Health Economics Journal, 2019, 7(1).
[26] Wickham, Hadley, and Jennifer Bryan. R packages. « O'Reilly Media, Inc.», 2023.
[27] Drzyzga O, Prieto A. Plastic waste management, a matter for the 'community'[J]. Microbial biotechnology, 2019, 12(1): 66.
[28] Vattanasit U, Kongpran J, Ikeda A. Airborne microplastics: a narrative review of potential effects on the human respiratory system[J]. Science of The Total Environment, 2023: 166745.
[29] Mensa Sorato M, Davari M, Abdollahi Asl A, et al. Why healthcare market needs government intervention to improve access to essential medicines and healthcare efficiency: a sco** review from pharmaceutical price regulation perspective[J]. Journal of Pharmaceutical Health Services Research, 2020, 11(4): 321-333.
[30] Faisol F, Dwi B S, Arif H. Does The Effectiveness of The Government Expenditure Accelerate Economic Growth?[C]//Proceedings of the 23rd Asian Forum of Business Education (AFBE 2019). Atlantis Press, 2020: 7-14.
[31] LI L, ZHOU X, ZHAO Y, et al. Degree of coordination between primary care resource allocation and economic development in eastern, central and western China[J]. Chinese General Practice, 2021, 24(22): 2777.
[32] Lundbäck B, Rönmark E, Jönsson E, et al. Incidence of physician-diagnosed asthma in adults—a real incidence or a result of increased awareness? Report from the Obstructive Lung Disease in Northern Sweden Studies[J]. Respiratory medicine, 2001, 95(8): 685-692.
[33] Roemer M I. Market failure and health care policy[J]. Journal of Public Health Policy, 1982, 3(4): 419-431.
[34] Liu G, Liu X, Meng Q. Privatization of the medical market in socialist China: A historical approach[J]. Health policy, 1994, 27(2): 157-174.
[35] Zuiderent-Jerak T, van Egmond S. Ineffable cultures or material devices: What valuation studies can learn from the disappearance of ensured solidarity in a health care market[J]. Valuation Studies, 2015, 3(1): 45-73.
[36] Kang Ailin. Environmental impact assessment of plastic pollution control policy in China [D].Shandong University,

2022.DOI : 10.27272 / d.cnki.gshdu.2022.002086.
[37] Wei Zhengzheng, Xiang Yuejiao, Guo Yun, et al. Analysis and Suggestions on Environmental Management Policy of New Pollutants at Home and Abroad [J].Environmental Science Research, 2022,35 (02) : 443-451.DOI : 10.13198 / j.issn.1001-6929.2021.11.17.
[38] Jambeck, J. R. et al. Plastic waste inputs from land into the ocean. Science 347, 768–771 (2015).
[39] Comprehensive List of Environmental Protection (2017 Edition)
[40] ‘ Industrial structure adjustment guidance catalogue (2019 edition) ‘
[41] Catalogue of Prohibited and Restricted Production, Sale and Use of Plastic Products (Draft for Comment)
[42] COMMISSION REGULATION (EU) 2023/2055