This is the accepted version of the article https://doi.org/10.1016/j.spc.2021.07.032

The invisible enemy. Public knowledge of microplastics is needed to face the current microplastic crisis

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Abstract

Microplastics are emerging pollutants that threaten marine resources globally today. Being difficult to see for the human eye, their public perception and risk perception depend upon the information given to citizens. Since the psychosocial theory postulates the importance of knowledge, attitude, and perceived control to undertake pro-environmental behaviors, in this review we have analyzed relevant literature in order to look for solutions of psychosocial nature to stop microplastic emissions. We employed qualitative contingency statistics and clustering analysis of relevant terms. The consumer's knowledge about microplastics was central and directly connected with the willingness to adopt a pro-environmental behavior, while risk perception and perceived control were less important. Significant geographical gaps and differences between cultures were identified. Based on our analyses, the following measures are recommended: 1) Create baselines of knowledge about microplastics to design ad-hoc interventions for their control; 2) Explore the role of environmental values as mediators between knowledge and behavior against microplastics; 3) Enlarge the geographical scope of present studies, at least to include African countries; 4) Undertake intercultural studies to determine the scale of interventions for public awareness about the problem; 5) Study the perspective of the industry, politicians and journalists; 6) Improve scientific communication about this new threat; 7) Introduce the topic in formal and non-formal education settings.

Key words: Global microplastic crisis; Psychosocial perspective; Knowledge; Risk perception; Collective and individual actors; Intercultural differences.

1. Introduction

Today, the planet is in the middle of what has been called the microplastic crisis. The term, employed by scientists (Katsnelson, 2015) and politicians, describes the raise of huge amounts of small plastic particles that are part of the planet habitat in the Anthropocene era. Microplastics are typically particles smaller than 5 mm that can either be directly produced of this size (primary microplastics) or be a consequence of the degradation of larger plastics (secondary microplastics) (see Figure 1). Primary microplastics are micro- or nanobeads that are added to many products employed for personal care (e.g., whitening toothpaste, face and body scrubs) and for industrial use

(e.g., abrasive cleaning treatments). A great proportion of the secondary microplastics consists of fibers generated while doing laundry, because many washing machines do not retain microfibers efficiently (Andrady, 2011; Law & Thompson, 2014). Microplastics are especially abundant near big urban settlements, in estuaries and around river mouths –because rivers collect and transport plastics and microplastics from all basins downstream (Lebreton et al., 2017). Although the great majority of microplastic sources are in land (Rochman, 2018), the ultimate fate of plastics and microplastics is the ocean (Thompson et al., 2004). Some secondary microplastics may appear in situ by breakage of plastic litter due to sun radiation and the physical action of waves and currents (Efimova et al., 2018). They also come from land (Wagner & Lambert, 2017), as wastewater treatment plants cannot capture 100% of the microplastics because of their small size. After entering the ocean, microplastics become part of the beaches' sand, are suspended in the water column, get eaten by marine animals, are deposited on the algae, or form a part of the sediments in the deepest abyssal plains (Woodall et al., 2014; Auta, Emenike, & Fauziah, 2017). Because of the oceans' role as microplastic sinks, marine microplastics were researched first, although there is a recent expansion of research in microplastics in land and in freshwater, where the problem is just as important (Rochman, 2018).

The microplastic crisis is intertwined with other global problems like climate change (Shen et al., 2020), through greenhouse gas emissions along the life cycle of plastics and microplastics (Hu et al., 2019). Another global problem that may accelerate due to microplastics is biodiversity decline, because plastic particles cause harm to organisms all across the trophic web, from plankton to top predators (e.g., de Sá et al., 2018). Likewise, microplastics are a global concern for human health too. The prolonged ingestion of microplastics via diet, not well known yet, is thought to enhance inflammatory responses and disrupt the gut microbiome (Smith et al., 2018). The accumulation of microplastics acquired via breath is suspected to produce lung cancer (Prata, 2018), and, accompanying toxic molecules that cause chemical and biochemical damage, they can have adverse neurological effects (Campanale et al., 2020). Looking for solutions is urgent because, even if the studies are still scarce and the global impact of microplastics in the planet has not yet been accurately estimated (Hale et al., 2020), by precautionary approach we should stop their emissions now before the amount is so high that the damage is irreparable.

The environmental threat represented by microplastics has promoted reactions at international and national level. The industry of plastics and allied associations created the *Global Plastic Alliance* aiming at a better global management of plastics (Marine Litter Solutions, 2019). The United Nations (UN) have, literally, declared war on ocean plastics (UN, 2017), and clean oceans to sustain marine resources is one of the UN Sustainable Development Goals, specifically SDG 14, "Life below water" (UN, 2021). There are international campaigns addressed to companies to urge them to redesign the use and disposal of plastic, like the WWF initiative *ReSource,* launched in 2020 (https://resource-plastic.com/; accessed February 2021). After the first international conference on microplastics in Lanzarote (Spain) in 2016, the *Lanzarote Declaration* (SAM, 2018) has been followed by country efforts to reduce microplastic emissions, including bans to cleaning products containing microplastics. They are today being considered at EU level, although their implementation seems to be difficult under current international rules of the World Trade Organization (Kentin & Kaarto, 2018). Da Costa et al. (2020) point at many norms, regulations, laws, and recommendations proposed and implemented in the last years to mitigate

(micro)plastics in the environment, principally based on levies or bans, although for these authors the real benefits of these norms are still to be proven. In this subject governance seems to follow a top-down strategy, with companies and politicians starting changes without a wide demand from the society. Da Costa et al. (2020) concluded that, beyond regulations, consumers have to adjust their behaviors, and, together with manufacturers, adhere to a culture of reduction, reuse, and recycle.

The problem is global, and changing consumer behavior worldwide is not an easy task. Knowing factors leading to the direct or indirect emission of microplastics is the first step on the way to find solutions to stop such behaviors. The general objective of this study was to identify key psychosocial and sociodemographic aspects involved, and propose solutions accordingly.

2. Literature review

Psychosocial approaches are needed for the adoption of pro-environmental behaviors, especially regarding the specific problem of the invisible, overlooked microplastics. We will describe the theoretical frameworks employed so far in the next paragraphs.

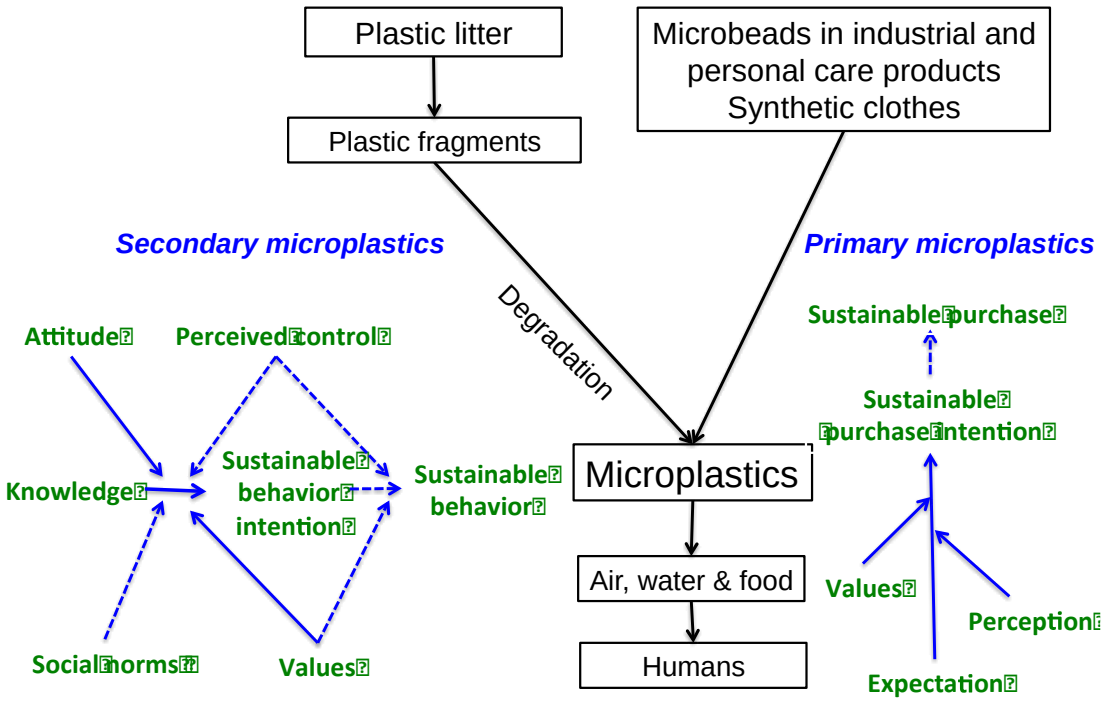
The difference between primary and secondary microplastics is not trivial because the actions required to prevent and mitigate pollution are essentially different. The ultimate cause of the release of primary microplastics in the environment is the consumption of products with such microplastics, while the causes of secondary microplastics are related with failures to apply R-imperatives in plastic consumption and waste behavior. These 10R options, initiated by consumers and companies, prevent waste, and retain value through the entire life cycle of a product (plastic in this case): Refuse (to buy), Reduce, Reuse/Resell, Repair, Refurbish, Re-manufacture, Re-purpose (or Rethink = find a new use of old components), Recycle, Recover, Re-mine (Reike, Vermeulen, & Witjes, 2018). In other words, primary microplastics could be prevented by just not consuming products that contain them. In contrast, secondary microplastics are much more complex because the sources are varied, as the uses and disposal of plastic are in current societies.

As for other subjects in environmental and health psychology, the main theoretical framework that could be applied in pro-environmental consumption and waste behavior is the Theory of Reasoned Action (Ajzen & Fishbein, 1980) and its further development as the Theory of Planned Behavior (Ajzen & Madden, 1986; Ajzen, 1991; Ajzen, 2002). Individual behavioral intention is determined by subjective norms – the individual thinks it is acceptable by their referents; by attitude – the individual is favorable to that behavior; and by the perceived control – the individual thinks they can do it (visual summary in Figure 1 on the left). Perceived behavioral control also influences the actual behavior, not only the intention to behave. This theory has been widely applied in studies of recycling behavior (Tonglet, Phillips, & Read, 2004; Sun et al., 2017). It is likely applicable to behaviors against microplastic emissions as well. Although this research field is very new, the influence of attitude and behavioral control on the intention to purchase clothes that do not emit microfibers has already been proven in the USA (Nam, Dong, & Lee, 2017).

In the Value-Belief-Norm theory, pro-environmental behavior (or behavior intention) is predicted from values, awareness of consequences, ascription of responsibility, and personal norms (Stern, 2000; Chen, 2015). Environmental knowledge itself does not induce pro-environmental behavior (Kollnuss & Agyeman,

2002); however, it will do depending on social norms, feelings of guilt, and attitude (Mohiuddin et al., 2018). These authors extended the Theory of Planned Behavior adding values as a variable that affects consumer behavior (Figure 1), in emerging countries like Malaysia, where, although knowing the importance of using green vehicles, the effect of subjective norms may not be significant for their actual use (Mohiuddin et al., 2018). In other words, consumers may have the knowledge, but if they do not have the values, they will not buy green products. Henderson and Green (2020) found similar gaps in the fields of plastic consumption and its potential contribution to microplastic emissions: although people were aware of plastic pollution (not so much about microplastics), plastic consumption was valued as positive for hygienic issues, thus that behavior was not changed.

Figure 1. Schematic representation of the route of primary and secondary microplastics (black arrows), and psychosocial frameworks related with their control (blue arrows). Broken arrows are relations proposed in psychosocial models still to be proven in the field of microplastics.



Regarding sustainable consumption, the relationship between expectation and perception is a key determinant of the final consumer's behavior. Individuals compare their expectation with their perception of a product and if the expectation is met, they will purchase the product. Tsioutsou (2006) found that perceiving the quality of a product and its adequacy to consumer's values – the environmental quality in the case of sustainable products- increases consumer's satisfaction and also the probability of purchasing the product (Figure 1 on the right). This theory could be applied to the consumption of products to control microplastic emissions; Herweyers et al. (2020) found that Belgians would buy devices to retain microfibers in washing machines only if they are really effective.

Deng et al. (2020) identified some research gaps about the psychosocial aspects involved in microplastic emissions –or their control: principally the relation between the knowledge of the impacts of microplastics, public attitudes towards this emerging pollutant, and pro-environmental behavior. Our study aimed at exploring these gaps through the analysis of current literature. From the characteristics of microplastics and the theoretical frameworks above, our expectations (departure hypotheses) were:

i. Knowledge of the impacts of microplastics will be determinant to adopt a pro-environmental behavior, like supporting plastic restrictions or stop buying products with microplastics;
ii.

iii. Perception and knowledge of microplastics will depend on external information sources, due to the invisibility of microplastics;
iv. The environmental values of the people aware of the problem will be important to change the behavior about both primary and secondary microplastics.

3. Methods

The methodology followed in this study will be described next, starting with the protocol of literature review, the criteria employed to select an article for review, the source of data consulted, how the search was done, the quality filters applied (inclusion and exclusion criteria), the process of data collection from the selected articles, and how the data were organized. Finally, we consider the risk of bias in the individual studies selected and describe the data analysis.

3.1. *Protocol*

A systematic literature search was conducted following PRISMA methodology (Preferred Reporting Items for Systematic reviews and Meta-Analyses; Moher et al., 2009), with minor modifications for the novelty and social impact of the topic.

3.2. *Eligibility criteria*

The bibliographic search aimed to identify key literature where psychosocial aspects of the global microplastic crisis are addressed. Geographical or temporal limits were not set. Language limits were not employed, but the search was done using only English words so that most articles retrieved were in English. The search was done in January 2021, ending on the 31st.

3.3. Data source

Database selection can have a large effect on conclusions from reviews, especially in interdisciplinary topics, thus following the recommendation of Harari, Parola, Hartwell and Riegeman (2020), we have explored databases with different level of specificity: Psychology, PsycINFO; Social Sciences, ERIC and Social Sciences Citation Index; interdisciplinary, Google Scholar, PubMed, ScienceDirect. They were supplemented with manual searches for references (forward search) and references of other reviews (backward search).

3.4. *Search*

Search terms were: Microplastics, microfibers, microbeads, the abbreviation MP (because it is frequently employed in specific literature about microplastics), marine litter, litter, plastic; psychology, psychosocial, interventions, plastic, theory of planned behavior, knowledge, perception, social norms, risk; review, perspectives, meta-analysis, focus, research. The terms “microplastics” and “psychology” were employed simultaneously in all searches. Considering the enormous volume of recent articles about microplastics published in environmental sciences, we tried to follow a conservative search strategy in order to exclude information limited to the environmental point of view. For this, the Boolean terms used in search were: “AND”, between at least one microplastic-related and one psychology-related terms, to retrieve relevant references; “OR” of “AND/OR”, when multiple terms referred to any of the two main topics (microplastics and/or psychology) were employed together in the same search.

3.5. *Study selection*

Strict quality filters for eligibility were chosen, because the novelty and potential implications of microplastics for human and environmental health attracts an enormous interest of media, environmentalist NGOs, plastic lobby and companies, and conscious citizens. However, as commented above, the scientific support of many articles and press releases is unclear. For this reason, we have retained only peer-reviewed articles and studies, or reports issued by authoritative institutions and organizations of international relevance such as UN, UNESCO, FAO, and Academies. Employing the criteria described above, a total of 994 articles were retrieved. All articles complying with the selection criteria were selected. These criteria were the following:

i) Academic peer reviewed article.
ii) Participant characteristics: filters for age, gender, or occupation were not set. The sample could be comprised of individuals of any gender and age (adults and/or children).
iii) Admissible study designs: qualitative, correlational, experimental, as well as reviews and perspectives.
iv) For full quantitative analysis: articles with new original data.
v) Construct being researched: any psychosocial trait.
vi) Time range: no limits were set, but the issue of microplastics is relatively recent and studies before 2000 are not expected.

Exclusion criteria (in addition to a failure to comply with the inclusion criteria outlined above) were:

i) Articles published in conference communication format.
ii) Books where peer-review was not stated.
iii) Unpublished theses and dissertations.
iv) Articles published in popular science magazines.
v) Articles published in media and social media.

3.6. Data collection process

A form was designed to enable the data from the studies included in the systematic review to be extracted, summarized, presented, and critically evaluated. This form was organized in spreadsheet format. The following data were collected from each eligible article:

i) Digital object identifier (DOI).
ii) Internet link where the article can be found.
iii) Authors.
iv) Year.
v) Journal.
vi) Title.
vii) Country/ies.
viii) Sample size (or sizes if there were several studies in the same article).

ix) Gender ratio (proportion of females).

x) Age (range and/or mean with standard deviation).

xi) Scope (national, international, local).

xii) Study design.

xiii) Instruments.

xiv) Variables.

xv) Raw data (link to them if available in a repository).

xvi) Summary of results (one to three sentences).

xvii) Summary of conclusions (one-two sentences).

xviii) Key words.

xix) Abstract.

3.7. Data list

Once the articles complying with the established eligibility criteria were selected, a coding manual was designed, along with a protocol for registering the characteristics of each study. The aim was to guarantee that the coding process is transparent and replicable. An ad hoc scale was compiled in accordance with Rubio-Aparicio et al.'s recommendations (Rubio-Aparicio, Sánchez-Meca, Marín-Martínez, & López-López, 2018), organized in three general categories:

A. Methodological variables: these refer to the type of design used and the research methods applied during the studies, the quality of the measures obtained, and the procedures followed for the data analysis. This category contained the following variables:

A.1. Type of microplastics in the study framework (1: primary; 2: secondary; 3: any type).

A.1. Sample size.

A.2. Assessment instrument used to evaluate the variables (measures used e.g., willingness to pay; too diverse for simple coding, thus one or a few descriptive words were used, with no codification).

A.3. Dimensions or variables included in the assessment instrument (1: knowledge; 2: perceived efficiency/control; 3: awareness; 4: attitude; 5: concern; 6: engagement; 7: risk perception; 9: pro-environmental behavior).

A.4. Design used (1: qualitative; 2: quasi-experimental; 3: correlational; 4: experimental).

A.5. Data collection (1: online or by convention mail or telephone; 2: at the workplace or in the interviewees' homes; 3: in public spaces).

B. Substantive variables: sociodemographic characteristics of the sample and characteristics of the treatment, as well as to the research context. This category included the following criteria:

B.1. Age of the sample.

B.2. Percentage of women.

B.3. Target population sector/s (e.g., general public, university or school students, fashion industry, environmentalists/environmental workers; too diverse for simple coding, which was described using one or a few words).

B.4. Education background (e.g., main formation discipline, educational level – when too diverse for simple coding, descriptive word/s were employed).

B.5. Characteristics of the specific tool/s employed in the treatment (1: brochure/information in writing; 2: oral information; 3: hands-on activities to visualize microplastics).

C. Extrinsic variables, referred to those characteristics which have nothing to do with the object of study, but which may be associated with the results. Those included:

C.1. Year of article publication.

C.2. Country or countries where the study was carried out.

3.8. Risk of bias in individual studies

Bias risk assessment was not carried out for the studies included in the review, since the issue has been scarcely studied to date and the number of available studies was small.

3.9. Data analysis

The main foci of research were explored using two different approaches. First, we compared keywords of review papers and articles with new data (eligible papers retained for analysis of qualitative variables) using a categorical classification and contingency statistics, to have a general view of the current state of the art in this novel discipline. Keywords were extracted from the list of keywords in each article and classified in five categories: Actors (individuals, collectives), Goods (affected by microplastics), Pollutants (microplastics, microfibers, litter, nanoplastics), Solutions (explored, proposed, or sought) and Understanding (perception, knowledge, awareness, risk perception). Two minimum occurrences of a term in the whole dataset were considered, not to overweigh very specific singletons (keywords used only once). Comparison of the keyword categories between the two types of papers was done using Fisher's exact test and Cramer's V to estimate the effect size. SPSS © version 26 was employed.

Second, we did a thorough quantitative analysis of the articles containing original data: a cluster analysis of key terms, following Klingerhöfer et al. (2020). With this analysis we intended to identify the main psychosocial variables, solutions, and the relationships between them. Since the number of articles with new data was small, we have here employed the keywords, the titles, and the abstracts to enrich the number of eligible terms. The free software VOSwiever version 1.6.15 (van Eck & Waltman, 2010) was employed to create a network-based map. When keywords, titles, and abstracts were included we used the following settings: binary counting; thresholds of 4 minimum occurrences of a term and the 60% most relevant terms selected. Common methodological terms like item, program, study, or subject/participant were eliminated from the selected list of terms.

4. Results

A descriptive analysis of reviews and articles reporting new data on psychosocial issues directly related with microplastics was done addressing different aspects like the geographical and temporal coverage, and the main topics covered by each type of article. Then articles with new data were analyzed based on the microplastic type (primary or secondary microplastics), the methodology (observational or experimental, qualitative or quantitative), and especially the

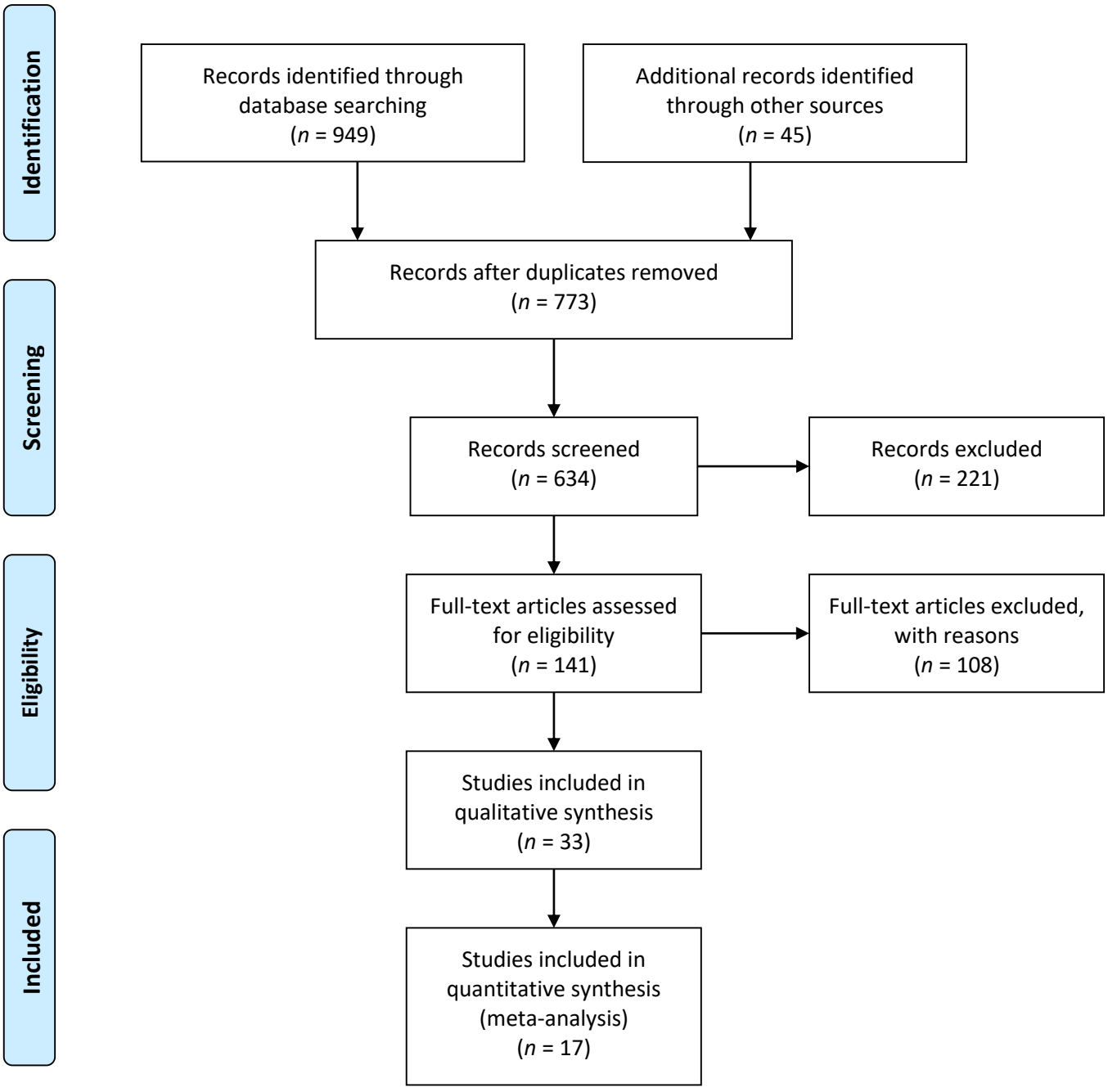
psychosocial variables considered. Dependent, independent, and mediator/moderator variables were identified. Relevant terms and links between them were analyzed to test departure hypotheses quantitatively.

4.1. *Article selection: Analysis of specific issues related with microplastics*

The number of results found in the literature search using the strategy described above (994) was disproportionately large in comparison with the scarce number of articles containing real information about microplastics and psychology at the same time, only 33 (3.3%), see Figure 2. Other 108 articles (10.8%) discarded in the phase of eligibility (Figure 2), contained information of psychosocial nature (perception, knowledge, behavior…) related with plastics, trash, and marine litter. In these articles, as in others discarded in previous steps, microplastics were just mentioned in the introduction or discussion as a potential product or consequence of degradation of bigger litter objects, or even as an environmental threat, but were not specifically treated in the study. For the nature of the secondary microplastics, which are derived from previous litter, it is obvious that all the behavior related with litter will be indirectly related with microplastics, preventing or promoting their load in the environment and food. However, for the easier perception and visibility of the impacts caused, the psychosocial determinants involved in pro-environmental behavior related with general trash and plastics are not expected to be the same as those involved in invisible microplastics. For this reason, in our study we have not analyzed thoroughly those 108 papers (18 reviews and 90 articles with new research data) indirectly related with microplastics that are outside the focus of this review.

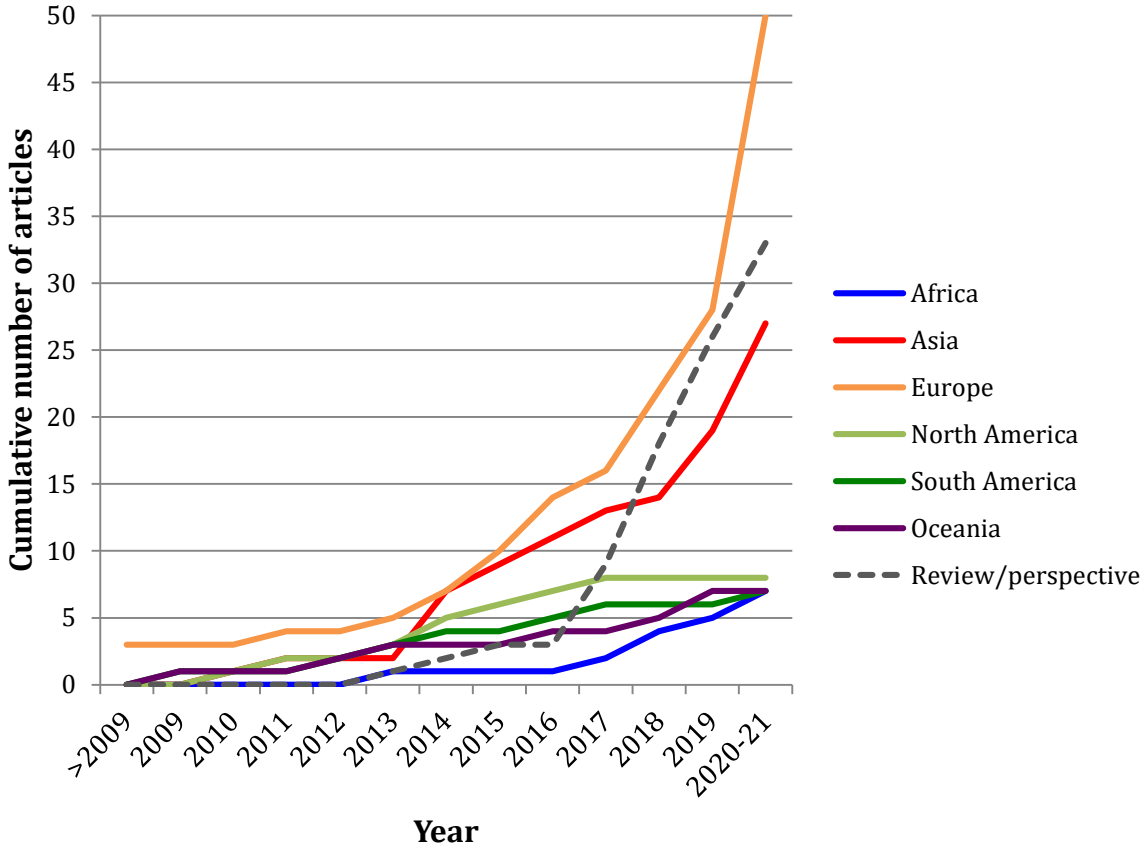
Of the articles retained as eligible for qualitative or quantitative analysis containing psychosocial issues related with microplastics, almost one half were reviews or perspectives (16 articles; references listed in Annex 1). Only 17 (51.5% of the 33 eligible articles) contained new data of diverse nature. These were considered for full quantitative analysis (Figure 2).

Figure 2. Flow diagram summarizing the number of retained and discarded articles in different steps, following Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group (2009).



The majority of articles assessed for eligibility (N = 141), related directly (33) or indirectly (108) with microplastics, had a very unbalanced geographical coverage (Figure 3): most studies were carried out in Europe, followed by Asia and the reviews, then the rest of continents at a distance. The studies focused on Africa were clearly fewer and started growing the latest of all the continents, after 2017.

Figure 3. Regional context of research on psychosocial determinants involved in marine microplastics crisis. Cumulative number of articles fully assessed in this review by continent.



The studies with original research data addressing the subject of psychosocial determinants of microplastic pollution are very few to date (Figure 2). All of them have been published since 2015, with a noticeable concentration in the last year. Although this review was done in January of 2021, there were already two articles with new data (11.8%) published in 2021. The number of participants was larger in studies conducted since 2019 (see Table 1), demonstrating the increasing importance of this research field.

The 17 articles with new data were published in 13 journals mainly of environmental governance and health scope (Table 1). Two journals published more than one article: *Marine Pollution Bulletin* (5) and *Sustainability* (2). Regarding the geographical context (Table 1), the majority has been conducted in Europe (11 studies, 6797 participants), followed by Asia (three studies, 1282 participants in total) and North America (three studies: two summing 717 participants and one using tweets

from the social network site Twitter as data source). Peer-reviewed studies from Africa or Oceania were not found.

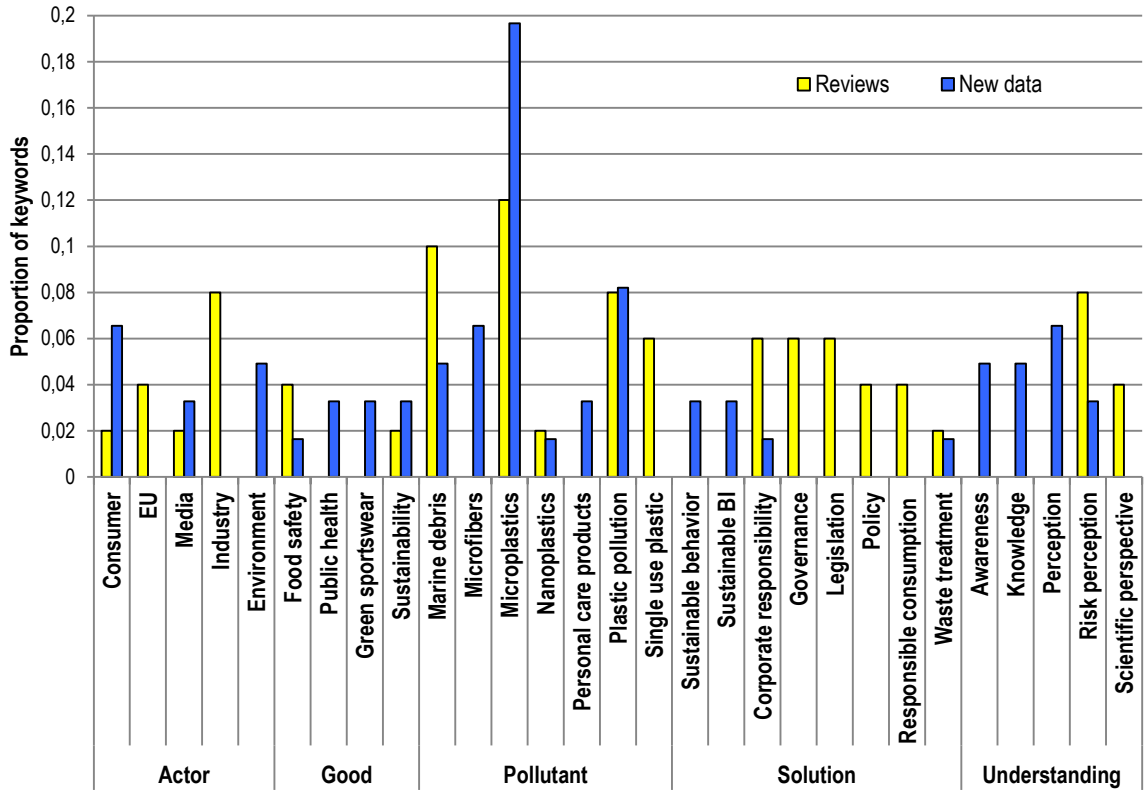
4.2. Study characteristics: Psychosocial issues specifically involved in the microplastic crisis

The analysis of the keywords of the 33 articles that specifically referred to microplastics evidenced that psychosocial research was done with different foci in review/perspective articles and in articles with new data (Figure 4). Considering wide categories of keywords, the two types of studies were significantly different (Fisher's exact test with $p = .04$, moderate Cramer's $V = 0.28$), Pollutants being the category with more keywords in both types (38% and 44.2% in reviews and new data papers respectively), followed by Solutions (28%) in reviews, and Understanding (19.7%) in articles with new data.

Considering all the keywords separately, the difference was highly significant ($p < .001$ with relatively strong Cramer's $V = 0.57$). Actors were principally industry (corporations) and large collectives as the EU in the reviews, in contrast with the most frequent keyword of this category in articles with new data: individual consumers (Figure 4). A big difference was the type of solutions highlighted. Corporate social responsibility, legislation, and governance were keywords more employed in reviews/perspectives, while sustainable individual behavior and behavioral intention were keywords more frequent in articles with new data (see Figure 4). The category Understanding was very different too. While reviews focused on the perception of risk posed by microplastics followed by scientific perspective, new data focused on individual knowledge, perception of microplastics, and awareness instead.

Summarizing this comparison between the two types of articles, current research is measuring the individual perception and knowledge of these small particles. However, authors thinking on prospective application of psychosocial tools to mitigate the current microplastic crisis are more focused on global solutions pushed by the perceived risk and science.

Figure 4. Use of keywords in reviews and perspectives (*n* = 50 keywords) versus articles with original data (*n* = 61 keywords). Results are presented as the frequency of each keyword in each category of papers. BI, behavioral intention.



4.3. Theoretical frameworks, methodology, and psychosocial variables

From this point on we will analyze in depth only the articles with new data, which will serve to test our expectations. Regarding the theoretical framework, or the rationale that supports the study from grounded psychosocial theories (Table 1), only a few studies identified by name classic theories like the Theory of Planned Behavior (Ajzen, 1991), in Nam et al. (2017); and the Value-Belief-Norm (Stern, 2000; Chen, 2015), in Jeong, Yoon, and Chon (2021). In most articles, the scientific rationale was introduced straightforward citing studies where the same psychosocial or sociological variables had been applied, without specific references to a consolidated theory that was however implicit. The majority of studies (11 out of 17) referred to the importance of knowledge and/or awareness for sustainable behavior, while Abate et al. (2020), Deng et al. (2020), and Yan et al. (2020) highlighted the role of attitude in such behavior. Anderson et al. (2016) and Janouskova et al. (2020) departed from values and beliefs. The rationales of Didegah, Mejlgaard and Sørensen (2018) and Henderson and Green (2020) were based on how media or social media shape the public knowledge about this invisible environmental threat.

Although not so often mentioned in the keyword list (Figure 4), the psychosocial variable most frequently studied (Table 1) was knowledge about microplastics (Chang, 2015; Cammalleri et al., 2020; Deng et al., 2020; Henderson & Green, 2020; Herweyers et al., 2020, and many others). Other variables were

awareness of their impacts, risk perception as a more specific awareness of environmental or health threats caused by microplastics, concern, and intention to behave against microplastics (Table 1). In the latter are included the willingness to change consumption habits and willingness to pay for actions, microplastic-free products, or devices for microplastics or microfibers mitigation. A few studies included moderator or mediator variables like perceived control or efficiency, feeling of guilt, and social responsibility. We have retained one research article where the variable analyzed was not psychosocial but related with the communication and outreach of scientific knowledge about microplastics (Didegah et al., 2018). Didegah et al. (2018) analyzed tweets from different Twitter users about scientific topics. Although it is far from psychosocial variables, communication explains the public knowledge in this topic. This article adds *social media* as a source of information, related with other articles that show media as main public information sources. As shown in those articles, public risk perception will depend on how the sources transmit scientific knowledge.

From the methodological perspective, there was an overwhelming number of observational (versus experimental) studies (Table 1). Only three could be considered experimental interventions. Chang (2015) informed USA university students about the content of primary microplastics in cleanser products and measured post-intervention intention to refuse the consumption of those products. Cammalleri et al. (2020), working with Italian university students, used a brochure informing about microplastics as intervention and measured knowledge and awareness pre- and post-intervention. Raab and Bogner (2020) designed an educational module to make microplastics visible and tested it in a sample of 450 German primary education students aged 9-10.

The main results of the analyzed articles revealed important implications of psychosocial variables in pro-environmental behavior about microplastics. The few experimental studies examined would support the applicability of the Theory of Reasoned Action (Ajzen & Fishbein, 1980), where knowledge is fundamental to change behavior (or at least behavioral intention), thus our departure hypothesis i). Students informed about the presence of microplastics in cleansing products refused to use them again (Chang, 2015). With their educational module, Raab and Bogner (2020) demonstrated a gain of knowledge about microplastics and increased awareness of daily actions that can be done to reduce microplastic pollution, while a simple informative brochure was enough to increase awareness in university students (Cammellieri et al., 2020) (Table 1).

Other observational studies went in the same direction: individuals better informed and more concerned about microplastics would pay more for cleaning the environment (Abate et al., 2020), for a device to filter microfibers (Herweyers et al., 2020), or intend to reduce microplastic emissions (Deng et al., 2020) and to buy sustainable clothes (Yan et al., 2020). In contrast, unaware individuals would provide little support to cleaning campaigns (Choi & Lee, 2018).

539 Table 1. Summary of articles with new research data analyzed in this study. Type of microplastics: P, primary; S, secondary. Gender: % of
540 females. WTP, willingness to pay. MP, microplastics; MPF, microplastic fibers; NP, nanoplastics. BI, behavior intention. SD in parenthesis. NA,
541 not available.

Reference	Country	MP type	N	Gender	Age	Subjects	Study	Rationale	Main variables	Relevant results
Abate et al. (2020)	Norway	S	1804	49	44 (17.2)	Online survey	Quantitative	Knowledge & attitude determine behavior	Concern, perceived efficiency, WTP	Concerned respondants and those believing in the effect of proposed measures: >WTP. Males less concerned but, for the same concern, willing to pay more.
Anderson et al. (2016)	England	P	22	90.9	16 - >55	Three focus groups	Qualitative	Beliefs & values determine awareness	Awareness, attitude	Only aware participants support MP reduction for unnecessary and unnatural. Public outreach needed to phase out microbeads
Cammalleri et al. (2020)	Italy	S	151	59.6	22.5 (6.16)	University students	Quantitative, quasi-experimental	Knowledge & awareness determine behavior	Knowledge, awareness	Main info source Internet. Awareness increased significantly after information in less formed/specialized students
Chang (2015)	USA	P	175	-	-	University students	Quantitative, quasi-experimental	Knowledge & awareness determine behavior	Knowledge, awareness, intention to change consumption	Majority of consumers unaware of MP in products; after information, refused to consume the product again
Choi & Lee (2018)	Korea	Any	400	47	43 (8.9)	Households	Quantitative	Awareness determines behavior intention	Awareness, WTP	Low perception of MP and of MP risk. WTP for cleaning the ocean, only 50% interviewees
Deng et al. (2020)	China	S	437	45.3	18-60	General public	Quantitative	Perception & attitude determine behavior	Knowledge, concern, Intention to reduce MP emissions	Knowledge but not concern increases intention. Females & environmental workers stronger intention.
Didegah et al. (2018)	Canada Denmark	Any	-	-	-	Social networks	Quantitative	Twitter a vehicle for engagement	Tweet consultation & dissemination	Twitter as important source to communicate knowledge about MP; undigested dissemination of scientific facts
Henderson & Green	UK	S	42	66.7	20-77	Six focus groups	Qualitative	Media shape MP discourse & public	Knowledge, awareness,	MP information from media. Barriers to change: undetectable scale, poor

(2020)								awareness	engagement against MP	understanding of science, cultural ideas about plastic. Disconnection plastics use - distant ocean pollution.
Herweyers et al. (2020)	Belgium	S	638	69	Adults all ages	Two online surveys	Quantitative	Environmental knowledge influences buying behavior	Knowledge, awareness, WTP for devices against MPF	Despite little MPF awareness, intention to buy preventive device. Mediators: price & perceived environmental benefits. Awareness younger>older.
Janouskova et al. (2020)	Czech Republic	Any	384	NA	NA	University students	Quantitative	Knowledge, awareness & values determine behavior	Knowledge, awareness	Knowledge from mass media; little awareness; significantly lower awareness in humanity students
Jeong et al. (2021)	Korea	Any	445	48.8	20-69	Online survey	Quantitative	Value-Belief-Norm theory	Knowledge, risk perception, proenvironmental BI; social responsibility, feelings of guilt	Risk perception affects pro-environmental behaviour, influenced by knowledge. Guilty & social responsibility mediators.
Misund et al. (2020)	Germany Norway Portugal	Both	3018	50	19 - 74	Online survey	Quantitative	Knowledge determines purchasing decisions mediated by price and environmental values	WTP for MP-free products, demographics	MP-free products preferred but will not pay more for them. Cultural differences: WTP Portugal>Germany>Norway.
Nam et al. (2017)	USA	S	542	53	18-74	Online survey	Quantitative	Theory of Planned Behaviour + expectation & perception	Intention to purchase green clothes, expectation, perception, attitude	Subjective norm & perception affect attitude, perceived control & intention to purchase. Attitude mediates between perception, expectations & purchase intention. Perceived control doesn't affect attitude and purchase intention, contrary to expectations
Ojinnaka & Aw (2020)	UK	Both	72	68.1	25-54	Ethnic minorities	Focus group	Awareness enhances support to plastic reduction	Knowledge, awareness, WTP	Control support & WTP despite low knowledge. Education & social group associated with awareness. Main information: media. Awareness: MP>NP, environmental>food threats.
Raab & Bogner (2020)	Germany	Any	450	-	9-10	Children	Quantitative, quasi-experimental	Knowledge enhance motivation & responsibility	Knowledge, awareness, engagement	Making MP visible through an education module students gain knowledge & awareness and propose actions to reduce MP

Soares et al. (2021)	Portugal	Both	428	70,8	18-69	Online survey	Quantitative	Awareness, perception, environmental concern & motivation predict pro-environmental behavior	Knowledge, awareness pro-environmental behaviour	Knowledge, perceived impacts & awareness increase pro-environmental behaviour. Pro-environmental behaviour older > younger
Yan et al. (2020)	UK	S	15	53.3	21 - >40	Fashion industry	Qualitative	Knowledge determines attitude and purchasing behavior	Knowledge, awareness of MFP impacts	Unawareness caused by MFP invisibility

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4.4. Information Sources and Awareness

Departure hypothesis ii) was the dependence on external information sources for knowing about microplastics, since being very small their direct observation is uncommon in normal life. The role of media was highlighted in the analyzed studies. The Internet was the main information source about microplastics in the study of Cammelleri et al. (2020), as was mass media in Henderson and Green (2020), Janouskova et al. (2020), and Ojinnaka and Aw (2020). Articles about microplastics were amongst the most re-tweeted and commented, but the scientific facts described in the articles were disseminated undigested (Didegah et al., 2018), revealing an inadequate outreach of scientific knowledge about this topic.

On the other hand, poor understanding of science was identified as a barrier to change behavior about microplastics in the study of Henderson and Green (2020). Studies worldwide emphasize the fact that there is little public awareness about microplastics (Chang, 2015, in USA; Choi & Lee, 2018, in Korea; Janouskova et al., 2020, in the Czech Republic; Anderson et al., 2016, and Yan et al., 2020, in the UK). All of them mentioned the invisibility of these pollutants as one of the main causes, indirectly supporting our departure hypothesis ii).

4.4. Environmental Values

As expected in the departure hypothesis iii), environmental values are decisive to reduce the consumption of products containing microplastics (Anderson et al., 2016), and to purchase green clothes (Nam et al., 2017). However, the perceived control that is key in the Theory of Planned Behavior was not significant in the study of Nam et al. (2017), contrary to the expectations of Ajzen (2002).

Another important factor found in these studies was the concern about microplastics and their perceived risks. The perceived impacts, together with knowledge and awareness, determined pro-environmental attitudes in the study of Soares et al. (2021) in Portugal; however, concern did not increase significantly pro-environmental behavior intention in the study of Deng et al. (2020) in China.

Risk perception was also key in pro-environmental behavior intention in Korea, mediated by guilt and social responsibility (Jeong et al., 2021). Indeed, the relation between expectations and perception (Tsioutsou, 2006) has been also important in purchase decisions about green microplastic-free products (Nam et al., 2017).

4.5. Sociodemographic Variables

The demographic variables considered in the studies here examined were age and gender; the main socioeconomic variables were the education background and the family income. The sociodemographic variables showed different effects on the variables examined depending on the particular study. In the few studies reporting an effect of the gender, females seemed to be more sensitive about this environmental problem than males; for example, females declared stronger intention to reduce microplastic emissions in China (Deng et al., 2020), and would pay more to remove microplastics from Arctic waters (Abate et al., 2020), although in this particular study the effect disappeared and even took the opposite direction, males willing to pay more, after controlling concern (Abate et al., 2020). For the factor age, older Portuguese people would have more pro-environmental behavior than the young, regarding the control of microplastic emissions (Soares et al., 2021), while younger Belgians would be more aware about the specific problem of microfibers (secondary microplastics

derived from clothes) than older ones (Herweyers et al., 2020).

In contrast with the variables gender and age, that have different effect depending on the study, the educational background was consistently related with pro-environmental behavior and awareness about microplastics, individuals with higher education level and environmental background being more sensitive to this issue in different cultures, from the Czech Republic (Janouskova et al., 2020) to China (Deng et al., 2020) to ethnic minorities in the UK (Ojinnaka & Aw, 2020).

4.6. Differences between European countries

The cross-cultural aspect has been little investigated in studies about microplastics, but it is likely very important. In countries like Portugal, where trust in the institutions is not very high, individuals would pay more for microplastic-free products than in countries where individuals have higher political trust, like Germany or Norway (Misund et al., 2020). Private (versus public) governance and certification labels to facilitate individual purchase decisions would be more effective in countries with low political trust (Misund et al., 2020).

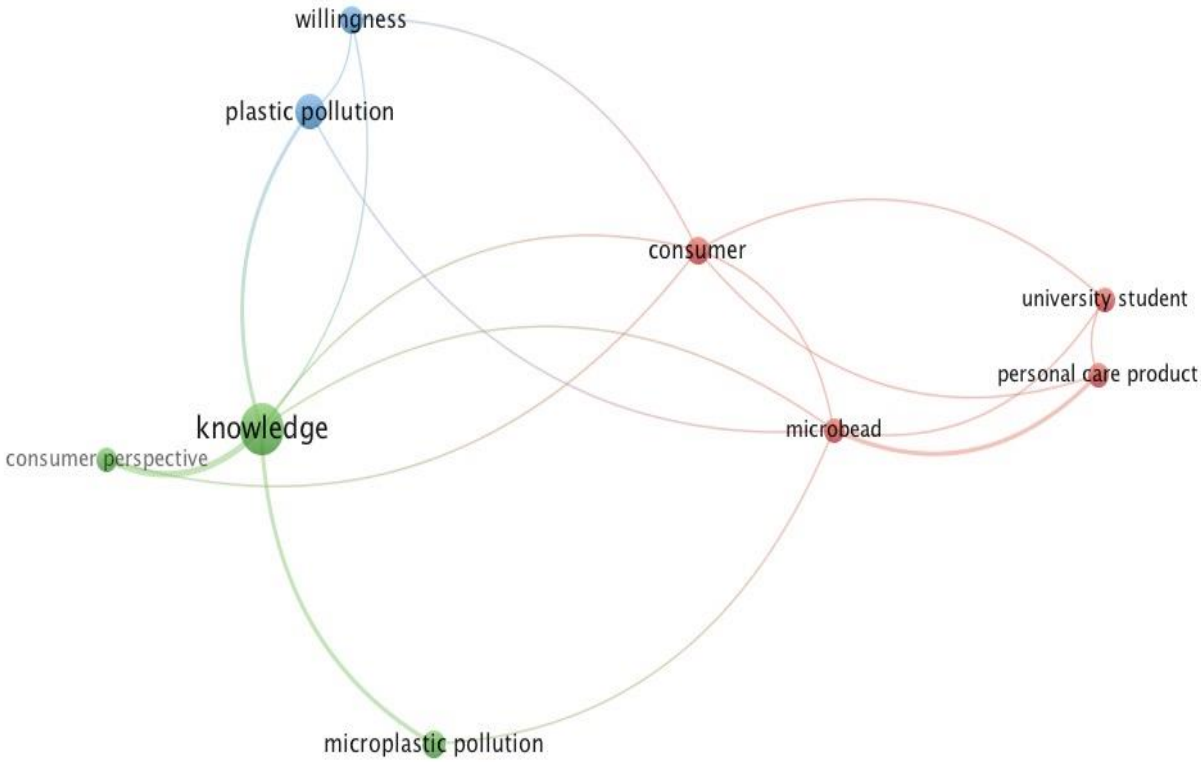
The importance of knowledge seems to be different depending on the culture. UK ethnic minorities would economically support the control of microplastic emissions even if they do not know much about the issue (Ojinnaka & Aw, 2020), and little aware Belgians would buy devices to control microfiber emissions (Herweyers et al., 2020), in clear contrast with informed German and Norwegian consumers that would prefer microplastic-free products but would not pay more for them (Misund et al., 2020).

4.8. Clustering analysis of relevant terms

Knowledge was the central and most frequently used word in the analysis of relevant terms (Figure 5). In the map created from terms employed in the title, abstract, and key words of research articles with original data (Figure 5), knowledge had the highest weight and was clustered with microplastic pollution and consumer's perspective (Cluster 1, green), and directly connected with willingness – to pay or to change behavior. Plastic pollution clustered in Cluster 2 (blue) together with willingness, while in Cluster 3 (red) microbeads were together with university students (the main subjects in experimental studies), consumers, and personal care products. Unlike what was seen in the reviews in the previous analysis, here awareness was not retained as an important term; instead, knowledge– that comes before awareness in the development of pro-environmental behavior– was the main subject of new psychosocial investigations.

The network map of Figure 5 reflects a high weight of consumers and individuals too. It could be read as "*Knowledge of microplastic pollution determines the consumer's perspective about the use of microbeads and their willingness to stop plastic pollution; at least several collectives, like university students, will change their use of personal care products to reduce microbeads*". These results would support the departure hypothesis i), with not much information about hypothesis ii) and iii).

Figure 5. Network map created from research articles with original data using VOSviewer software. Titles, keywords, and abstracts were employed to extract significant terms.



5. Discussion

When we started this review, we expected that studies would demonstrate: i) the effect of knowledge about microplastics and their risks for stopping pollution behaviors; ii) the dependence on external sources for microplastics perception; and iii) the importance of environmental values to adopt behaviors that cut microplastic emissions. Expectation i) i.e. the relationship between the knowledge of consumers about microplastic pollution and their willingness to stop plastic pollution (or pay for controlling it) was fully confirmed from our meta-analysis. Knowledge was central in the papers analyzed quantitatively, and linked directly to willingness - to pay or to change behavior. This main research gap identified by Deng et al. (2020) would be solved from our study.

Expectation ii) was not directly confirmed from the quantitative analysis because perception or knowledge sources did not appear amongst the relevant terms of articles with new data. Knowledge sources appeared in the list of keywords in both reviews and articles with original research data, but they were secondary and not the

main research focus. This is an important novelty of our study, and it emphasizes a research gap in science communication that is essential to understand the little public knowledge there is about microplastics.

Regarding Expectation iii), indeed environmental values were frequently tackled in articles with original data (not so much in reviews); however, terms related with values were not retained as relevant in the quantitative analysis, highlighting another research gap.

From our results, we have identified some psychosocial aspects that should be taken into account to properly design and implement interventions for pro-environmental behavior about microplastics. We will discuss the relevant findings next.

5.1. Psychosocial frameworks to promote sustainable behavior towards microplastics

One of the first observations in the handle of articles reviewed is the scope of the journals where they are published, that are not specialized in the field of Psychology. Perhaps for the enormous importance and potential impact of the current microplastics crisis, psychosocial implications are being published in journals of a quite generalist scope that interest a wide audience and stakeholders. As authors repeat in the examined studies, this subject is still in its infancy (e.g., Pahl & Wyles, 2017). According to this, the theoretical frameworks that support the psychosocial studies, although solid, are not developed much nor discussed in the articles reviewed. They may be different in primary and secondary microplastics. Behaviors to control the emission of primary microplastics would rely on the purchase of products with microbeads; theories of sustainable consumption are to be applied in this case (Figure 1, framework on the right). Meanwhile, general pro-environmental behaviors are needed to control secondary microplastic emissions, from acquiring plastic-free products to reducing and disposing waste adequately (Figure 1, framework on the left). We have seen in our review, often without naming them, the Theory of Reasoned Action (Ajzen & Fishbein, 1980) and the Theory of Planned Behavior (Ajzen, 1991, 2002), as well as Value-Belief-Norm theory (Stern, 2000; Chen, 2015) and the theory of Perception-Expectation (Tsioutsou, 2006) regarding purchase decisions. These are solid foundations and will be likely used in further studies of the global microplastic crisis.

Supporting the Theory of Planned Behavior in pro-environmental behavior, Tonglet, Phillips and Read (2004) found a significant effect of the attitude, perceived control, and social norms on the intention to recycle in Brixworth, UK, with the concern and previous recycling experience being significant predictors of actual recycling behavior. The theory has been applied in other cultures too, like in China, where attitude, perceived norms, and subjective norms significantly influence the use of plastic bags (Sun et al., 2017). However, we have seen in our study that some aspects of the Theory of Planned Behavior, like the perceived control or subjective norms, could not be verified (Nam et al., 2017), as indicated in Figure 1 with broken arrows. Perhaps the perception, attitude, and environmental values are enough to determine pro-environmental behavior about microplastics in some cases.

The importance of knowledge, that is key in the Theory of Planned Behavior, is undeniable from our results. However, the subject of microplastics is a difficult one from the psychosocial perspective for two main reasons. One is that being barely visible to the naked eye, their perception depends principally on the information

received from external sources. A microscope is needed to see them, and, when we see them, we change our behavior to stop their production (Lim, 2021). This aspect was remarked as one of the main barriers to behavior change regarding microplastics (Henderson & Green, 2020).

Another difficulty resides on the insufficient number of objective data about the environmental and health risks they pose. As commented in the introduction, the effects of microplastics are accumulative, thus adverse consequences will likely be detected mid- or long-term. Moreover, both primary and secondary microplastics are originated far from the sites where they will accumulate (the ocean). Thus, there is a real spatial and temporal distance between the production of microplastics and their effects. This lack of evident, rapid association between cause and effect adds to the difficult perception of the real microplastics nuisance, as highlighted by Henderson and Green (2020). Such psychological distance has to be taken into account when targeting potential psychosocial mechanisms that could be used in microplastics management.

All together, these difficulties may explain the subtle mismatch found in our study between review studies and those creating new data. Studies with new data were clearly focused on the knowledge of consumers about microplastics, being review papers more focused on awareness and risk perception. The two latter depend on knowledge, which is not easy in the case of microplastics, as we have seen (e.g., Lim, 2021), so it is research priority in new studies. One of the main recommendations derived from our study is the need of creating baselines of microplastic knowledge, to identify main knowledge gaps and design ad-hoc educational campaigns or interventions.

5.2. Unequal geographic and cultural coverage

The second observation to be remarked is the irregular geographical coverage of specific studies about microplastics, where African countries were absent, as seen in Figure 3. This gap can be explained from many reasons, like lower investments in science in Africa, where many developing countries are located; but not from less microplastic pollution in African waters, that produce a large part of the total microplastics emitted today (van Wijnen, Ragas, & Kroeze, 2019). Alimi, Fadare, and Okoffo (2021) found a higher level of microplastics in fish collected in Egypt than in any other part of the world; however, we could not find any study about knowledge or behaviors related with microplastic emissions from that country. Oceania was absent, too, but its population is much smaller.

The unequal geographical coverage of psychosocial studies is not associated to the level of knowledge about microplastic pollution in the considered regions. In general, scientific publications about this topic are correlated with the plastic waste generation per country (Klingelhöfer et al., 2020), with more studies on pollution from Asia. Although the annual amount of microplastics released into the environment in the EU is enormous (between 75 000 and 300 000 tons; European Commission, 2018), Europe is not the most polluted continent. Van Wijnen et al. (2019) showed that East Asia and Pacific waters receive the largest microplastic import from rivers and the land, followed at a distance by OECD countries (Europe and North America), then African waters. Many of the big rivers on the planet are in Africa, and recent investigation has shown a relatively large number of publications about microplastics in South Africa and the Gulf of Guinea (Alimi et al., 2021). However, there is a clear mismatch between the production of microplastics and the

socioeconomic studies about their impact. The latter aspect is much more studied in European countries than in other continents (Klingelhöfer et al., 2020). The results of our study add psychosocial research about microplastics to the list of insufficiently covered aspects of sustainability in the African continent.

On the other hand, we found indicators of cultural differences in some psychosocial perspectives about microplastics that could be of importance for future interventions to cut microplastic emissions. The level of trust in the country's institutions and authorities could have an influence on the individual effort to behave pro-environmentally, as demonstrated in Misund et al. (2020). The effect of some demographic factors like age and gender varied between countries, like China and Norway for the relative willingness to act (or to pay) of females and males, being higher in females in China (Deng et al., 2020) and the opposite in Norway – controlling concern in this case (Abate et al., 2020). Regarding age, it had contradictory effects depending on the study. For example, the young were more concerned about microplastics than older citizens in Belgium (Herweyers et al., 2020) and the other way around in Portugal (Soares et al., 2021). Perhaps there is a difference between south and north European countries, because the Greek older population would also be more aware of this environmental issue than the younger generations (Charitou et al., 2021). This topic should be thoroughly explored, because if these differences are confirmed, interventions should be designed ad hoc for each culture and region.

5.3. Top-down governance and the importance of science communication

In this study we have observed a clear difference between the perspectives and the studies with actual data regarding the control of microplastics. These are more focused on individual behavior, while reviews seem to be more focused on governance. This discrepancy can be explained, at least in part, from the importance of what has been called the *third power* (mass media) in the dissemination of knowledge about microplastics. Scientific facts about microplastics pass rapidly to stakeholders and politicians through media (Volker et al., 2020), and decisions like banning microbeads from European and American beauty products have been made without clear evidence and even without extensive public pressure, which is generally limited to environmentalist sectors very aware of microplastics. Public knowledge is limited about microplastics, and about environmental legislation and directives too. For example, Charitou et al. (2021) demonstrated that, although the Greek public declared a positive attitude about the EU Single-Use Plastics Directive, the majority ignored the items to be banned.

We have seen in this review that media are the main source of public information about microplastics. One of the barriers to behavior change concerning microplastic emissions is poor understanding of science (Henderson & Green, 2020). Moreover, Anderson et al. (2016) highlight the need of a better public outreach of science to find more public support and phase out microbeads. Therefore, improving science communication seems to be one of the priorities in the next years, and finding the ways to make microplastics visible is surely one of the first needs.

5.4. Limitations of this study

A limitation of the current study is an inevitable cultural bias, since all the articles retained are in English. Peer-reviewed articles included in the Web of Science (WoS), that have been the majority of the papers that passed the filters applied here, are strongly biased towards English language literature (Lillis & Curry, 2010). This is

especially important in the present case, where we have seen intercultural differences regarding the attitudes towards microplastics (Misund et al., 2020).

Another limitation was the reduced number of articles found passing the quality filters applied. Here we prioritized peer-reviewed published articles, thus unpublished studies like Master or PhD theses were not retained. Surely these studies will be published in the next years, thus revisiting the topics worked in the present study in a few years would be advisable.

5.5. Solutions to microplastics issues derived from this study

The central psychosocial term identified in this study was knowledge. Knowledge about microplastics is the first step needed for people to become aware of the risks of microplastics and change their behavior. Thus, measures to increase the public knowledge about microplastics should be taken. They could be implemented at different levels. For the public lack of knowledge about microplastics and current legislation to control them, Charitou et al. (2021) recommended more publicity on European directives, and also the integration of the topic of microplastics in formal education programs. This is interesting because it points at two different, complementary directions: increase public information campaigns, generally addressed to adults and families, and at the same time introduce microplastics in school syllabi. Attractive activities like the example provided by Raab and Bogner (2020) could be employed in primary and secondary education.

The psychological distance between the microplastic production and the sites and organisms damaged by microplastics, that is one of the problems highlighted by Henderson and Green (2020), could be shortened by different means. Pictures of local food with a zoom on attached microplastics, or videos showing plastic particles in the air could serve for this purpose. Visual examples of cause-effect clearly understandable could also be used. An easy example could be the drastic behavior alteration of shrimps like *Artemia* in presence of microplastics (e.g., Gambardella et al., 2017): they change swimming speed (inhibiting movement first, then accelerating after prolonged exposure) and eat microplastics instead of normal food. A video showing such changes, accompanied by explanations about the importance of *Artemia* as food for wild fish, could be useful for approaching the subject to the general public. Live *Artemia* is used as fish food in most aquaria worldwide, thus the proposed example should be easy to develop in practice.

5.5. Research gaps and recommendations for future research

Future directions of research can be drawn from the gaps found in this study. Some of them are:

i) Create baselines of knowledge about microplastics, by country, population, and age sector, for future design of psychosocial interventions and creation of tailored educational activities.

ii) Explore the importance of consumers' environmental values as mediators between knowledge and sustainable behavior regarding microplastics. If values were essential, investigate how to promote these values in the consumers.

iii) Increase the coverage of psychosocial perspectives worldwide, especially in Africa where microplastics emissions are important while there is a lack of studies on the psychosocial side.

iv) Explore the intercultural aspects of the psychosocial issues involved in microplastic mitigation, to be able to better determine the scale of intervention designs.

v) Prioritize studies about how to make microplastics visible to the general public, that is, finding the best practices of science communication about this topic.
vi) Investigate the perspectives of companies, politicians and journalists about microplastics from a psychosocial point of view, to involve all actors in the common goal of fighting this emerging global threat.

6. Conclusions

The analysis of publications about psychosocial issues involved in microplastic emissions allowed to obtain some concluding remarks and directions for new investigations. These are:
i) Knowledge of microplastics is central in the psychological framework of plastic and microplastic pollution. It is directly connected with the willingness to pay for more control and to adopt more sustainable consuming behaviors.
ii) Due to their small size, knowledge of microplastics is acquired indirectly from external sources, principally the media.
iii) Pro-environmental values seem to be more important than the risk perception of microplastics for the adoption of a pro-environmental behavior towards plastic and microplastic consumption.
iv) The geographical coverage of psychosocial studies about microplastics is irregular, being principally focused on Europe.
v) There are differences between countries in the awareness about this environmental issue.
vi) Recommendations to key stakeholders are to design interventions at various levels, to make microplastics visible through dissemination campaigns. and to include the subject in formal and non-formal education programs.
vii) Recommendations for future research are to increase studies in understudied regions (e.g., Africa), and to consider cultural differences.

Acknowledgments

This study has been supported by the Spanish Ministry of Science and Innovation Grants GLOBALHAKE PID2019-108347RB-I00 and EIN2019-103189. We are grateful to the Editor and three anonymous reviewers of Sustainable Production and Consumption who helped very much to improve the manuscript. Aida Dopico revised the language.

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Annex 1. List of papers about psychosocial issues of microplastics pollution that were included in this study but are not cited in the text.

The following articles were fully evaluated and analysed in the qualitative synthesis but were not retained for quantitative meta-analysis because they do not contain original research data (see Figure 2).

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