Environmental Health Engineering and Management Journal. 2025;12:1461
http://ehemj.com
doi 10.34172/EHEM.1461

Environmental Health Engineering and Management Journal

Original Article

Environmental Health Engineering and Management

Open Access Publish Free

Exploring the microplastics health impacts risk perception in Iranian people: Challenges and improvement strategies

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Abstract

Background: The growing production of plastic and its integration into consumption patterns have raised significant concerns regarding its environmental and health impacts. The presence of microplastics in various environmental contexts and the excessive exposure of individuals pose serious health risks that must be addressed at multiple levels—from national policy-making to individual and family behaviors. Understanding public perception of microplastics is crucial for effective risk management and mitigation. This study aimed to clarify the understanding of microplastic risks to the health of Iranian citizens.

Methods: This study employed a conventional qualitative content analysis approach. Data were collected through purposive sampling via in-depth semi-structured interviews with 29 ordinary citizens and disaster and environmental health professionals. Data collection continued until concept saturation was achieved.

Results: Continuous data analysis revealed four main categories and 23 subcategories: (1) Poor management practices and lack of coordination in public administration, (2) Nature of the phenomenon and health and environmental factors, (3) Weakness in education on risk communication, and (4) Improvement strategies.

Conclusion: Iranian citizens' understanding of the harmful effects of microplastics is linked to effective management of this issue, the nature of environmental impacts, the complexity of health effects, and educational challenges. To mitigate the adverse conditions associated with microplastics, it is essential to enhance public awareness of their dangers, promote alternative consumption patterns, and coordinate efforts across all sectors. Effective environmental management is vital for safeguarding human interests and the rights of future generations, reducing financial and environmental damages, and fostering community participation.

Keywords: Microplastics, Health impact, Risk, Perception, Iran

Citation: Farrokhi M, Khankeh H, Mehralipour J, Shojafard J, Pourvakhshoori N. Exploring the microplastics health impacts risk perception in Iranian people: Challenges and improvement strategies. Environmental Health Engineering and Management Journal. 2025;12:1461. doi: 10.34172/EHEM.1461.

Article History:
Received: 3 November 2024
Revised: 2 December 2024
Accepted: 2 December 2024
ePublished: 3 May 2025

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Introduction

The invention of plastic is regarded as one of humanity's most significant achievements, influencing various aspects of life. Plastic is integral to economic, social, industrial, scientific, and cultural activities, enhancing human life. However, as a synthetic material, plastic does not naturally decompose. Due to its non-biodegradability or slow degradation, nearly all plastics produced since their inception remain in the environment. Plastics gradually break down into microplastics or nanoplastics through crushing and abrasion (1). Microplastics are synthetic, high-molecular-weight compounds micronized into plastic particles smaller than 5 mm. Such materials have a low biodegradation rate and, thus, mostly remain in the environment and adversely affect the human body, the final consumer in the food chain (2). Microplastics can be classified according to their source and fragment size. In general terms, microplastics can be categorized as primary and secondary microplastics. Primary microplastics are intentionally created plastic particles, such as consumer-care products (e.g., detergents and cosmetics) or industrial products. Microplastics are also referred to as

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"microbeads." Currently, microbeads are prohibited for use both domestically in South Korea and internationally. Secondary microplastics are products containing plastics, such as plastic waste and fibers, or plastic products that have decomposed after being exposed to the environment (3). Each year, approximately 400 million tons of plastic waste are added to the environment, taking hundreds of years to decompose. Both nano and microplastic particles result from the breakdown of larger plastics. Consequently, the issue of plastic degradability is often overlooked, with research efforts primarily focused on this area. Plastics transition from large, visible pieces to tiny particles invisible to the naked eye, yet all manufactured plastics persist on the planet, polluting every corner (4). As plastic production expands and becomes embedded in consumption patterns, concerns about its environmental and health effects have intensified. Advances in analytical methods for detecting plastic compounds in low concentrations across various environments—such as water, soil, and air—have also heightened awareness of their health risks (5,6).

In recent decades, the significant side effects of plastic use have become increasingly evident, impacting both the environment and human health (7). Many individuals remain unaware that plastic use is "harmful" to health and can lead to serious consequences. Furthermore, they may not realize that plastic can enter the human body through various pathways, including inhalation, ingestion, and dermal contact. Microplastic and nanoplastic particles have been detected in nearly all human organs, including the lungs, liver, breast milk, bloodstream, testicles, and even the fetus (8). Microplastics can cause inflammation and damage lung tissue, affecting the immune system. They are suspected to contribute to liver failure and cirrhosis and may disrupt hormonal functions (9). Medical knowledge regarding the health effects of microplastics is limited, and significant research on their impacts has been ongoing for several years. Although findings regarding microplastics' effects can be contradictory, they are associated with cancer, hormonal disorders, DNA damage, increased inflammation, weight gain, stroke, and fertility issues. However, many complications remain poorly understood (8).

Given the evidence presented, the presence of microplastics in various environmental sources and excessive human exposure constitutes a significant health risk that must be addressed at multiple levels. Therefore, it is essential to develop policies at both macro and individual levels to reduce environmental pollution and mitigate the health impacts of microplastic contamination. Understanding public perception of microplastics is crucial for managing and reducing their risks in society. This issue has been emphasized in international documents, such as the Sendai Framework, which prioritizes understanding disaster risks to inform disaster risk management policies and activities (10).

Despite the significant progress that has been made in understanding the psychological basis of risk perception, there is still little knowledge on how to apply it to the risk of microplastics, and understanding the risk of microplastics requires an assessment of people's perception of it (11). This understanding has an important intervention role in reducing or stopping the effects of microplastics (11,12). In general, the perception of risk is a cognitive decision-making process in which people make probabilistic judgments about the probability of events and the number of negative outcomes associated with them (13,14). Therefore, for the development of risk reduction policies, the compatibility and application of management strategies and the intended actions regarding microplastics, it is necessary to be aware of the public attitude, beliefs, and perceptions about their risks (15). This study was conducted to clarify the understanding of the risk of microplastics on health in Iranian citizens and extract challenges and solutions to improve it.

Materials and Methods

Design

This qualitative study employed content analysis methodologies to achieve a comprehensive understanding of the health risks associated with microplastics. The conventional qualitative content analysis approach was utilized, which serves as a systematic tool for analyzing spoken, written, or visual messages (16).

Participants

In-depth semi-structured interviews were conducted with 22 general public participants and 7 disaster and environmental health experts, comprising 14 men and 15 women. A purposive sampling method was employed to select participants who were willing and able to discuss the subject matter. To maximize information diversity, a sampling strategy that prioritized maximum variation was implemented (17). Participants who declined to participate at any stage of data collection were excluded from the study. The sampling process continued until data saturation, meaning no new data or codes emerged, and further interviews were deemed unnecessary.

Data collection

Semi-structured in-depth interviews were utilized for this qualitative study. Initially, participants responded to open-ended questions, followed by clarifying inquiries, as shown in Table 1. To adhere to scientific interviewing principles and obtain informed consent, a preliminary questioning guide was prepared. Each interview followed a protocol that included explaining the project title, summarizing the necessity of the project, obtaining permission for the interview with an emphasis on confidentiality, and informing participants of their right to withdraw at any

Table 1. Interview questions to explore Microplastic Health Impacts Risk perceptions

Beginning open-ended questions
What do microplastics mean to you?
Have you had any special experience with the effects of microplastics on your (or others') health?
What are the health effects of microplastics?
Who do you think is most harmed by microplastics?
Clarifying/probing questions
Would you clarify more?
Did I understand your meaning correctly?

stage. The confidentiality of participants was maintained using numerical codes instead of names. Interviews were conducted in locations chosen by participants to ensure their comfort, lasting between 35 and 65 minutes. With participants' permission, interviews were recorded, and field notes were taken as needed (18). The research environment was the natural setting where participants lived and experienced the phenomenon, specifically in Iran.

Data analysis

Data analysis followed the steps proposed by Graneheim and Lundman (19,20). Initially, the content of recorded interviews was transcribed multiple times by researchers to ensure accurate understanding. All interviews and observations were treated as units of analysis. Semantic units, defined as related words, sentences, or paragraphs, were summarized and categorized based on their content. These units were abstracted and conceptualized into codes, which were then compared for similarities and differences, leading to the formation of more abstract categories. Ultimately, the main themes of the study were identified through careful reflection on the data.

Trustworthiness

To ensure the validity, reliability, and acceptability of the qualitative data, a participant review method was employed. Participants were allowed to confirm or correct the data collected, ensuring that the codes accurately represented their perspectives. Guba and Lincoln's four criteria—Credibility, Transferability, Dependability, and Confirmability—were utilized to evaluate the findings (21). The interview texts, along with emerging codes and categories, were reviewed by experienced colleagues to verify the accuracy of data analysis. The research process was meticulously documented to allow for future verification and reliability checks. Transferability was assessed through confirmation from individuals outside the research who shared similar characteristics with participants. Long-term engagement and continuous observation were employed to enhance precision, as the researcher's extensive experience in the field contributed to the study's validity.

Results

Demographic characteristics of the participants

A total of 29 participants were involved in this study, including 22 ordinary citizens and 7 health experts specializing in disasters and environmental issues. The average age of participants was 38.75 years (± 11.29), with ages ranging from 18 to 65 years. Notably, 14 participants had died, and 15 were women, as shown in Table 2.

Main results

Through continuous data analysis and comparison of similarities and differences, we identified four main categories and 23 subcategories: 1) Poor Management Practices and Lack of Coordination in Public Administration, 2) Nature of the Phenomenon and Health and Environmental Factors, 3) Weakness in Education on Risk Communication, and 4) Improvement Strategies, as shown in Table 3. The main categories and their related subcategories are explained in the following sections.

1. Poor management practices and lack of coordination in public administration

One of the primary concerns expressed by participants was the lack of scientific knowledge among officials and managers regarding microplastics and environmental issues. Many participants felt that scientific management principles were not applied, leading to decisions based on personal preferences rather than a logical framework. Additionally, the lack of prioritization of environmental issues and poor coordination among government departments regarding plastic use were significant concerns. This category includes seven subcategories: "Weak scientific accountability and insufficient expertise," "inadequate training and public awareness," "lack of foresight regarding health consequences," "unclear laws and weak enforcement," "poor coordination among responsible bodies," "erosion of public trust in managers," and "weak accountability among managers."

Weak scientific accountability and insufficient expertise

Participants noted a general lack of awareness among managers about their responsibilities in this field. Many participants emphasized that effective management requires comprehensive scientific knowledge and experience. However, it appears that many officials lack the necessary expertise. The risks associated with microplastics are often not perceived as urgent, leading to delayed responses. Participants expressed that environmental health issues are not managed scientifically and are often addressed reactively rather than proactively. One of the participants mentioned in this context:

"To properly respond to an environmental hazard affecting health, such as microplastics, it is necessary to know its causes and factors, and this requires knowledge and experience, and we must have the necessary and

Table 2. Demographic characteristics of participants

Number	The job of the interviewee	Sex	Age (year)
1	University faculty member/environmental specialist	Male	54
2	Physician	Female	43
3	Psychologist	Female	39
4	University staff	Female	48
5	Nurse	Male	42
6	Physiotherapist	Male	36
7	Civil engineer	Male	39
8	University of medical sciences faculty member	Female	47
9	Hospital service worker	Male	34
10	Citizen	Male	27
11	Citizen	Male	22
12	Citizen	Female	19
13	Citizen	Female	58
14	Citizen	Male	18
15	Citizen	Female	65
16	Medical science student	Male	20
17	PhD student (Health in emergencies and disasters)	Male	46
18	PhD student (Health in emergencies and disasters)	Male	39
19	PhD student (Health in emergencies and disasters)	Female	33
20	Environmental health faculty member	Female	38
21	PhD student (Environmental health)	Male	44
22	Bank employee	Female	35
23	Elementary school teacher	Female	38
24	Housekeeper	Female	28
25	Housekeeper	Female	51
26	Housekeeper	Female	44
27	Psychologist	Male	42
28	PhD student (Health in emergencies and disasters)	Male	42
29	University employee	Female	33

relevant expertise in this field."

Inadequate training and public awareness

Effective public response to environmental health issues relies on proper education. Participants stressed that education should be systematic, scientifically based, and tailored to community needs. One participant remarked,

"The effects of such risks are long-term, similar to the education process itself; results may take years to manifest."

Lack of foresight regarding health consequences

Understanding the future health impacts of microplastics requires a deep comprehension of the issue. Experts indicated that there is a lack of proactive measures to address these health risks, despite awareness of their necessity. One participant stated:

"If these issues are not managed now, their destructive consequences will emerge later, which may be too late."

Unclear laws and weak enforcement

The existence of clear legal frameworks is essential for effective action. Participants noted that many laws regarding environmental changes are either unclear or not enforced, resulting in a lack of accountability. One participant commented:

"Without specific frameworks, the health effects of microplastics are overlooked, and we fail to understand their impact."

Poor coordination among responsible bodies

Effective environmental management requires collaboration among various organizations. Participants highlighted that without coordination, efforts to address the health effects of microplastics are often duplicated or ineffective. One participant noted:

"In dealing with health effects from microplastics, we see either a lack of action or multiple organizations working in parallel without achieving results."

Erosion of public trust in managers

Many participants expressed a loss of faith in the systems designed to protect the environment, citing repeated failures and poor management. One participant remarked:

"The Environmental Protection Organization should lead environmental issues, but its performance continues to decline."

Weak accountability among managers

Participants emphasized the need for responsible leadership to promote organizational success. One participant stated:

"Many managers prioritize personal interests over public welfare, leading to a lack of accountability."

2. Nature of the phenomenon, health, and environmental factors

The research revealed that the health effects of microplastics are complex and often overlooked. This category includes five subcategories: "Complex nature of microplastics' health effects," "ignorance of microplastics

Table 3. The Categories, sub-categories, and codes extracted from the data

No.	Categories	Sub-categories	Example code
1	Poor management practices and lack of coordination in public administration	Weak scientific accountability and insufficient expertise	In line with these non-scientific thoughts, as a result of non-scientific measures, work is prioritized, and eventually, instead of optimally solving the created problems, we will see more damage and destruction.
		Inadequate training and public awareness	The essence of such risks, which will leave their effects in the long term, is like the education process itself, that is, you will see the results in 20 years. But if you want to buy a chair, you will see the results right away. Maybe this is why a manager who is in charge of an organization cares more about the chair than training.
		Lack of foresight regarding health consequences	These cases are mostly administrative and if they are not managed now, their destructive results will be seen later, which is too late.
		Unclear laws and weak enforcement	Since there are no specific frameworks related to environmental changes, and if there are, it is not a priority, the health effects of microplastics are not paid attention to, and ultimately, we will not understand its effects.
		Poor coordination among responsible bodies	In the field of the health effects of microplastics, like other critical issues in our country, there is a lot of work and parallel work in it, or nothing is done, or several organizations are involved, and in the end, the work does not reach a result.
		Erosion of public trust in managers	Do you see this Environmental Protection Organization? This organization should be a demanding organization and be at the top of all environmental issues, but in reality, it is not, and every day its performance is worse than the previous day. Unfortunately, with every manager who comes, the situation continues as it is, so we cannot expect a positive change from this organization.
		Weak accountability among managers	They just want to hold a position, and they do not have any commitment to their duties, they do whatever they want, and they do not feel responsible for their duties.
2	Nature of the phenomenon, health, and environmental factors	Complex nature of the health effects of microplastics	You cannot tell people what the plastic materials they use might have on their health, any more than you can tell them what a catastrophe will happen when the temperature of the planet changes by 3 degrees. Most people do not. They do not understand. Even the academic community does not understand
		Ignorance of microplastics and their consequences	Honestly, I do not know what microplastics are, but there must be a connection between them and environmental pollution. Again, I am not sure if they cause disease or not, why have I not heard about this anywhere before? Not. It is not that dangerous and it is just a possibility, I do not know what to say.
		Weak community-based environmental management	No organization alone can apply this level of management. People should be brought into the field of action by educating people, and in this way, the environment can be improved with community-oriented management. People should feel responsible. And it is the responsibility of the environmental officials to prepare the preparations for this work.
		Changing consumption/utility patterns	Where do all these plastics that we encounter in our daily lives go? What percentage of them are recycled? Of course, these must harm the environment somewhere. Should we not use plastic bags and use envelopes like in the old days? Where are those envelopes? And what happens to these bags?
		Fragile health	Microplastics with their effects on water, air, or food sources can cause an increase in gastrointestinal or infectious diseases, and with the increase in cases of hospitalization due to allergic reactions in the form of asthma attacks and other respiratory diseases, they can affect health.
3	Weakness in education on risk communication	Inappropriate reactions and distrust in national media	Unfortunately, stubbornness happens when people do not trust the officials. I have experienced and seen that when an official talks about this matter, people happen to do the opposite because they have no trust in that official. They do not have. The reality is that, unfortunately, there is no special trust on the part of the people in the authorities and those who give these recommendations.
		Lack of emphasis on health effects	Our television prioritizes domestic and foreign crises wherever it benefits it, and looks at everything superficially wherever it does not benefit it.
		Ineffective public education	In the discussion of behavior change, there are many theories, such as the theory of planned behavior. Due to the complexity of behaviors, people's behavior cannot be changed simply by providing training. Before behavior change, the intention to change behavior must occur. If you want to create an intention, you must first make the person's attitude positive towards the new behavior, so to create a behavioral change in any field, you must act on a theory, just by talking on national television. There will be no change in behavior.
		Ineffectiveness of national media in conveying microplastics concepts	The health effects caused by microplastics are very slow and take so much time that even we experts do not realize it, let alone radio and television and ordinary people who often do not pay attention to such issues and do not know at all that they are caused by, on the other hand, maybe radio and television advertising is not effective because it uses a stereotyped method and lacks innovation.
4	Improvement strategies	Increasing public awareness	The government can only prevent the health effects of microplastics with the help of the people. People should understand that this danger affects everyone and everything, and people should be educated about these issues.
		Enhancing media's role in education	We see everything on TV and the news, so if they come and do all the advertising and training on TV and radio, anyway, people will see and slowly come forward and their cooperation will increase, and we can hope. Finally, the problem will be solved.
		Promoting responsible consumption	The discussion of culture is very important, with education and information, we can revive that sense of trust and sense of responsibility in people, and we can do many things.
		Comprehensive cooperation among stakeholders	The only way to overcome the health effects of microplastics is through coordination at all levels and the participation of the government and people. This is the only way.
		Encouraging community-based initiatives	Community-oriented discussion means that you can involve the mass of society in all processes of health risk management, including plan design, preparedness, response, monitoring, and reconstruction. When the mass of society participates in planning, it is natural to commit to fulfilling it. Therefore, the whole community-oriented program includes educating the community itself, the elders, and the people of that community and making the program created by them.
		Holistic management approaches	Even in the field of the environment, many people believe that you should leave the environment to society, for example, if a person does not know what effect the use of microplastics will have on his health and that of his family, he will not change his behavior. So until the actions are based on the society and the society does not understand its value and does not make its own decisions, no effort will be successful.
		Developing legal frameworks for plastic use	Other social factors are also involved. When there is no mental social pressure, force and social deterrence may be needed. For example, applying heavy fines. Because a large percentage of people understand this kind of pressure, mental pressure may be understood. Do not do it.

and their consequences," "weak community-based environmental management," "changing consumption patterns," and "fragile health."

Complex nature of the health effects of microplastics

The health impacts of microplastics are not immediately visible, and their long-term effects can take decades to manifest. One participant noted:

"It is challenging to convey the potential health risks of plastic materials to the public."

Ignorance of microplastics and their consequences

Many participants were unaware of microplastics and their health implications. Some confuse microplastics with macroplastics or other forms of pollution. One participant stated:

"I do not know what microplastics are, but I assume they relate to environmental pollution."

Weak community-based environmental management

Participants indicated that effective environmental management requires community involvement. One contributor stated:

"No organization can manage this issue alone; community engagement is essential."

Changing consumption/utility patterns

Participants expressed concern over the pervasive use of plastics in daily life and the challenges of adopting healthier consumption patterns. One participant asked:

"What happens to all the plastics we encounter daily?"

Fragile health

Participants believed that microplastics could lead to various health issues, including gastrointestinal and respiratory problems. One contributor noted:

"Microplastics can increase the risk of diseases and hospitalizations due to allergic reactions."

3. Weakness in education on risk communication

Education and information dissemination are crucial for effective public response. Participants criticized national media for failing to provide accurate health information. This category includes four subcategories: "Inappropriate reactions and distrust in national media," "lack of emphasis on health effects," "ineffective public education," and "ineffectiveness of national media in conveying microplastics concepts."

Inappropriate reactions and distrust in national media

Participants noted that public trust in national media has diminished due to past failures to address critical issues effectively. One participant stated:

"People often disregard official recommendations due to a lack of trust."

Lack of emphasis on health effects

Participants felt that national media often prioritize sensational stories over critical health issues. One contributor remarked:

"Our media focuses on crises that serve its interests, neglecting important health topics."

Ineffective public education

General public education efforts have been ineffective, as many people do not engage in training until they perceive a need. One participant stated:

"Behavior change requires more than just training; it necessitates a shift in attitude."

Ineffectiveness of national media in conveying microplastics concepts

Participants highlighted the need for structured educational programs to effectively communicate the health risks associated with microplastics. One contributor noted:

"The slow onset of health effects makes it difficult for the public to recognize their significance."

4. Improvement strategies

The final main category identified in this study is "Improvement Strategies." Effective management of the health effects of microplastics requires comprehensive planning and coordination across various sectors. This category includes seven subcategories: "Increasing public awareness," "enhancing media's role in education," "promoting responsible consumption," "comprehensive cooperation among stakeholders," "encouraging community-based initiatives," "holistic management approaches," and "developing legal frameworks for plastic use."

Increasing public awareness

To mitigate the health effects of microplastics, community awareness must be enhanced. Participants suggested using films and animations as effective educational tools. One participant stated:

"The government can only address the health effects of microplastics with community support."

Enhancing media's role in education

Participants emphasized the media's critical role in shaping public understanding of health issues related to microplastics. With declining trust in traditional media, many turn to online sources, which can lead to misinformation. One participant mentioned:

"We see everything on TV and news, so if they come and do all the advertising and training on TV and radio, anyway, people will see and slowly come forward, and their cooperation will increase, and we can hope. Finally, the problem will be solved."

Promoting responsible consumption

Creating a culture of responsibility regarding consumption is essential. Participants noted that government behavior sets an example for society. One participant remarked:

"Education and information can foster a sense of responsibility among the public."

Comprehensive cooperation among stakeholders

Effective management of microplastics requires collaboration among government, NGOs, and the public. One participant stated:

"Coordination at all levels is essential to address the health effects of microplastics."

Encouraging community-based initiatives

Community involvement is crucial for managing health risks. One participant noted:

"Engaging the community in health risk management fosters commitment to the initiatives."

Holistic management approaches

A comprehensive approach is necessary to address the multifaceted challenges posed by microplastics. One participant stated:

"Sustainable development must align with community values and needs."

Developing legal frameworks for plastic use

Participants stressed the need for clear legal requirements regarding plastic use. One contributor noted:

"Without social pressure, legal enforcement may be necessary to drive change."

Discussion

This study was conducted to clarify the understanding of the risks posed by microplastics to the health of Iranian citizens. Based on the findings, four main categories were identified, along with 23 subcategories: 1) Poor management practices and lack of coordination in public administration, 2) nature of the phenomenon, health, and environmental factors, 3) weakness in education on risk communication, and 4) improvement strategies. each category will be discussed further.

Category 1: Poor management practices and lack of coordination in public administration

One of the primary concerns articulated by participants in the study was the erratic and inadequately grounded management of environmental and health-related issues. It is well-established that knowledge and awareness are critical indicators that empower local managers during times of crisis. When confronted with urgent challenges, these managers often experience confusion and exhibit passive responses, primarily due to a deficiency in their understanding of effective crisis management strategies (22). This imperative for enhanced knowledge is underscored in several international frameworks, notably Japan's Hyogo Framework for Action. Within the second statement of the 2005 international protocol document, prominent gaps and challenges in the domains of crisis risk reduction and management are delineated into five cardinal areas, one of which distinctly emphasizes knowledge-based disaster management that prioritizes the transformation of pre-accident knowledge (22,23). Participants in the research conducted by Janzik et al highlighted that their nation had taken significant and transparent actions to address the pervasive issue of microplastics, indicating the pivotal role that scientific management plays in mitigating environmental threats (24). In a similar vein, Garcia-Vazquez and Garcia-Ael articulated the urgent necessity for enhanced scientific communication regarding the emerging risks associated with microplastics (25). Furthermore, a variety of studies have indicated that numerous managers remain largely uninformed of the extensive ramifications posed by environmental changes and harbor uncertainties regarding their responsibilities in planning and adapting to these evolving challenges (26,27). Moreover, the existence of robust executive laws is crucial for the effective management of environmental concerns (28). Henderson and Green identified the roles played by scientific communication, non-governmental organizations, industry stakeholders, and policy frameworks as integral components in alleviating the detrimental impacts of microplastics. They emphasized the necessity for managers to account for media representations and the broader cultural context concerning plastic use in society (29). A study conducted in Iran illuminated that the current state of crisis management knowledge among local managers is marked by a lack of structured frameworks, and the absence of regular training further exacerbates this shortcoming (22). This deficiency can erode public trust in governmental authorities. Participants also voiced apprehensions regarding the lack of comprehensive environmental management legislation within the nation. The scant existing laws are frequently inadequately enforced, and pertinent officials often evade accountability, resulting in insufficient prioritization within executive and management frameworks (30). Environmental crises, when compounded by inadequate planning mechanisms, can lead to substantial resource depletion and enduring negative consequences. Effective policymaking, judicious resource allocation, comprehensive scenario preparation, and the operationalization of intervention measures before, during, and after crises are essential responsibilities that fall upon governmental entities. Comparisons of crisis management approaches across different countries reveal significant variations in developmental trajectories and disaster management planning. Countries with advanced infrastructures frequently adopt balanced

strategies throughout all stages of disaster management, with decentralized planning processes that promote citizen participation and ensure alignment of planning initiatives with the realities of societal needs. Such approaches ultimately serve to diminish vulnerability to disasters (31).

Category 2: The nature of the phenomenon, health, and environmental factors

A critical theme that emerged from the study is "The Nature of the Phenomenon, Health, and Environmental Factors." The findings suggest that the health impacts associated with microplastics are often perceived differently than those attributed to other environmental hazards, frequently remaining undetected or underestimated. When individuals do notice alterations in their environment, they tend to ascribe these changes primarily to climatic or meteorological fluctuations. Supporting literature indicates that, in the face of uncertainty, individuals often extrapolate their understanding of macroplastics to microplastics, leveraging concepts such as accumulation and dose-response relationships to conceptualize the issue at hand. Participants acknowledged the intricate interconnectedness between human health and environmental factors but frequently expressed a sense of helplessness regarding the formulation of viable solutions (24). Research conducted by Kramm et al demonstrated that a significant portion of the population perceives the risks posed by microplastics to both environmental integrity and human health as substantial (32). Conversely, Catarino et al highlighted that while exposure to microplastics is undeniable, the majority of existing studies point to minimal detrimental effects on biota, and comprehensive risk assessments regarding human health are conspicuously lacking. Nonetheless, there remains a prevailing sentiment that microplastics represent a serious threat, propelling political action and advocacy (33). Raab and Bogner explored the multifaceted mechanisms that link microplastics to adverse health outcomes, with many respondents attributing the origins of microplastics primarily to household plastic consumption (34). Henderson and Green found that while general public awareness of microplastics is limited, environmentally conscious individuals have encountered the term "microbeads" through media discourse. However, the majority of the populace fails to make connections between their personal plastic use and the broader issue of ocean pollution (29). Deng and colleagues' research found that only 26% of surveyed individuals possessed prior knowledge of microplastics, yet a significant 75% expressed heightened concern upon learning about the potential health risks associated with them (35). Furthermore, findings from Utari et al revealed a statistically significant correlation between knowledge levels and practices related to plastic waste management, indicating that individuals with limited knowledge are more likely to demonstrate suboptimal waste management behaviors (36). Therefore, initiatives aimed at enhancing awareness and education regarding the health implications of microplastics are both urgent and necessary (37).

Category 3: Weakness in education on risk communication

The third predominant theme identified is "Weakness in Education on Risk Communication." An overwhelming number of participants voiced their dissatisfaction with national media coverage concerning environmental issues, expressing a notable lack of trust in these sources. Participants reported that they obtained more substantial information from alternative media outlets, especially social networks, indicating a discernible shift in the sources of influence. Nonetheless, the efficacy of official media in risk communication remains essential (38,39). The World Health Organization (WHO) delineates five key strategies for effective risk communication: building trust, disseminating early announcements, ensuring transparency, validating public concerns, and planning for both current and anticipated issues. Effective risk communication is characterized by dynamic interactions wherein information is exchanged regarding risk management (40). Research has shown that public reactions to health threats encompass a diverse range of emotional, cognitive, and behavioral responses (41,42). Thus, the establishment of trust between health professionals and the public is paramount during crises; the absence of such trust can lead to public health messages being disregarded. Fostering trust necessitates clear communication, accountability, and transparency (43). In the contemporary information age, the concealment of news is nearly impossible; thus, health experts must proactively engage with the public to mitigate the spread of misinformation. Additionally, addressing public concerns and planning for ongoing issues is vital to achieving effective communication outcomes (13,44). Media engagement poses inherent challenges, as the objectives of media organizations may not always align with public health aims. However, social media platforms can emerge as valuable tools for disseminating critical health messages (45,46).

Category 4: Improvement strategies

The final theme identified is "Improvement Strategies." Participants acknowledged the profound impact of microplastics on the environment across the nation, particularly in certain regions where the effects are markedly severe. This acknowledgment necessitates the implementation of proactive measures to effectively address the crisis. Sustainable development hinges on community awareness and engagement to prevent

detrimental actions (25). Creating this awareness involves fostering social commitments that require foundational efforts within society (47). Effective training initiatives, particularly geared towards younger demographics, can be enhanced through the use of engaging content such as animations. Media institutions should prioritize the dissemination of information on environmental issues to inform the public better. Increasing public knowledge, advocating for accountability from authorities, and countering misinformation represent essential responsibilities of the media (48). The media plays a pivotal role in shaping public opinion and influencing attitudes regarding environmental issues; therefore, their engagement is critical in promoting responsible behaviors and delivering targeted educational initiatives (49). Given the widespread health implications of environmental issues in Iran, extensive collaboration must occur between government entities and citizens. Cultivating a culture of responsibility necessitates cooperation among relevant organizations, with coordinated efforts from media and educational institutions that prioritize community engagement and uphold legal frameworks (49,50). In the context of developing countries, achieving sustainable development remains a principal concern. Contemporary development paradigms must encompass elements of security, social participation, environmental justice, and human rights. Initiatives must be tailored to the distinctive conditions and challenges faced by each nation. Regrettably, numerous programs that are labeled as development often fail to effectuate meaningful progress. The United Nations Development Program endeavors to tackle environmental challenges in Iran by fostering synergistic partnerships across government, civil society, and the private sector (51).

The participants' inherent busyness, impatience, and varying emotional states presented notable limitations to the study. To mitigate these challenges, the researcher prioritized scheduling appointments in advance and conducting interviews at times and locations that were convenient for the participants. However, the researcher's absence from all interactions meant that the opportunity to observe participants' activities and individual behaviors firsthand was limited, which may have affected the richness of the data collected.

To enhance future research on this critical topic, several areas for exploration are recommended:

- Investigating the perception of microplastic risk across diverse geographical and cultural contexts within the country. This approach would provide a nuanced understanding of how local factors influence perceptions and responses to microplastics.
- Analyzing the short-term and long-term economic implications of microplastic pollution specific to various geographical regions. Such an assessment could inform policymakers and stakeholders about the economic fallout from this environmental crisis and guide resource allocation.
- Conducting studies on the short-term and long-term health impacts of microplastics, particularly as they pertain to specific geographical areas. This line of inquiry would deepen our understanding of the potential health risks associated with microplastic exposure.
- Exploring the development of environmentally sustainable infrastructure upgrades within affected regions. This research could identify pathways for mitigation and adaptation, fostering resilience in communities impacted by microplastic pollution.

By addressing these recommendations, future research can contribute to a more comprehensive understanding of microplastics and their multifaceted implications for health, the economy, and the environment.

Conclusion

Microplastics have emerged as a widespread and pressing environmental pollutant, igniting increasing concerns regarding their potential health implications. Despite the growing awareness of these risks, our understanding remains insufficient when compared to the perceived gravity of the situation. The media plays a pivotal role in shaping public consciousness about environmental issues, yet the influence of national media appears to be diminishing, which may hinder the effective dissemination of information regarding microplastics.

The adverse effects of microplastics on both human health and the environment underscore the urgent need for decisive action. In light of this, effective environmental management becomes essential not only for safeguarding the rights of future generations but also for minimizing financial and ecological repercussions. Governance must establish a clear relationship between enhancing the economic well-being of citizens and the reduction of plastic consumption.

Furthermore, by integrating sustainable development goals into national strategies, we can better address and mitigate various environmental risks, including those associated with microplastics. This holistic approach will not only contribute to a healthier environment but also promote long-term sustainability and resilience within our communities. As we move forward, fostering collaborative efforts among governments, media, and the public will be vital in tackling the challenges posed by microplastics and ensuring a safer, healthier future for all.

Acknowledgments

This research was supported by the University of Social Welfare and Rehabilitation Sciences (Grant Number 3248). The authors would like to thank all participants for their collaboration in this research.

Authors' contributions

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Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical issues

This study received approval from the Ethics Committee of Tehran University of Rehabilitation Sciences and Social Health (Ethical code: IR.USWR.REC.1403.142). Interviews and data collection adhered to the established protocol, with written informed consent obtained from all participants. Participants' confidentiality was maintained through coding, and they were informed of their right to withdraw from the study at any time without explanation.

Funding

This research was supported by funding from the University of Social Welfare and Rehabilitation Sciences.

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