Contents lists available at ScienceDirect

Science of the Total Environment

Review

The effect of information about hazardous chemicals in consumer products on behaviour – A systematic review

Anders Boman [a,*], Mécia Miguel [b], Ida Andersson [c], Daniel Slunge [b,d]

[a] *Department of Economics, University of Gothenburg, Sweden*
[b] *Environment for Development, University of Gothenburg, Sweden*
[c] *Gothenburg Centre for Sustainable Development, University of Gothenburg, Sweden*
[d] *Centre for Future chemical Risk Assessment and Management, University of Gothenburg, Sweden*

HIGHLIGHTS

- 48 scientific articles on consumer response to hazard information analysed
- Most research on household chemicals; little on hazards in consumer products
- Warning symbols effective in signalling danger, but specifics often misinterpreted
- Consumer willingness to pay for safer products is generally positive but low.
- Identifies specific research needed to inform policy on hazards in consumer products

GRAPHICAL ABSTRACT
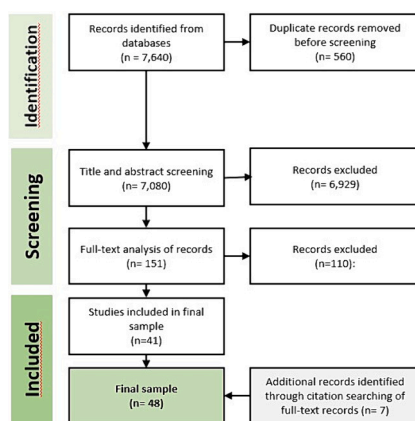
ABSTRACT

Exposure to hazardous chemicals in consumer products poses significant risks to personal health and the environment, and the combined effects may be negative even if each individual exposure is low. This necessitates informed and effective policies for risk reduction.

This systematic review aims to identify and analyse existing evidence on how consumer preferences, product use, and product disposal are affected by information on harmful chemicals in consumer products and by price interventions. The review is conducted according to the PRISMA 2020 guidelines, synthesises forty-eight scientific articles on the relationship between information and consumer responses. No corresponding studies on the effects of price interventions were found. A large share of the identified articles focused on household chemicals, where warning labels are common, while less has been published on "everyday products" where the presence of hazardous chemicals is less clear to consumers. Effects of information on hazardous chemicals on consumer behaviour are highly contextual and dependent on the type of product, consumer behaviour and what kind of label is used. Warning symbols are effective in communicating a general warning of a potential danger,

* Corresponding author.
 E-mail address: anders.boman@economics.gu.se (A. Boman).

although consumers often misinterpret specifics regarding the exact nature of that danger or what means should be taken to minimise it. Informational texts are more informative but are also often missed or quickly forgotten. Consumer willingness to pay for safer products is generally positive but low. Additional research on how consumers react to information and price signals on chemical hazards is needed to improve policy design.

1. Introduction

In a recent study, approximately 20 % of products screened on the European market were found to contain hazardous substances,[1] consequently violating current chemical regulations[2] (European Chemicals Agency, 2023). Also in the U.S., hazardous chemicals are commonly found in consumer products (Knox et al., 2023). The prevalence of hazardous chemicals in everyday consumer products, such as toys, electronics, clothes, and cosmetics, is associated with their presence in blood and urine samples of a large share of both the European and the U. S. population (Dodson et al., 2020; Fabelova et al., 2023; Li and Suh, 2019), as well as in various environmental compartments (Johnson et al., 2020). While the exposure dose from hazardous chemicals in each individual product may be within safe limits, the cumulative exposure to a mixture of these chemicals can pose significant health and environmental risks (Kortenkamp and Faust, 2018; Wang et al., 2020; Persson et al., 2022). As many as two-thirds of European citizens have expressed concerns about exposure to hazardous chemicals in consumer products, but less than half feel adequately informed (European Commission, 2017).

There are several ways to reduce risks associated with hazardous chemicals in consumer products and measures are therefore taken at different levels. Each measure can stop or reduce certain risks, but not all. Several different approaches must therefore be used simultaneously in order to eliminate risk as far as possible, sometimes referred to as the Swiss Cheese Model (Reason, 1997; Larouzee and Le Coze, 2020). Measures such as bans and restrictions as well as incentive programs are commonly used by regulatory agencies to encourage substitution of hazardous chemicals and reduce the risks to human health and the environment (Slunge et al., 2023). In addition, informational strategies, providing users with information about hazardous chemicals, precautionary measures, and the possibility to use safer alternatives are used. However, while there is a globally harmonised system of classification and labelling of chemicals (United Nations, 2021), there is no equivalent system for labelling consumer products containing these chemicals. Examples of national or regional policies do exist, such as the California Safe Drinking Water and Toxic Enforcement Act of 1986, known as Proposition 65 (OEHHA, 2023), whereby any product sold in California must be scrutinised against a list of hazardous substances. If a product contains any of the listed chemicals, it must bear a label indicating its potential cause of cancer, birth defects, or other reproductive harm.

In the EU, manufacturers and importers of products are required to inform customers of the presence of any Substances of Very High Concern (SVHC) in their products exceeding 0.1 % by weight and provide instructions on safe use[3],[4] Labels like the Safer Choice by the US EPA and the EU Ecolabel are examples of information policies that certify a consumer product as free from hazardous chemicals and compliant with specific health and environmental criteria (EPA, 2022; European Commission, 2023). There are also several industry and third-party initiatives providing information on the presence or absence of hazardous chemicals in consumer products. These initiatives can either form part of some of the many broader health and environmental labelling initiatives or have a specific focus on hazardous chemicals and certain product categories, such as textiles or electronics.

There is an extensive and growing literature on the effects of environmental labelling and information systems (e.g. Gruère, 2015; Klintman, 2016; Taufique et al., 2022). Based on a systematic review of sustainability labels, Majer et al. (2022) conclude that "labels affect attitudes, provide utility for consumers, increase willingness to pay (for labelled products) and can change behavior", but the "effects vary widely in size and depend on a variety of individual, contextual, and label characteristic factors". There are also several systematic reviews finding behavioural effects from health warning labels on tobacco, alcohol and food, but that effects vary depending on factors such as label design, choice context and target group (e.g., Asioli et al., 2017; Bastounis et al., 2021; Clarke et al., 2021; Dimova and Mitchell, 2021; Pang et al., 2021; Potter et al., 2021).

Generally, the linkages between information, knowledge, risk perception, and consumer behaviour are far more complex than portrayed by the simple information deficit model which implicitly underpins many information strategies (Fischhoff, 1995; Slovic, 1987; Slovic et al., 2004; Sturgis and Allum, 2004). For example, Laughery and Wogalter (2014) use an information processing model to analyse the effects of product warnings where the compliance behaviour is dependent on (i) the ability of the information to attract the attention of the target audience, which can be particularly difficult in relation to consumer products where habits and simple heuristics are important in forming decisions (see also Asioli et al. (2017) in relation to food choice behaviour) (ii) that the information is understood by the often very heterogenous group of receivers, (iii) the beliefs and attitudes of the target group, and (iv) the motivation to comply with the information, which is critically dependent on the cost of compliance.

Earlier research also indicates that risk communication in relation to chemicals in consumer products may be particularly challenging. People in general have difficulties understanding dose-response relationships and misperceptions about chemicals are common, not only in the general public but also among interested consumers (Jansen et al., 2020; Scheibehenne et al., 2010; Siegrist and Bearth, 2019; Viscusi and Zeckhauser, 1996). Such misperceptions can lead to both overestimation and underestimation of actual risks. In addition, there is also a large scientific uncertainty about the actual risks as there is limited knowledge about the hazardous properties and exposure routes for many of the substances in consumer products (Jansen et al., 2020; Nazaroff et al., 2012; Persson et al., 2022).

However, in contrast to the broader field of environmental and labelling, there is a lack of systematic reviews on how information about

---

[1] Examples of hazardous substances present in the products were phthalates (DEHP,DPB, DIPB,BBP,DINP), Persistent Organic Pollutants (SCCP, PFOA, HBCDD), metals (lead, cadmium, nickel) and dichloromethane. The monitored substances are included in the REACH Candidate list of substances of very high concern for authorisation.

[2] The regulations considered were (i)Regulation (EC) No. 1907/2006 of the European Parliament and of the council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), (ii)Regulation (EU) No 2019/1021 of the European Parliament and of the Council of 20 June 2019 on persistent organic pollutants (POP), (iii)Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive), (iv)Directive 2009/48/EU of the European Parliament and of the Council on the safety of toys (Toys Directive).

[3] See article 33(1) of the REACH Regulation.

[4] Increased requirements on information about the presence of substances of concern in products are also included in the European proposal for a new Ecodesign for Sustainable Products Regulation (ESPR). This information can be provided via digital product passes, labels, tags etc.

hazardous chemicals in consumer products influences consumer choice and behaviour. This review therefore aims to synthesise existing research on how consumer behaviour and preferences for safer products are affected by various types of information on hazardous chemicals in consumer products. Do consumers react to information on hazardous chemicals, and if so, how does the format or style of the label matter for consumer response? Besides the academic contribution, the study identifies factors that are important to consider in the design of future policy instruments to reduce harmful chemicals in consumer products.

The review covers forty-eight scientific articles with a specific focus on hazardous chemicals in consumer products and consumer behaviour. The review does not cover food, alcohol, or tobacco as there are already existing reviews of the literature on health and environmental labels related to these product categories.

The article is structured as follows: Section 2 describes the systematic review methodology; Section 3 provides a descriptive analysis of the final sample, and presents results organised according to consumer behaviour. Section 4 discusses the main findings, research gaps, study limitations, and provides suggestions for a future research agenda. Section 5 concludes.

2. Materials & methods

The methodology used is based on the Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines from 2020 (Page et al., 2021). These guidelines were originally developed in 2009 to standardise how results from systematic reviews are reported, including a description of how the results were obtained. (Page et al., 2021).

2.1. Analytical framework

We assume that information about hazardous chemicals can affect consumer decisions regarding purchase, use and disposal of a product and the presentation of results follows this structure (Fig. 1). Initially, the consumer has some pre-existing knowledge, habits, and beliefs influencing their preferences regarding a product. New information can then be acquired, reshaping preferences and influencing consumer interest in buying the product, the "purchasing decision". For most products, there are different possible ways a product could be used, affecting exposure and risks from chemicals in the product. Information added at this stage may consequently affect how the product is used ("usage decision") and on how the consumer later disposes of the product after use ("disposal decision"). Information before purchase can also affect use and disposal behaviour. In each of these steps, models for information transfer can be applied such as the AKC- or C-HIP-models (Laughery and Wogalter, 2014).
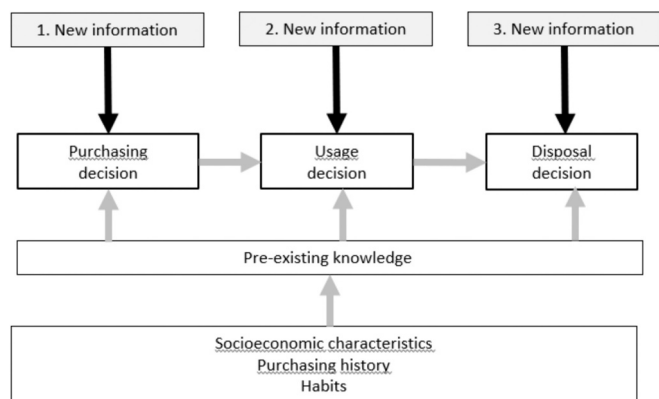

Fig. 1. Information on hazardous chemicals and decisions related to consumer products.

2.2. Search strategy

Initially, five articles were identified as highly relevant to the aim and purpose of this article (Holmquist et al., 2018; Lakhan, 2016; Mokan et al., 2018; Kim et al., 2019; and Patak et al., 2021). These articles were selected as they cover a large scope both geographically and in terms of research fields to reflect the diversity in research in this area. In consultation with two professional librarians, the title, abstract, and subject index of these studies were used to construct candidate search terms, which were then refined after testing on the Scopus database. In order to keep the search broad and inclusive the suffix (*) was used when needed to capture all derivational and inflectional suffixes (e.g., "label*" was used to include labels, labelling, etc. Names of specific hazardous chemicals or consumer products were not included in the search blocks. Search keywords were modified as necessary to meet the requirements of specific databases (see Appendix). The final search strategy, Table 1, was validated by establishing that it could identify all five of the initially identified relevant studies. Table 1 should be read as each search block being required, but not every part in each search block must be fulfilled. Only one of each keyword separated by "OR" needs to be found, but at least one keyword in each search block must be found. In search block 1 ""chemical" is not qualified but the keywords "Compound", "Substance", Environment", or "Health" must be found within 5 words from "Hazard", "Danger", "Harm", or "Toxic".

The literature search was conducted in Scopus and subject-related databases (i.e., APA PsyInfo, GreenFILE and Business Source Premier) on February 25, 2023. Publications up to and including 2022 were retrieved and a "peer-review" filter was applied to the searches conducted in the subject-related databases. Apart from this, no other search restrictions were implemented.

2.3. Study screening & selection criteria

The search retrieved 7080 publications (7640 including duplicates). These were downloaded into the Rayyan web application for systematic reviews (https://www.rayyan.ai/). Then, authors independently screened abstracts of 150 publications and agreed on the following inclusion/exclusion criteria:

1. Only publications in English language were *included.*
2. Original peer-reviewed publications and books were *included;* literature reviews, conference proceedings, commentary, or letters to the editor were *excluded.*
3. Publications focusing on hazardous chemicals were *included.*
4. Studies focusing on consumer products were *included,* except articles with a focus on food and beverage, pharmaceuticals, illegal drugs, and tobacco products.
5. Publications that considered the effect of prices or information on consumer behaviour were *included.*

Table 1
Search blocks, keywords, and operators ("AND", "OR") used in the systematic review.

Search block 1 **AND**	Search block 2 **AND**	Search block 3 **AND**	Search block 4
Chemical **OR** Compound, Substance, Environment, Health *within five words* from Hazard, Danger, Harm, Toxic	Consumer **OR** Consumption	Behaviour **OR** Willingness to pay **OR** Willingness to buy **OR** Purchase **OR** Attitude **OR** Preference **OR** Perception	Price **OR** Tax **OR** Information **OR** Label **OR** Fee

In a third step, authors independently assessed the remaining titles based on these 5 criteria. In cases where the title did not disclose enough information, abstracts were analysed. Screening of titles and abstracts resulted in the exclusion of 6929 publications, leaving 151 publications for full text analysis. The main reasons for exclusion were that the articles focused on food, tobacco, or pharmaceutical products, or on producer behaviour. In a fourth step, the full-text analysis led to the exclusion of a further 110 publications. During the full-text analysis, the reference list of each publication was screened by one author, identifying eight additional publications. After analysing abstracts and full-texts, seven of these publications were included, resulting in a final sample of 48 publications. Fig. 2 outlines the full screening and selection procedure.

2.4. Final sample analysis

A critical analysis of the forty-eight included articles was performed to identify relevant existing knowledge on information effects on consumer behaviour regarding hazardous chemicals in consumer products. Table 2 provides an overview of the main dimensions and categories used to analyse the final sample. Descriptive elements for each article, such as title, authorship, publication year and journal were also recorded.

3. Results

3.1. Sample characteristics

The included 48 articles were published between 1981 and 2022 in 34 different journals. The sample is very heterogeneous and dispersed across multiple research fields, such as environmental sciences,

toxicology, safety science, health science and economics. Table A1 in the appendix gives an overview of the focus, methodology and key findings for each analysed article. As shown in Fig. 3, there has been an increase in the number of publications per year during the last years of our study. The most common journals in the sample were the *Journal of Cleaner Production* (4 articles), followed by *Food and Chemical Toxicology, Environmental Sciences Europe, and International Journal of Consumer Studies* (each with 3 articles).

The United States (13 articles), followed by South Korea (7 articles), Switzerland and Germany (each with 4 articles) were the most common geographical areas covered. Cross-country comparisons are scarce, with only two studies identified (Geuens et al., 2021; Zollo et al., 2021) where two or more countries were compared.

The articles also differ in methodological approach, with surveys and experiments being most common, see Table 3. Most articles are empirical (45 articles), with sample sizes ranging from an in-person focus group study with 22 participants to an online consumer survey with 10,000 participants. Three articles are theoretical, not using any empirical findings, but rather focusing on developing theoretical frameworks or models to explain consumer behaviour regarding consumer products with hazardous substances.

The reviewed articles focus on four types of consumer behaviour: purchasing (24 articles), willingness to pay (14 articles), product use (23 articles), and product disposal (7 articles). In total, 31 articles analysed only one of these, while 14 articles studied two different consumer behaviours, and 3 articles studied three behaviours (i.e., purchasing or willingness-to-pay, use and disposal). As shown in Table 4, cleaning, cosmetic and personal care, and other household chemicals were the most common product categories. Interestingly, 6 articles did not specify the product analysed during the study, these studies were either theoretical in nature or used vague terms, such as "consumer products".
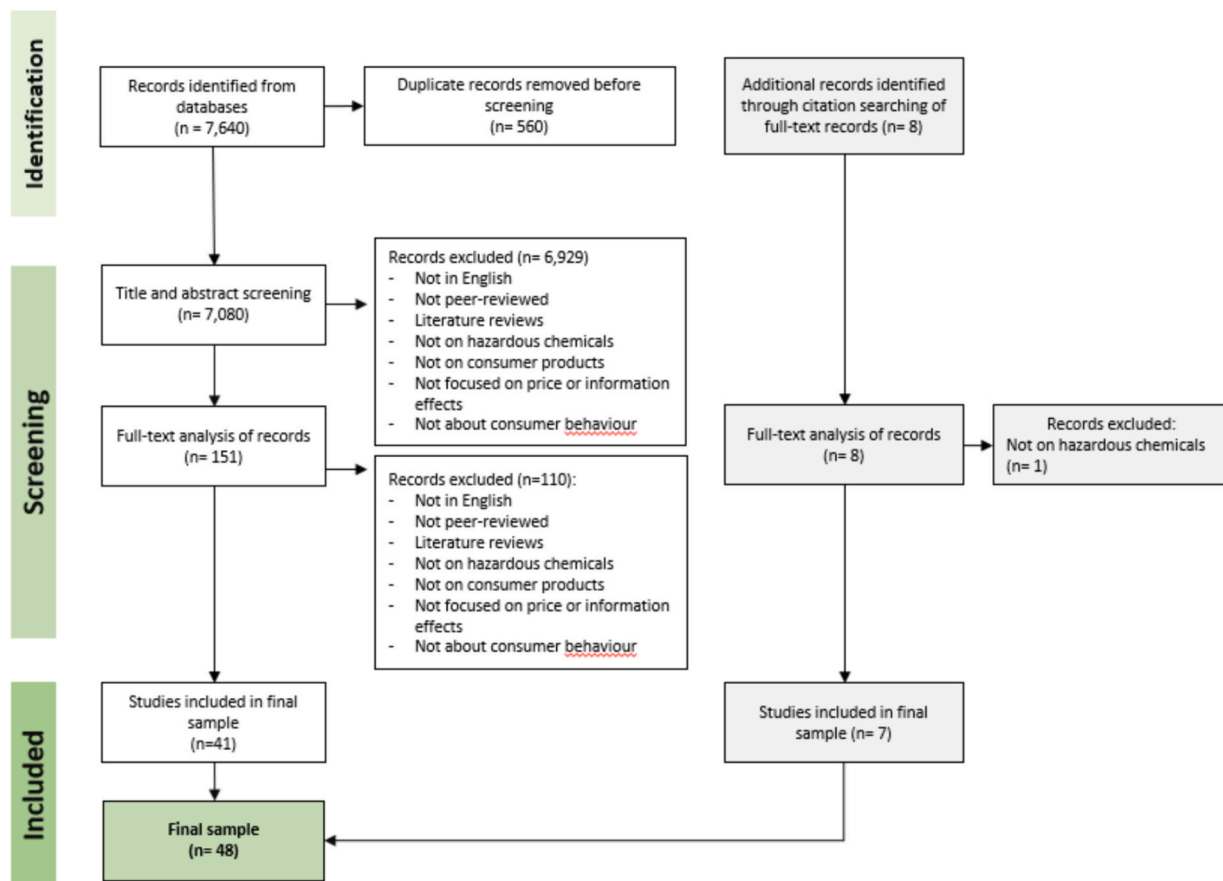

Fig. 2. Screening and selection procedure following PRISMA 2020 guidelines by Page et al. (2021).

Table 2
Overview of classification dimensions.

Classification dimension	Description
Consumer behaviour	**Purchasing (P)** – Publications focusing on purchasing preferences or intentions of alternative consumer products. **Willingness to pay (W)** – Publications focusing on eliciting willingness to pay for alternative consumer products or environmental fees. **Use (U)** – Studies focusing on handling, storage, attitudes, awareness and/or risk perception of using consumer products with hazardous chemicals. **Disposal (D)** – Publications focusing on attitudes, preferences, and willingness to engage or pay in specific disposal behaviour associated with consumer products with hazardous chemicals.
Product categories	**Clothing** – Any clothing item and/or shoes. Examples include children's clothing and outdoor clothing. **Cleaning** – Any cleaning products or agents used in the household, such as kitchen counter sprays and laundry detergent. **Cosmetic & personal care** – Any cosmetic and personal care products commonly used in the household. Examples include deodorant, sunscreen, and perfume. **Electric & electronic** – Any electronic and/or electric appliances used in households. Examples include mobile phones, batteries, and hair dryers. **Other household chemicals** – Any chemical product used in the household, excluding cosmetics & personal care products, examples include air freshener and pesticides. **Other household products** – Any other product frequently used in the household, but not included in the previous categories (e.g., ladder, toys). **Not specified** – Vague terms are used to describe the product(s) analysed (e.g., consumer product) or no information is given.
Location	Countries or regions where the study took place.
Research method	**Survey** – Information collection from a sample of individuals by using an instrument (i.e., questionnaire), which can include close-ended or open-ended questions, and can be administered in-person, online, through mail or over the phone. **Interview** – Qualitative research method, which can either be unstructured, semi-structured, structured or use focus groups. Often focusing on small samples of individuals. Interviews can take place in person, over the phone or online. **Experiment** – Quantitative research method, which takes place either in-person or online in a controlled environment. **Theory** – The use of theory (e.g., economic theory) to explain, predict or understand a phenomenon.
Detailed research method	Information on sample size, target audience for research method, aims of the study and how research methods were implemented.
Key result(s)	The main outcomes of the study are briefly described.

3.2. Information on hazardous chemicals and the purchasing decision

Pre-existing knowledge about product environmental impacts, eco-labels, and the like has been found to increase Malaysian consumer intentions to purchase products labelled as "green", broadly defined as products with minimum negative effects on the environment (Mokan et al., 2018). Similarly, product knowledge, environmental concern, and a green lifestyle, are important incentives for Czech consumers when buying consumer chemicals labelled as less harmful to the environment or personal health (Patak et al., 2021). Unfortunately, neither of the above studies have analysed the size of these effects, but focus on if the effect is statistically significant.

Consumer knowledge and awareness about of risks related to hazardous chemicals are not fixed and constant but can be influenced by information interventions. Blackman and Luskin (2006) found that informational outreach can have effects on the purchasing behaviour for household chemical products. The study was based on an ambitious outreach initiative in Massachusetts USA, and found a substantial

reduction (36.9 %) in the purchases of countertop cleaners or laundry brightening products classified as "toxic" and a corresponding increase in "less toxic" or "non-toxic" cleaners. A second sample asked if respondents changed their behaviour after being given information about the intervention. Results show that consumers used the toxic version of the product less often, as 54.8 % of respondents reported using the "toxic" counter top cleaner less often. The corresponding number for laundry brightening products was 21.5 %. Klaschka (2020) found that information about fragrance ingredients would alter the purchasing decision for about one third of respondents, but it is not clear from the reported results in what direction or how strong the effect is.

When given new information, differences in the response between consumer groups may be rational, as some consumers may be more, or less, careful than others. As shown by Ippolito (1981), in a theoretical article, what can be seen as a rational reaction to new information, in terms of changes in consumption of products with hazardous chemicals, will vary depending on age, the timing of the effect of the hazard and other factors. Another theoretical article identifies how the effects of eco-labels on products with different environmental effects can vary between different consumer groups, such that egoistic consumers focus on private benefits, and altruistic consumers focus on public benefits (Grolleau et al., 2009). This is supported by several empirical studies, showing that women and older individuals are more aware of chemical hazards associated with household chemicals (Buchmüller et al., 2020) and there is large heterogeneity in preferences for "green products", in terms of age and income but not gender (Jo and Shin, 2017). Goswami (2008) found that concern about environmental issues (i.e. public goods) was positively associated with survey respondents' willingness to pay for eco-friendly clothes.

The effect of information about hazardous chemicals also depends on the type of product. A survey in Germany showed that information about risks to personal health were more prominent for products used directly on the human body, whereas information about environmental effects were more important for products used outdoors or applied to the environment, such as air fresheners (Hartmann and Klaschka, 2017). Almost three quarters of respondents said they would avoid purchasing a product to reduce the health risk from harmful substances, whereas slightly fewer would do so to protect the environment. Special interest in an activity or use of a specific product range may also influence consumer choice. Consumers interested in skin care have been found to put more importance on information about product safety when buying cosmetics, and thus not only focusing on the cosmetic short-term effect of the product but also the more long-term effect on skin health (Choi and Lee, 2019). These consumers were also more brand loyal, arguably because personal experience had shown the brand they already used to be safe.

The decision to buy green products is affected by information received from peers and other social influences (Mokan et al., 2018) and the most important source of information is word-of-mouth, including online reviews, etc. (Zollo et al., 2021). Promotions (sales, other campaigns) have also been found to influence the choice of green chemicals (Patak et al., 2021). Social influences are particularly important to some groups, primarily men and consumers with lower education (Patak et al., 2021).

Avery (1982) showed that (hazardous) flame retardants made consumers less willing to buy the product. Akerboom and Trommelen (1998) showed that information on the hazardousness of household chemicals, provided as text and with symbols, increases awareness and understanding of risks and affects purchasing behaviour. In a later study, Anderson et al. (2016) showed that consumers were generally unaware of the amount of microplastics in facial cleaners. When labels were added, this affected consumers' product choices. However, Laughery et al. (1993) found no clear relationship between warning labels and purchase preferences. The opposite of a warning symbol is a safety claim, signalling that the product is safe to use. Kim (2022) found that safety claims did decrease consumers' perceptions of hazards and made
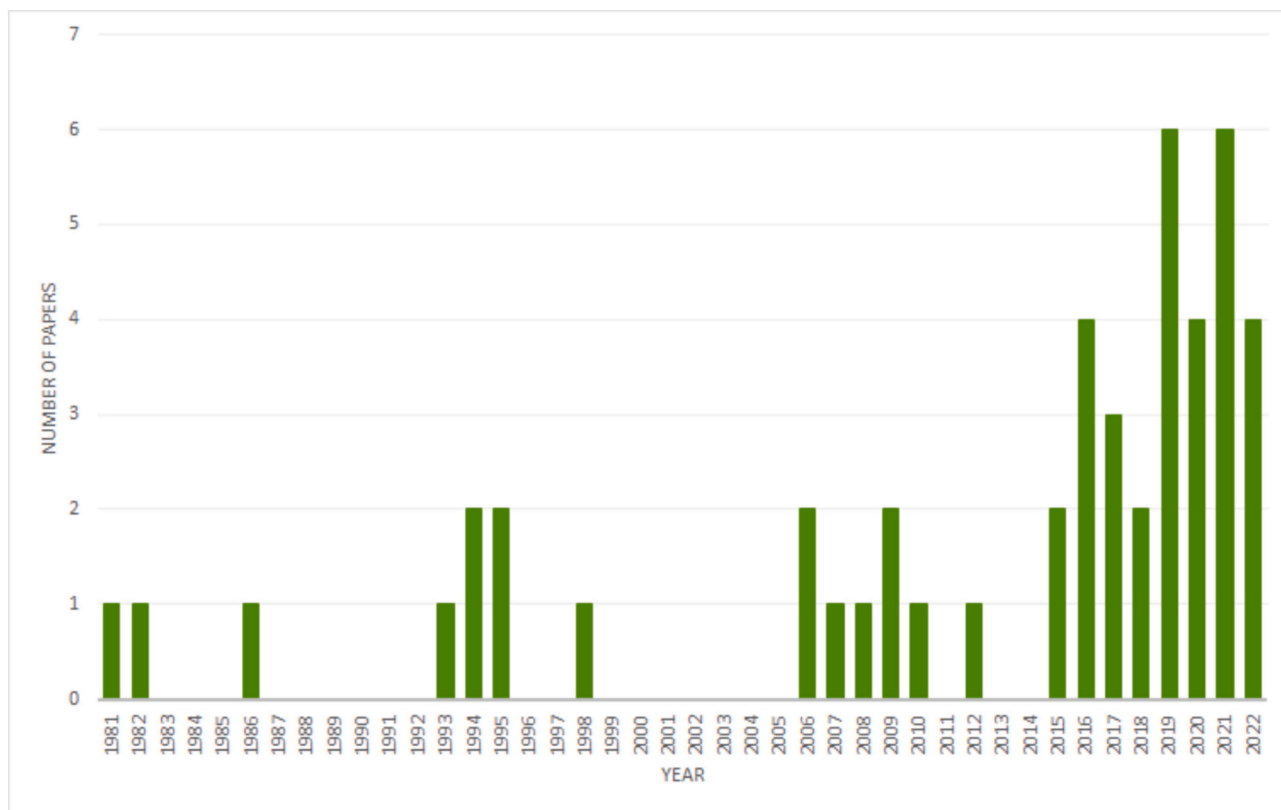
Fig. 3. Distribution of publications per year (years without publication excluded).

Table 3
Research methods in the sample.

Research methods	Number of articles
Survey	29
Experiment	18
Interview	3
Theory	3
Total	**53**

Note: Total number of articles in the table is greater than 48 as some articles include multiple research methods.

Table 4
Product categories covered by the sample.

Product category	Number of articles
Cleaning	19
Cosmetic and personal care	12
Other household chemicals (e.g. mold remover, air freshener)	9
Electric & electronic products (e.g., mobile phone, batteries, computer)	7
Not specified	6
Other household products (e.g., toys, plastic packaging)	5
Clothing	4
Total	**62**

Note: Total number of articles in the table is greater than 48 as some articles include several product categories.

participants more likely to purchase the products with safety claims, compared to products without safety claims.

To influence the purchasing behaviour, information needs to be both noticed and understood, but warning labels often go unnoticed by consumers. Even when noticed, there are large variations as to the importance and reliability consumers put on various sources of information (Buchmüller et al., 2022b). One large study of Korean consumers showed that only about one quarter of the consumers found hazards symbols reliable (Sim et al., 2019). However, in Germany, almost three quarters of respondents found the hazard symbols used in the CLP regulation reliable (Hartmann and Klaschka, 2017). Buchmüller et al. (2020) found that some consumers may have an irrational fear of chemicals, so called chemophobia, resulting in an overestimation of the severity of hazardous chemicals. This variation in trust in labels may partially explain the varying results found in studies of consumer choice and labels related to hazardous chemicals.

When noticed and trusted, the consumer must also understand the information for it to influence consumer behaviour. Banda and Sichi-longo (2006) found that 85 % of consumer respondents in a Zambian study had difficulties understanding the meaning of the most common warning symbols. Hartmann and Klaschka (2017) found that even those most interested and chemically knowledgeable can have difficulties interpreting labels and their meanings and underestimated the hazards to health and environment.

Although aware of the potential risks of hazardous chemicals, consumers are more interested in other characteristics of the product. Price, origin of raw materials and ecological product characteristics were found to be more important than chemical contents of the product (sand toys) except for ecologically sensitive respondents (Scherer et al., 2017). Tribby et al. (2021) found that consumers of sunscreen considered the list of active ingredients before purchase, and that certain ingredients could make them choose away from a particular product, but the main interest of consumers was still the sun protection factor. Anderson et al. (2016) found that, when informed about the presence of plastic microbeads in facial cleansers, some focus group participants favoured alternative products instead.

Closely related to the choice of product, the willingness to pay (WTP) for a cleaner product may also be influenced by information. Using a game theoretic approach, Kaushal and Nema (2012) show that consumers prefer hazardous free mobile phones if promoted with a discount

from the manufacturer through a take back scheme. Several empirical articles have found a positive WTP among consumers if informed that products contain less hazardous substances. Products studied include bio-based batteries (Choi et al., 2020), laundry detergents (Findrik and Morawetz, 2019; Siwayanan et al., 2015), mobile phones (Nnorom et al., 2009; Milovantseva, 2016), and soap (Yao et al., 2019). However, the increase in WTP is in many cases small or very small (Viscusi and Magat, 1986; Saphores et al., 2007; Gam et al., 2010). Holmquist et al. (2018) found a positive WTP for children's overalls that did not contain PFAS chemicals, but also that the WTP increase further when consumers were given more information about risks related to PFAS. Finally, Kim et al. (2019) found that consumers would be willing to pay for a labelling scheme on endocrine disrupting chemicals through an increase in income taxation.

A more informed choice does not necessarily mean a reduced demand or lower WTP for products containing hazardous chemicals. Information about trace chemicals, traceable amounts of unwanted chemicals in the consumer product at levels below the safety exposure limits, may increase acceptance and the WTP for products containing them (Bearth et al., 2021a; Bearth et al., 2021b).

3.3. Information on hazardous chemicals and product use

Once the product has been purchased, risks to the consumer from hazardous substances depend on how the product is used. Several studies investigate how information given to consumers can affect product use and find that usage behaviour is generally influenced by information, but the size of the effect varies. This may to some extent be explained by differences in consumer preferences but also different circumstances, as discussed in Ippolito (1981). However, attendance to labels has been found to be low. In one study, only half of respondents read the labels on medications and less than 21 % read the labels for cleaning substances (Mostafa et al., 2022). In another study Sim et al. (2019) found that about 40 % of South Korean users of household chemicals and personal care products read instructions and followed recommended instructions (Sim et al., 2019).

Behavioural changes following new information also varies. Akerboom and Trommelen (1998) found that 65 % of Dutch consumers would change their use of a product, but did not specify how, if presented with standardised hazard information. Similarly, Klaschka (2020) found that about half of respondents would not use a fragranced product if aware that the product emitted hazardous substances into the air. Ashley et al. (2015) showed that although information on correct usage influenced usage, other factors limited this effect, such as feasibility and cost. Wogalter et al. (1994) found that the use of signal words on labels led to a statistically significant increase in the mean hazard rating by consumers for all signal words analysed. However, the analysis did not include effects on actual or stated consumer behaviour.

There is a risk of label confusion, consumers mistaking a label to mean something it does not. Sim et al. (2019) found that about half of consumers thought eco-labelled products or products made from natural materials did not contain harmful chemicals, while about one in four thought so regarding children's products. Similarly, Bearth and Siegrist (2019) found that consumers underestimated the hazardousness of eco-labelled products. However, Saleh et al. (2020) compared two different communication strategies, informational and affect-based, with the stated purpose of reducing chemophobia. They found larger effects from the informational than the affect-based approach, suggesting that consumers are quite capable of taking in information and making informed choices.

High awareness of product toxicity does not necessarily lead to behavioural changes. Laughery et al. (1993) found that warning labels' explicitness increased hazards perception and improved intent to act cautiously when handling the products, while Deturck et al. (1994) found that usage behaviour was more influenced by the observed behaviour of others than by warning labels. Pollack-Nelson (1995)

found that only a small portion of users changed their actual behaviour as a result of reading the warning label on the product.

The effect on behaviour also depends on the design of warning labels, where red warning labels made a larger difference than green or black labels (Braun and Silver, 1995). Similarly, combinations of symbols and colours may send stronger or weaker signals than the symbols or colours alone. Green colour weakens the warning signal from the symbol whereas red enhances it (Banda and Sichilongo, 2006). Buchmüller et al. (2022) found that consumers perceive products in black containers as more dangerous than in other colours. The same study also found that labels with flowers or food elements decreased the perceived hazardousness. Similarly, Basso et al. (2016) found that products in food- or drink-like shapes led participants to perceive product's contents as edible/drinkable and safe. Labels did not elicit the same perception about product safety. However, while pictograms may be effective in signalling risk, Bearth and Siegrist (2019) found that they are not effective in correctly conveying actual risks. Geuens et al. (2021) found that label design did not improve participants' information recall, hazards perception, and behavioural compliance.

Viscusi and Magat (1986) analysed the role of warning labels in a stepwise approach. In a first step they estimated the effect of a warning label on the precautions respondents said they would take and found that labels did influence behaviour. They then analysed the effect of the share of the label devoted to the warning and found that larger share increased precautionary behaviour. In a third step they analysed the importance of specific warnings and found that warnings that more specifically targeted certain precautionary behaviours further increased such behaviours.

3.4. Product disposal

Several studies find that information about hazardous chemicals can also inform product disposal behaviour. Akerboom and Trommelen (1998) found that 79 % of survey respondents stated that warning labels and texts about hazardous chemicals would affect their disposal behaviour, while Nnorom et al. (2009) found that 65 % of the respondents were either 'willing' or 'very willing' to drop-off no-longer-in-use electronics at a nearby recycling facility. Hartmann and Klaschka (2017) found that safer disposal was one of the top two options, when asking consumers how they would prefer to reduce the risk of a product with harmful substances.

Lakhan (2016) found a willingness to pay environmental handling fees that increased with a product's perceived environmental harm at the end of life. However, Banda and Sichilongo (2006) found that warning symbols, warning texts and distinct colours had almost no effect on disposal decisions of potential product users in Zambia.

4. Discussion

Consumer products constitute an important source of exposure to toxic chemicals for humans and the environment (Knox et al., 2023; Dodson et al., 2020; Fabelova et al., 2023; Li and Suh, 2019; Wang et al., 2020). This systematic review of research articles on how consumer behaviour is affected by price changes and information on hazardous chemicals provided valuable insights based on a heterogenous sample. In this section, we draw and discuss a number of conclusions and identify knowledge gaps where further research would be valuable.

The articles analysed were found in journals with diverse topics, applying different methods, and exhibiting significant variations in sample sizes and sample characteristics. Moreover, the products analysed in these studies varied greatly, making direct comparisons of results challenging. However, a number of conclusions can be drawn. One notable observation is the predominant focus of the analysed articles on the role of information, with a surprising dearth of studies examining the impacts of price changes or taxes on hazardous chemicals. This lack of research on price-related factors may at least partially be attributed to

the limited application of taxes to hazardous chemicals in consumer products (Slunge and Alpizar, 2019). Several articles instead examined consumer willingness to pay (WTP). Generally, WTP for products labelled as safer was positive but low with large variations across studies. The generally positive WTP for safer products is similar to that generally found for eco-labelled food (Bastounis et al., 2021), but it is important to note the potential presence of hypothetical bias in the WTP estimates (List and Gallet, 2001). Even the small WTP found may consequently be overestimated compared to real life decisions, but without further studies, we cannot determine if this is the case.

In line with findings from systematic reviews on the effects of environmental and health labelling on other product categories (e.g., Majer et al., 2022; Asioli et al., 2017), this review found the effects of information on hazardous chemicals on consumer behaviour to be highly contextual and dependent on the information given as well as on the type of consumer behaviour. There are also indications that the effects vary depending on the product category analysed, where the behavioural effect of information about health risks from chemicals in skin care products is larger than information about health risks from chemicals in outdoor products. However, comparative studies using the same settings for testing information effects across various products would be needed to draw definitive conclusions.

Following the AKC-model (Attention, Knowledge, Compliance) of information processing (Laughery and Wogalter, 2014), we can conclude that there is a substantial risk that product labels go unnoticed by consumers, failing to draw attention to the message. When noticed, warning symbols were generally effective in signalling a general sense of hazard, but consumers often confused the specific meaning of these symbols and awareness of specific risk was limited. There is consequently a risk that relevant consumer knowledge is unaffected by the message. Text-based information seemed to provide a more detailed understanding of product characteristics. Although consumers may see warning symbols or read text labels, they often fail to remember the specifics, or the contents of the warning label texts and information from peers, friends, or online reviews had a stronger impact on how a product was used. There appears to be a conflict between two purposes of warning messages, where attention to risk conflicts with knowledge about specific risks. Nevertheless, the lack of recall of specific information may not be problematic if the text or warning symbol effectively promotes improved product usage (i.e. compliance with warning messages). Several studies have demonstrated that warning labels do influence product use, which is their intended purpose. It therefore appears that adding warning labels to products can provide an extra layer of protection and therefore mitigate risks to consumers. Following the Swiss Cheese Model (Reason, 1997), this layer of protection does not need to be perfect to benefit consumers, but more research on the extent of that protection and mechanisms behind it is needed to improve policies.

Many articles identified in this review centred on consumer behaviour concerning household chemicals, which are generally recognised as hazardous, with common warning labels and recognizable symbols. However, there is a lack of research on "everyday products" where consumers may have limited awareness of the presence of hazardous chemicals. Consequently, more research is needed in this domain, as underestimating the risks can cause behaviour that leads to unnecessary exposure to hazardous chemicals.

Moreover, we identify significant knowledge gaps regarding how consumers value different types of hazards from chemicals in consumer products. Research on the relative concern among consumers for environmental hazards versus health hazards, as well as distinct types of health hazards like endocrine disruption, carcinogenicity, and allergenic potential, could provide crucial insights for policy design.

Despite the broad scope of the initial search for relevant articles, the number of articles included in the review was lower than expected. One reason for this could be the exclusion of specific product names or hazardous chemicals, such as PFAS, phthalates, or BPA, from the search

strings used. Given the number of potentially hazardous chemicals, including such specific terms would have resulted in an unmanageable number of potential products and still risk missing many. Additionally, articles related to consumables, such as food and alcohol, or tobacco were excluded from this review, as these fields have already been extensively researched and reviewed (e.g. Asioli et al., 2017; Bastounis et al., 2021; Dimova and Mitchell, 2021; Pang et al., 2021; Potter et al., 2021).

The results from the review consequently shed light on the complex nature of consumer behaviour in this area, but also shows that the research field is still immature despite the question being far from new.

5. Conclusion

This systematic review aimed to identify and analyse the scientific research on the effects of price of and information about hazardous chemicals in consumer products on consumer preferences and behaviour.

In conclusion, the review highlights the complexity of consumer behaviour and the large variation in responses to information. Consumers generally state that they are willing to pay a premium for products with less hazardous chemicals, but the amounts consumers are willing to pay vary significantly between studies. There is also a variation in consumer reactions to information, depending on the type of product, consumer behaviour and what kind of label is used. Warning symbols are found to be effective in signalling general hazard, although consumers often confuse the different symbols. More detailed information is often better at delivering specific information, but this information is then often quickly forgotten.

In spite of a broad and inclusive search strategy, this literature review identified a small and heterogeneous sample of studies. Relatively few research articles were found on the effects of information regarding hazardous chemicals and no articles on effects of implemented price changes. Considering the documented health and environmental risks associated with hazardous chemicals and the high level of consumer concern, this is surprising and indicates a clear and substantial need for further research to improve the understanding of how consumers value and respond to information and pricing strategies aiming at safer products. Such knowledge is crucial for designing effective policies that protect consumer health and the environment.

CRediT authorship contribution statement

Mécia Miguel: Writing – original draft, Visualization, Investigation. **Ida Andersson:** Methodology, Investigation. **Daniel Slunge:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Declaration of competing interest

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.

Data availability

Literature review, no data analysis

Appendix

Table A1
Summary of the 48 articles included in the sample
(Consumer behaviour: P- Purchasing decision; U- Use; D- Disposal; W- Willingness to Pay; Research methods: T- Theory; E- Experiment; S- Survey; I- Interview)

Article	Consumer behaviour	Product(s) analysed	Location	Research method	Description of research method	Key result(s)
Akerboom and Trommelen (1998)	P, U, D	Household chemicals (e. g., paint stripper)	Netherlands	S, E	In-person survey to assess environmental warning labelling understanding and its effects on consumer behaviour ($N = 167$); In-person experiment with students to assess environmental information effects on information recall ($N = 60$)	In general, environmental information was well understood among participants and their purchasing, use and disposal behaviour was influenced by the warning labelling text. Participants were not always able to determine environmental hazardousness levels or distinguish between labelling symbols. Adding environmental information reduced retention of warning information.
Anderson et al. (2016)	P, U	Facial cleanser	United Kingdom	I	In-person focus group with environmental activists, trainee beauticians, and university students to test awareness of microplastics and effects of information ($N = 22$)	Overall, participants were unaware of the amount of microplastics in facial cleansers. Clear labelling of products with microbeads affected participants' purchasing, use and disposal behaviour.
Ashley et al. (2015)	U	Household chemicals (Phthalates)	Canada	I	In-person semi-structured interviews with pregnant women to assess information effects on behaviour ($N = 23$)	Information not sufficient for adoption of exposure avoidance strategies, participants also took in consideration financial costs, practicality of change and responsibility. Perceived reliability of information sources (e.g., physician) also influenced behaviour change.
Avery (1982)	P	Children's sleepwear	United States	S	Mailed in survey to identify changes in behaviour and attitudes of nursery parents after Tris controversy ($N = 269$)	Tris controversy (i.e., use of potential carcinogenic as flame retardant in children's sleepwear) was well-known among participants. Most parents reported to have changed their purchasing behaviour but did not provide specific examples. Some parents stopped buying chemically treated sleepwear and others sought more information about chemicals. Participants also showed confusion about flame retardant terminology.
Banda and Sichilongo (2006)	U, D	Bayetone	Zambia	S	In-person survey to assess warning labelling understanding and perceived hazardousness ($N = 48$)	Colours in the label were useful to communicate hazards, however symbols were not well-recognised by participants. Product familiarity and use influenced participants' perceived hazardousness of Bayetone.
Basso et al. (2016)	U	Cleaning products	France	E	Online experiments in lab room with university students to evaluate product safety perception of food-imitating products (i.e., shape and label) ($N = 122$)	Food or drink-like shapes led participants to perceive product's contents as edible/drinkable and safe. Labels did not elicit the same perception about product safety.
Bearth et al. (2021b)	P	Shampoo	South Korea	S	Online pre-post surveys to evaluate the effect of informational video on consumers' acceptance of trace chemicals and willingness to purchase ($N = 600$)	The informational video increased consumers' acceptance of trace chemicals (i.e., chemicals or impurities not intentionally added) in products. Levels of acceptance vary between consumer product categories (higher for cleaning and other household chemicals). Participants were also more willing to purchase consumer products with trace chemicals after watching the video.

Table A1 (*continued*)

Article	Consumer behaviour	Product(s) analysed	Location	Research method	Description of research method	Key result(s)
Bearth and Siegrist (2019)	U	Cleaning products	Switzerland	E	Online experiment to assess consumers' risk perception while using a cleaning product, based on different risk scenarios ($N = 893$)	Presence of pictograms did not change participants' risk perception. Participants' underestimated hazardousness of products labelled as "eco." Risk perception influenced participants' behaviour.
Bearth et al. (2021a)	P	Shampoo	South Korea	S, E	Online survey followed by online experiment to determine consumers' knowledge and chemophobia and effect of toxicological information text on willingness to buy products with trace chemicals ($N = 1019$)	Information about toxicological principles increased participants' acceptance of trace chemicals in products, decrease their perception of harmfulness and improved their purchasing preference for products with trace chemicals.
Blackman and Luskin (2006)	P, U	Cleaning products (e.g., kitchen); Household chemicals (e.g., nail care)	United States	S	In-person pre-post surveys with parents to assess the effects of informational campaign (N = 112)	Participants reported changes in the frequency of use of toxic countertop cleaners, but results for laundry brightening products were less clear. Only minor change in behaviour to reduce exposure while handling and using "toxic" household chemical products, particularly cleaning products.
Braun and Silver (1995)	U	Pool-water test kit and two-part adhesive	United States	E	In-person experiments to assess hazards perception of signal words and colours ($N = 30$) and to determine behavioural compliance of three labelling colours ($N = 65$)	Compliant behaviour increased with red warning labelling compared to green and black. Red labelling also associated with higher injury or hazards perception among respondents.
Buchmüller et al. (2020)	U	Household chemicals (e.g. mold remover and descaler)	Switzerland	S	Online survey ($N = 1109$) and mailed in survey ($n = 146$) to assess consumers' risk perception, attitudes, and behaviour	Low-risk perception among participants, but high applied product knowledge (e.g., products without hazard symbol can be dangerous for human health). Perceived severity of home chemical accidents determined by personal risk awareness, self-reporting behaviour and chemophobia.
K. Buchmüller et al. (2022)	U	Cleaning products	Germany	E	Online experiment to evaluate the effect of packaging (i.e., colour and label) on consumers' risk perception ($N = 523$)	Participants considered cleaning products in black bottles as more dangerous than other packaging colours (i.e., pink). Participants also perceived products with food elements or flowers on the label as less dangerous.
Kim Buchmüller et al. (2022)	P	Laundry detergent	Switzerland	E	Online experiment (virtual reality supermarket setting with eye-tracking) to test effects of warning information on purchasing preferences and risk assessment ($N = 147$)	Existing warning labels in household chemicals (e.g., laundry detergents) considered an ineffective way to communicate risks, because these were often unnoticed by participants (unless prompted to consider product risks).
Choi and Lee (2019)	P	Skincare products (e.g., hydrating cream and sunscreen)	South Korea	S	Online survey to assess the effect of trusted information on perceived safety and purchasing intention of online shoppers ($N = 236$)	Perceived personal importance of skin safety and trust in domain-specific information had positive effect on purchasing intentions of green-grade skincare products (i.e., high safety ingredients).
Choi et al. (2020)	W	Bio-based batteries	United States	S	Online survey, contingent valuation to assess effects of product information on willingness to pay ($N = 1493$)	Product information about environmental attributes and health benefits increased participants' willingness to pay a premium for bio-based batteries. Willingness to pay for a premium was lower for individuals that reported price, rechargeability and green production processes as key factors in their purchasing decisions.
Deturck et al. (1994)	U	Oven cleaner	United States	E	In-person experiment with students to evaluate the importance of a role-model and labelling information on safety behaviour ($N = 166$)	Product's warning label affected participants' perception of hazards. However, compliance with recommended safety behaviour was influenced by role model behaviour (i.e., participants followed role model behaviour instead of labelling information).

Table A1 (*continued*)

Article	Consumer behaviour	Product(s) analysed	Location	Research method	Description of research method	Key result(s)
Findrik and Morawetz (2019)	W	Fragrance-free laundry detergent	Austria	S	In-person survey, contingent valuation to determine how information influences participants' willingness to pay for a fragrance-free laundry detergent ($N = 122$)	Without information, participants were willing to pay on average 0.51€/L less than the current average price (3.24€/L) for fragrance-free laundry detergents. After receiving information about the health risks associated to fragrances in laundry detergents, the respondents were willing to pay on average 0.03€/L less than current average price.
Gam et al. (2010)	P, W	Baby bodysuit	United States	S, E	In-person survey, choice experiment, mothers of children (0–4 years old) asked for their willingness to purchase and pay a premium for organic cotton ($N = 156$)	Participants' environmental concerns, environmental purchasing and recycling behaviour influenced their willingness to purchase organic cotton baby bodysuit. However, most participants were not willing to pay a premium for an organic baby bodysuit (with only 9 participants accepting to pay a 10 % premium).
Geuens et al. (2021)	U	Laundry detergent	France, Poland, Sweden, and Spain	E	Online experiment to assess safety communication effectiveness of existing and alternative back labels ($N = 1812$)	Alternative labels did not improve participants' information recalling, hazards perception, and behavioural compliance with safety guidelines compared to existing label. In case of a product accident, participants relied on their pre-existing knowledge, experience, and intuition instead of label.
Goswami (2008)	W	Clothes (i.e., shirt and trousers)	India	S	In-person survey to determine consumers' willingness to pay for eco-friendly clothes ($N = 480$)	Concern about environmental issues positively influenced participants' willingness to pay more for eco-friendly clothes.
Grolleau et al. (2009)	P	Not specified	Not specified	T	Development of theoretical framework to explain the success of eco-labelling schemes	Success of eco-labels might be explained by differences in public and private environmental benefits and consumer composition (i.e., altruist and egoist).
Hartmann and Klaschka (2017)	P, U, D	Not specified	Germany	S	Online survey with interested consumers in chemical risk and chemical experts to assess risk perception, attitudes, and own risk-mitigation behaviour ($N = 1030$)	Most participants reported not buying products with harmful chemicals, following recommended safety and disposal instructions as strategies to reduce exposure to harmful chemicals in consumer products. Respondents also assumed eco-labelled products, natural personal care products, products without hazards labelling or products produced in the EU did not contain harmful chemicals.
Holmquist et al. (2018)	W	Children's overalls (PFAS-free)	Sweden	S, E	Online pre-survey followed by experiment to evaluate the effects of environmental and health information framing and price changes on parents' willingness to pay for PFAS-free clothing ($N = 3532$)	Participants demonstrated high willingness to pay for PFAS-free children's overalls, irrespective of information. The effect on willingness to pay was stronger when information was more specific. At higher prices, health information had a stronger effect on WTP than environmental information.
Ippolito (1981)	P, U	Not specified	Not specified	T	Development of life cycle models to explain consumer's decision of consuming hazardous products	Hazard type and consumption duration influences consumers' rational responses to new information on hazardous products.
Jo and Shin (2017)	P, W	Laundry detergent (green vs conventional)	South Korea	S	In-person survey, choice experiment to elicit consumers' purchasing preferences and willingness to pay for a green laundry detergent (i.e., natural ingredients, biodegradability, and skin irritation potential) ($N = 919$)	Consumers have a high marginal willingness to pay for a laundry detergent made of natural ingredients.
Kaushal and Nema (2012)	D	Mobile phone	India	T	Game theory model to determine consumers' and manufacturers' preference for hazardous or hazardous-free mobile phones	Consumers will prefer hazardous free mobile phones with a take back scheme promoted by the manufacturer, if there is an incentive for the consumer (e.g., discount in purchasing a new phone). The incentive will depend on the cost difference between hazardous free and

Table A1 (*continued*)

Article	Consumer behaviour	Product(s) analysed	Location	Research method	Description of research method	Key result(s)
						hazardous phones (at least 2.9 % of the hazardous free phone cost for a 5 % cost difference).
Kim (2022)	P	Household chemical products (e.g., odour eliminator)	South Korea	E	Online experiments to assess the effect of manipulated safety claims ($N = 300$) and of safety claims and warnings ($N = 600$) on consumer perception	The presence of safety claims decreased consumers' perception of hazards compared to products without safety claims or warning symbols. Participants were also more likely to purchase the products with safety claims than products without safety claims.
Kim et al. (2019)	W	Not specified	South Korea	S	In-person survey, contingent valuation to elicit consumers' willingness to pay for labelling scheme ($N = 1000$)	Consumers were willing to pay on average 2.05 USD per year for an endocrine disrupting chemical free (EDC-free) labelling scheme through an increase of income taxes.
Klaschka (2020)	P, U	Cosmetics & personal care (e.g., perfume); cleaning product (e.g., laundry detergent)	Germany	S	Online survey to compare risk awareness and purchasing preferences between "fragrance-sensitive" and general participants ($N = 1102$)	Almost half of the general participants would not use a fragrance product, if they knew that the product emitted hazardous air pollutants. Over 40 % of the general participants prefers fragrance-free alternatives, when available. Information about a specific fragrance ingredient would affect the purchasing decision of a third of the general participants compared to half of the "fragrance-sensitive" respondents.
Lakhan (2016)	W, D	Electric & electronic products (e.g., mice); Household chemicals (e.g., paints and varnish)	Canada	S	In-person survey, contingent valuation to determine consumers' perception of environmental harm and willingness to pay for environmental fees ($N = 271$)	Participants' willingness to pay for environmental handling fees increased with a product's perceived environmental harm at the end of life. Consumers did not consider electronic products as harmful and were averse to pay an environmental fee. Consumer preference for fee visibility has a positive correlation with perceived environmental harm.
Laughery et al. (1993)	P, U	Household chemicals (e.g., oven cleaner); Hair dryer; Ladder	United States	E	In-person experiments with students to assess the effects of warning labelling on purchase preferences and use ($N = 226$)	Warning labels explicitness increased hazards perception and improved intent to act cautiously when handling the products. No clear relationship was found between warning labels and purchase preferences.
Milovantseva (2016)	W	Mobile phone	United States	S	Online survey, contingent valuation to determine consumers' willingness to pay for a non-toxic mobile phone ($N = 3156$)	General environmental awareness, positive attitudes towards electronics' recycling and pro-environmental behaviour (i.e., engaging in environmental activities in the past 12 months) are positively associated with higher willingness to pay for a non-toxic mobile phone.
Mokan et al. (2018)	P	Not specified	Malaysia	S	In-person survey to assess the effect of knowledge, eco-labelling, and social influence on purchasing intentions ($N = 93$)	Pre-existing knowledge about product environmental impacts, eco-label, and social influences (i.e., information obtained from peers) significantly increased participants' purchase intention of green products.
Mostafa et al. (2022)	U	Cleaning products	Lebanon	S	In-person survey to assess toxicity awareness, behaviour, and information sources ($N = 176$)	Product label deemed most effective source of information to communicate product toxicity and to elicit safe behaviours among the participants. Respondents responsible for domestic cleaning demonstrated high awareness of cleaning products toxicity, but most did not engage in safety behaviour.
Nnorom et al. (2009)	W, D	Mobile phone	Nigeria	S	In-person survey, contingent valuation to assess willingness to pay for a mobile phone with fewer toxics and more energy efficient ($N = 115$)	Environmental awareness and concern for the deteriorating environment influenced participants' willingness to pay for a premium for a green mobile phone, which uses fewer toxic materials, and it is more energy efficient.

Table A1 (*continued*)

Article	Consumer behaviour	Product(s) analysed	Location	Research method	Description of research method	Key result(s)
Patak et al. (2021)	P	Household chemicals (e.g., detergent); Cosmetics	Czech Republic	S	Online survey to identify determinants of purchase intention for "green chemicals" ($N = 250$)	Environmental concern, product knowledge (e.g., labelling information), green lifestyle (e.g., take initiative to reduce environmental impacts), and promotion increased participants' intentions to purchase "green chemicals" (i.e., non-toxic chemicals).
Pollack-Nelson (1995)	U	Household chemicals (e.g., paint strippers)	United States	S	Phone survey to assess effect of labelling information on consumer use ($N = 4997$)	After reading product instructions, only a small number of participants changed their product use behaviour, particularly, ventilation practices.
Saleh et al. (2020)	U	Not specified	Switzerland	E	Online experiment to evaluate the effect of two communication strategies in reducing chemophobia and on perceptions of chemicals in consumer products ($N = 448$)	Communication strategy based on toxicological information reduced chemophobia and preference for natural substitutes, whilst increasing participants' knowledge and perception of the use of chemicals in consumer products. The affect-based approach improved positive perception of using chemicals but did not influence chemophobia.
Saphores et al. (2007)	W	Green electronics: mobile phone and desktop computer	United States	S	Mailed in survey, contingent valuation to determine willingness to pay for hazardous-free mobile phone and desktop computer ($N = 372$)	Participants demonstrated a low willingness to pay for a premium for green electronics. Most participants willing to pay 1 % premium for a 'green' mobile phone or desktop computer. Low willingness to pay might be related to participants' lack of knowledge about toxicity of electronic waste.
Scherer et al. (2017)	P	Bio-based sand toys	Germany	E	Online choice experiment to determine product attributes influencing parents' purchasing preferences ($N = 521$)	Price, origin of raw materials and ecological product characteristics (e.g., % bio-based plastic and environmental impact) are the most important attributes influencing purchasing intentions. Information about additives (may include toxic substances) was of low importance for respondents, except for ecological sensitive respondents.
Sim et al. (2019)	U	Household chemicals (e.g., air fresheners)	South Korea	S	Online survey to assess consumers' awareness of potentially harmful chemicals in products ($N = 10{,}000$)	Most participants believed that natural, eco-labelled or children's products did not contain "harmful" chemicals. Participants reported using the products as little as possible and following safety instructions as the main risk-reduction strategies.
Siwayanan et al. (2015)	P, W	Eco-friendly laundry detergent powder	Malaysia	S	In-person survey to elicit consumers' purchasing preferences and willingness to pay for an eco-friendly laundry detergent powder (with green palm oil) ($N = 112$)	Most participants were unaware surfactants used in laundry detergents, as well as about the existence of laundry detergent powders with palm oil. However, most respondents would prefer the eco-friendly laundry detergent powder and would be willing to pay a premium.
Tribby et al. (2021)	P	Sunscreen	United States	I	Online pre-screening questionnaire followed by in-person interview to assess the effect of ingredient list on consumers' purchasing preference ($N = 47$)	Different ingredient list formats did not improve participants' information recalling. Active ingredient list was of low importance for participants when choosing a sunscreen to purchase. Instead, participants reported that ingredients are a reason not to choose a product (perceived adverse effects).
Viscusi and Magat (1986)	U, W	Cleaning products (liquid bleach and drain opener)	United States	E	Field experiment to determine the effect of warning labelling information on consumers' precautionary behaviour and willingness to pay ($N = 368$)	Participants' precautionary behaviour influenced by provision and specificity of risk information, amount of information and format used to communicate (i.e., labelling in product). Respondents were willing to pay an extra of $0.79 and $1.79 per bottle of bleach and drain opener, respectively, to avoid precautionary behaviours.

Table A1 (*continued*)

Article	Consumer behaviour	Product(s) analysed	Location	Research method	Description of research method	Key result(s)
Yao et al. (2019)	W	Handwashing liquid soap	New Zealand	S, E	Online survey, choice experiment to determine consumers' preference and willingness to pay for changes in product's attributes (*N* = 385)	Respondents willing to pay a premium for handwashing soap with natural ingredients and antibacterial properties, hypo-allergic and eco-friendly certified. The analysis also indicated that respondents would benefit from additional information on antibacterial ingredients.
Wogalter et al. (1994)	U	Household chemicals (e.g., fabric protector); personal care (e.g., toothpaste)	United States	E	In- person experiment with shoppers, high school, and university students to assess the effect of product labelling on perceived hazardousness (*N* = 135)	Warning pictograms did not influence participants' perception of hazards, while presence of warning words increased their perceived hazardousness (particularly, among young participants).
Zollo et al. (2021)	P	Personal care products	Italy and Spain	S	Online survey to evaluate the effect of online reviews on purchasing intentions (*N* = 473)	Electronic word-of-mouth (e.g., online reviews) influences purchasing decisions of personal care products.

References

Akerboom, S., Trommelen, M., 1998. Environmental labeling on household chemicals: comprehensibility and impact on warning information. Int. J. Cogn. Ergon. 2 (1), 107–122 s.

Anderson, A.G., Grose, J., Pahl, S., Thompson, R.C., Wyles, K.J., 2016. Microplastics in personal care products: exploring perceptions of environmentalists, beauticians and students. Mar. Pollut. Bull. 113 (1–2), 454–460. https://doi.org/10.1016/j.marpolbul.2016.10.048.

Ashley, J.M., Hodgson, A., Sharma, S., Nisker, J., 2015. Pregnant women's navigation of information on everyday household chemicals: phthalates as a case study. BMC Pregnancy Childbirth 15 (1). https://doi.org/10.1186/s12884-015-0748-0.

Asioli, D., Aschemann-Witzel, J., Caputo, V., Vecchio, R., Annunziata, A., Naes, T., Varela, P., 2017. Making sense of the "clean label" trends: a review of consumer food choice behavior and discussion of industry implications. Food Res. Int. 99, 58–71. https://doi.org/10.1016/j.foodres.2017.07.022.

Avery, C.E., 1982. Consumer response to the Tris controversy - a research study. Accid. Anal. Prev. 14 (6), 465–473. https://doi.org/10.1016/0001-4575(82)90060-4.

Banda, S.F., Sichilongo, K., 2006. Analysis of the level of comprehension of chemical hazard labels: a case for Zambia. Sci. Total Environ. 363 (1–3), 22–27. https://doi.org/10.1016/j.scitotenv.2005.10.011.

Basso, F., Bouille, J., Le Goff, K., Robert-Demontrond, P., Oullier, O., 2016. Assessing the role of shape and label in the misleading packaging of food imitating products: from empirical evidence to policy recommendation. Front. Psychol. 7, 450. https://doi.org/10.3389/fpsyg.2016.00450.

Bastounis, A., Buckell, J., Hartmann-Boyce, J., Cook, B., King, S., Potter, C., Bianchi, F., Rayner, M., Jebb, S.A., 2021. The impact of environmental sustainability labels on willingness-to-pay for foods: a systematic review and Meta-analysis of discrete choice experiments. Nutrients 13 (8). https://doi.org/10.3390/nu13082677.

Bearth, A., Siegrist, M., 2019. Situative and product-specific factors influencing consumers' risk perception of household cleaning products. Saf. Sci. 113, 126–133. https://doi.org/10.1016/j.ssci.2018.11.023.

Bearth, A., Kwon, S., Siegrist, M., 2021a. Chemophobia and knowledge of toxicological principles in South-Korea: perceptions of trace chemicals in consumer products. J. Toxicol. Environ. Health A 84 (5), 183–195. https://doi.org/10.1080/15287394.2020.1851834.

Bearth, A., Saleh, R., Lee, G., Kwon, S., 2021b. Trace chemicals in consumer products - Consumers' acceptance before and after receiving information about toxicological principles. Food Chem. Toxicol. 153 https://doi.org/10.1016/j.fct.2021.112252.

Blackman, A.B., Luskin, J., 2006. A community-based initiative to reduce children's exposure to toxics in household products. Health Educ. 106 (2), 98–113. https://doi.org/10.1108/09654280610650945.

Braun, C.C., Silver, N.C., 1995. Interaction of signal word and colour on warning labels: differences in perceived hazard and behavioural compliance. Ergonomics 38 (11), 2207–2220. https://doi.org/10.1080/00140139508925263.

Buchmüller, K., Bearth, A., Siegrist, M., 2020. Consumers' perceptions of chemical household products and the associated risks. Food Chem. Toxicol. 143, 111511 https://doi.org/10.1016/j.fct.2020.111511.

Buchmüller, K., Bearth, A., Siegrist, M., 2022. The influence of packaging on consumers' risk perception of chemical household products. Appl. Ergon. 100 https://doi.org/10.1016/j.apergo.2021.103676.

Buchmüller, K., Xu, C., Bearth, A., Siegrist, M., 2022b. Consumers' decision-making process when choosing potentially risky, frequently used chemical household products: the case of laundry detergents. Environ. Res. 209 https://doi.org/10.1016/j.envres.2022.112894.

Choi, E., Lee, K.C., 2019. Effect of Trust in Domain-Specific Information of safety, brand loyalty, and perceived value for cosmetics on purchase intentions in Mobile E-commerce context. Sustainability 11 (22). https://doi.org/10.3390/su11226257.

Choi, Y.R., Chen, K.J., Marsh, T.L., 2020. Consumer preference for bio-based batteries. J. Consum. Behav. 19 (4), 382–396. https://doi.org/10.1002/cb.1827.

Clarke, N., Pechey, E., Košĭte, D., König, L.M., Mantzari, E., Blackwell, A.K., Hollands, G. J., 2021. Impact of health warning labels on selection and consumption of food and alcohol products: systematic review with meta-analysis. Health Psychol. Rev. 15 (3), 430–453.

Deturck, M.A., Rachlin, R.A., Young, M.J., 1994. Effects of a role-model and fear in warning label on perceptions of safety and safety behavior. Adv. Consume. Res., Vol Xxi 21 (1), 208–212 doi:0098-9258.

Dimova, E.D., Mitchell, D., 2021. Rapid literature review on the impact of health messaging and product information on alcohol labelling. Drugs: Education, Prevention and Policy 29 (5), 451–463. https://doi.org/10.1080/09687637.2021.1932754.

Dodson, R.E., Boronow, K.E., Susmann, H., Udesky, J.O., Rodgers, K.M., Weller, D., Woudneh, M., Brody, J.G., Rudel, R.A., 2020. Consumer behavior and exposure to parabens, bisphenols, triclosan, dichlorophenols, and benzophenone-3: results from a crowdsourced biomonitoring study. Int. J. Hyg. Environ. Health 230, 113624. https://doi.org/10.1016/j.ijheh.2020.113624.

EPA, 2022. Safer Choice Standard and Criteria. Retrieved 11/04/2023 from. https://www.epa.gov/saferchoice/standard.

European Chemicals Agency, 2023. Harmonised Enforcement Pilot Project on integrated chemical compliance of products. ECHA-23-R-13-EN.

European Commission, 2017. Special Eurobarometer 456 - chemical safety. https://europa.eu/eurobarometer/surveys/detail/2111.

European Commission, 2023. EU Ecolabel. Retrieved 11/04/2023 from. https://environment.ec.europa.eu/topics/circular-economy/eu-ecolabel-home_en.

Fabelova, L., Beneito, A., Casas, M., Colles, A., Dalsager, L., Den Hond, E., Dereumeaux, C., Ferguson, K., Gilles, L., Govarts, E., Irizar, A., Lopez Espinosa, M.J., Montazeri, P., Morrens, B., Patayova, H., Rausova, K., Richterova, D., Rodriguez Martin, L., Santa-Marina, L., Palkovicova Murinova, L., 2023. PFAS levels and exposure determinants in sensitive population groups. Chemosphere 313, 137530. https://doi.org/10.1016/j.chemosphere.2022.137530.

Findrik, E.I., Morawetz, U.B., 2019. Who would pay more for a fragrance-free laundry detergent? How health information affects valuation. Appl. Econ. 51 (23), 2453–2467. https://doi.org/10.1080/00036846.2018.1545081.

Fischhoff, B., 1995. Risk perception and communication unplugged: twenty years of process. Risk Anal. 15 (2).

Gam, H.J., Cao, H., Farr, C., Kang, M., 2010. Quest for the eco-apparel market: a study of mothers' willingness to purchase organic cotton clothing for their children. Int. J. Consum. Stud. 34 (6), 648–656. https://doi.org/10.1111/j.1470-6431.2010.00898.x.

Geuens, M., Byrne, D., Boeije, G., Peeters, V., Vandecasteele, B., 2021. Investigating the effectiveness of simplified labels for safe use communication: the case of household detergents. Int. J. Consum. Stud. 45 (6), 1410–1424. https://doi.org/10.1111/ijcs.12662.

Goswami, P., 2008. Is the urban Indian consumer ready for environment-friendly apparel? Int. J. Green Econ. 2 (4), 411–426. https://doi.org/10.1504/IJGE.2008.022450.

Grolleau, G., Ibanez, L., Mzoughi, N., 2009. Too much of a good thing? Why altruism can harm the environment? Ecol. Econ. 68 (7), 2145–2149. https://doi.org/10.1016/j.ecolecon.2009.02.020.

Gruère, G.P., 2015. An analysis of the growth in environmental labelling and information schemes. J. Consum. Policy 38, 1–18. https://doi.org/10.1007/s10603-014-9275-z.

Hartmann, S., Klaschka, U., 2017. Interested consumers' awareness of harmful chemicals in everyday products. Environ. Sci. Eur. 29 (1), 29. https://doi.org/10.1186/s12302-017-0127-8.

Holmquist, H., Jagers, S.C., Matti, S., Svanstrom, M., Peters, G.M., 2018. How information about hazardous fluorinated substances increases willingness-to-pay for

alternative outdoor garments: a Swedish survey experiment. J. Clean. Prod. 202, 130–138. https://doi.org/10.1016/j.jclepro.2018.07.215.

Ippolito, P.M., 1981. Information and the life-cycle consumption of hazardous goods. Econ. Inq. 19 (4), 529–558. https://doi.org/10.1111/j.1465-7295.1981.tb00337.x.

Jansen, T., Claassen, L., van Kamp, I., Timmermans, D.R., 2020. 'All chemical substances are harmful.'public appraisal of uncertain risks of food additives and contaminants. Food Chem. Toxicol. 136, 110959.

Jo, M., Shin, J., 2017. Market strategy for promoting green consumption: consumer preference and policy implications for laundry detergent. Int. J. Consum. Stud. 41 (3), 283–290. https://doi.org/10.1111/ijcs.12339.

Johnson, A.C., Jin, X., Nakada, N., Sumpter, J.P., 2020. Learning from the past and considering the future of chemicals in the environment. Science 367 (6476), 384–387. https://doi.org/10.1126/science.aay6637.

Kaushal, R.K., Nema, A.K., 2012. An analysis of preferences for hazardous substances free products: manufacturing, use and end of life of mobile phones. Waste Manag. Res. 30 (11), 1169–1177. https://doi.org/10.1177/0734242x12454697.

Kim, H.J., Lee, H.J., Yoo, S.H., 2019. Public willingness to pay for endocrine disrupting chemicals-free labelling policy in Korea. Appl. Econ. 51 (2), 131–140. https://doi.org/10.1080/00036846.2018.1494803.

Kim, S., 2022. The effect of safety claims on consumer chemical product perceptions and the role of warnings. Hum. Factors. https://doi.org/10.1177/00187208221107721.

Klaschka, U., 2020. Between attraction and avoidance: from perfume application to fragrance-free policies. Environ. Sci. Eur. 32 (1), 98. https://doi.org/10.1186/s12302-020-00377-8.

Klintman, M., 2016. A review of public policies relating to the use of environmental labelling and information schemes (ELIS). *OECD Environment Working Papers*(105). https://doi.org/10.1787/5jm0p34bk7hb-en.

Knox, K.E., Dodson, R.E., Rudel, R.A., Polsky, C., Schwarzman, M.R., 2023. Identifying toxic consumer products: a novel data set reveals air emissions of potent carcinogens, reproductive toxicants, and developmental toxicants. Environ. Sci. Technol. 57 (19), 7454–7465.

Kortenkamp, A., Faust, M., 2018. Regulate to reduce chemical mixture risk. Science 361 (6399), 224–226. https://doi.org/10.1126/science.aat9219.

Lakhan, C., 2016. Consumer perception of environmental harm and willingness to pay environmental handling fees. Environments 3 (1), 1–12. https://doi.org/10.3390/environments3010008.

Larouzee, J., Le Coze, J.-C., 2020. Good and bad reasons: the Swiss cheese model and its critics. Saf. Sci. 126 https://doi.org/10.1016/j.ssci.2020.104660.

Laughery, K.R., Wogalter, M.S., 2014. A three-stage model sumarizes product warning and environmental sign research. Saf. Sci. 61, 3–10. https://doi.org/10.1016/j.ssci.2011.02.012.

Laughery, K.R., Vaubel, K.P., Young, S.L., Brelsford, J.W., Rowe, A.L., 1993. Explicitness of consequence information in warnings. Saf. Sci. 16 (5–6), 597–613. https://doi.org/10.1016/0925-7535(93)90025-9.

Li, D., Suh, S., 2019. Health risks of chemicals in consumer products: a review. Environ. Int. 123, 580–587. https://doi.org/10.1016/j.envint.2018.12.033.

List, J.A., Gallet, C.A., 2001. What experimental protocol influence disparities between actual and hypothetical stated values? Environ. Resour. Econ. 20, 241–254.

Majer, J.M., Henscher, H.A., Reuber, P., Fischer-Kreer, D., Fischer, D., 2022. The effects of visual sustainability labels on consumer perception and behavior: a systematic review of the empirical literature. Sustain. Product. Consum. 33, 1–14. https://doi.org/10.1016/j.spc.2022.06.012.

Milovantseva, N., 2016. Are American households willing to pay a premium for greening consumption of information and communication technologies? J. Clean. Prod. 127, 282–288. https://doi.org/10.1016/j.jclepro.2016.04.001.

Mokan, K.V., Lee, T.C., Bhoyar, M.R., 2018. The intention of green products purchasing among malaysian consumers: a case study of Batu pahat, Johor. Ind. J. Public Health Res. Develop. 9 (10), 996–1001. https://doi.org/10.5958/0976-5506.2018.01300.1.

Mostafa, H., Rizk, J., Kanaan, E., Hamade, H., Kaddoura, R., Tamim, H., Sakr, C., El Zahran, T., 2022. Consumer knowledge and awareness of the toxicity and handling of household products at a tertiary care center in Beirut. Lebanon. Toxicol. Indust. Health 38 (7), 408–416. https://doi.org/10.1177/07482337221106421.

Nazaroff, W., Weschler, C.J., Little, J.C., Hubal, E.A.C., 2012. Intake to production ratio: a measure of exposure intimacy for manufactured chemicals. Environ. Health Perspect. 120 (12), 1678–1683.

Nnorom, I.C., Ohakwe, J., Osibanjo, O., 2009. Survey of willingness of residents to participate in electronic waste recycling in Nigeria – a case study of mobile phone recycling. J. Clean. Prod. 17 (18), 1629–1637. https://doi.org/10.1016/j.jclepro.2009.08.009.

OEHHA, 2023. What is Proposition 65? Retrieved 11/04/2023 from. https://www.p65warnings.ca.gov/.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hrobjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P., Moher, D., 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 372 (71). https://doi.org/10.1136/bmj.n71.

Pang, B., Saleme, P., Seydel, T., Kim, J., Knox, K., Rundle-Thiele, S., 2021. The effectiveness of graphic health warnings on tobacco products: a systematic review on

perceived harm and quit intentions. BMC Public Health 21 (1), 884. https://doi.org/10.1186/s12889-021-10810-z.

Patak, M., Branska, L., Pecinova, Z., 2021. Consumer intention to purchase green consumer chemicals. Sustainability 13 (14). https://doi.org/10.3390/su13147992.

Persson, L., Carney Almroth, B.M., Collins, C.D., Cornell, S., De Wit, C.A., Diamond, M.L., Hauschild, M.Z., 2022. Outside the safe operating space of the planetary boundary for novel entities. Environ. Sci. Technol. 56 (3), 1510–1521.

Pollack-Nelson, C., 1995. Analysis of methylene chloride product labelling. Ergonomics 38 (11), 2176–2187. https://doi.org/10.1080/00140139508925261.

Potter, C., Bastounis, A., Hartmann-Boyce, J., Stewart, C., Frie, K., Tudor, K., Bianchi, F., Cartwright, E., Cook, B., Rayner, M., Jebb, S.A., 2021. The effects of environmental sustainability labels on selection, purchase, and consumption of food and drink products: a systematic review. Environ. Behav. 53 (8), 891–925. https://doi.org/10.1177/0013916521995473.

Reason, J., 1997. Managing the Risks of Organizational Accidents. Ashgate Publishing.

Saleh, R., Bearth, A., Siegrist, M., 2020. Addressing Chemophobia: informational versus affect-based approaches. Food Chem. Toxicol. 140, 111390 https://doi.org/10.1016/j.fct.2020.111390.

Saphores, J.-D.M., Nixon, H., Ogunseitan, O.A., Shapiro, A.A., 2007. California households' willingness to pay for 'green' electronics. J. Environ. Plan. Manag. 50 (1), 113–133. https://doi.org/10.1080/09640560601048549.

Scheibehenne, B., Greifeneder, R., Todd, P.M., 2010. Can there ever be too many options? A Meta-analytic review of choice overload. J. Consum. Res. 37 (3), 409–425. https://doi.org/10.1086/651235.

Scherer, C., Emberger-Klein, A., Menrad, K., 2017. Biogenic product alternatives for children: consumer preferences for a set of sand toys made of bio-based plastic. Sustain. Product. Consump. 10, 1–14. https://doi.org/10.1016/j.spc.2016.11.001.

Siegrist, M., Bearth, A., 2019. Chemophobia in Europe and reasons for biased risk perceptions. Nat. Chem. 11 (12), 1071–1072. https://doi.org/10.1038/s41557-019-0377-8.

Sim, S., Lee, J., Uhm, Y., Kim, S., Han, E.J., Choi, K., Choi, J., Ban, Q.M., Cho, T., Kim, A. Y., Lee, D.I., Lim, E., Lee, Y., 2019. Korean consumers' awareness of the risks of chemicals in daily consumer products. *Environmental Sciences*. Europe 31 (1). https://doi.org/10.1186/s12302-019-0278-x.

Siwayanan, P., Bakar, N.A., Aziz, A., Chelliapan, S., 2015. Exploring Malaysian household consumers acceptance towards eco-friendly laundry detergent powders. *Asian*. Soc. Sci. 11 (9) https://doi.org/10.5539/ass.v11n9p125.

Slovic, P., 1987. Perception of risk. Science 236 (4799), 280–285. https://doi.org/10.1126/science.3563507.

Slovic, P., Finucane, M.L., Peters, E., MacGregor, D.G., 2004. Risk as analysis and risk as feelings: some thoughts about affect, reason, risk, and rationality. Risk Anal. 24 (2), 311–322. https://doi.org/10.1111/j.0272-4332.2004.00433.x.

Slunge, D., Alpizar, F., 2019. Market-based instruments for managing hazardous chemicals: a review of the literature and future research agenda. Sustainability 11 (16). https://doi.org/10.3390/su11164344.

Slunge, D., Miguel, M., Lindahl, L., Backhaus, T., 2023. The implementation of the substitution principle in European chemical legislation: a comparative analysis. Environ. Sci. Eur. 35 (1), 107.

Sturgis, P., Allum, N., 2004. Science in society: re-evaluating the deficit model of public attitudes. Public Underst. Sci. 13 (1), 55–74. https://doi.org/10.1177/0963662504042690.

Taufique, K.M.R., Nielsen, K.S., Dietz, T., Shwom, R., Stern, P.C., Vandenbergh, M.P., 2022. Revisiting the promise of carbon labelling. Nat. Clim. Chang. 12 (2), 132–140. https://doi.org/10.1038/s41558-021-01271-8.

Tribby, C.P., Julian, A.K., Perna, F.M., 2021. Perceived usefulness and recall of sunscreen label information by consumers. JAMA Dermatol. 157 (5), 573–576. https://doi.org/10.1001/jamadermatol.2020.5394.

United Nations, 2021. Globally Harmonized System of Classification and Labelling of Chemicals (GHS).

Viscusi, W.K., Magat, W.A., 1986. Informational regulation of consumer health risks: an empirical evaluation of hazard warnings. Rand J. Econ. 17 (3), 351–365. https://doi.org/10.2307/2555716.

Viscusi, W.K., Zeckhauser, R.L., 1996. Hazard communication: warnings and risk. Ann. Am. Acad. Pol. Social Sci. 545, 106–115. https://www.jstor.org/stable/1047897.

Wang, Z., Walker, G.W., Muir, D.C., Nagatani-Yoshida, K., 2020. Toward a global understanding of chemical pollution: a first comprehensive analysis of national and regional chemical inventories. Environ. Sci. Technol. 54 (5), 2575–2584.

Wogalter, M.S., Jarrard, S.W., Simpson, S.N., 1994. Influence of warning label signal words on perceived Hazard level. Hum. Factors 36 (3), 547–556. https://doi.org/10.1177/001872089403600310.

Yao, R.T., Langer, E.R., Leckie, A., Tremblay, L.A., 2019. Household preferences when purchasing handwashing liquid soap: a choice experiment application. J. Clean. Prod. 235, 1515–1524. https://doi.org/10.1016/j.jclepro.2019.07.002.

Zollo, L., Carranza, R., Faraoni, M., Díaz, E., Martín-Consuegra, D., 2021. What influences consumers' intention to purchase organic personal care products? The role of social reassurance. J. Retail. Consum. Serv. 60 https://doi.org/10.1016/j.jretconser.2020.102432.