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CONSUMERS, FOOD SAFETY KNOWLEDGE, AND TRUST: INSIGHTS FOR EFSA RISK COMMUNICATION

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Consumers, Bisphenol A and Trust: Insights for EFSA Risk Communication

ABSTRACT

The scope of this research lies in the application of quantitative methods to serve public policy goals, specifically in supporting public institutions, as the European Food Safety Authority (EFSA), in communication activities, in their definition and evaluation phases. In this specific thesis, risk perceptions of Bisphenol-A in food contact materials is investigated along with the evaluation of possible risk communication formats on the topic.

The work on this specific dimension of the food system is introduced and contextualized in the Background section, which provides an overview of the global agri-food sector in the framework of Agenda 2030' objectives. This allows to highlight the relevance of investigating food-related public communications by global institutional actors, to be effective in targeting the population and redirecting consumption towards safer, more responsible and sustainable paths. The role of EFSA, as well as a brief historical analysis of the use of plastics and chemicals in EU food production, will pave the way, discussing why patterns of chemophobia have arisen and how changes in food consumption habits have occurred among Europeans. The present thesis thus aims at quantitatively assessing risk perceptions and knowledge measures about Bisphenol A (BPA) in the European population and to test related communication formats.

Bisphenol A (BPA) is a chemical substance used in combination with other chemicals to manufacture certain plastics and resins. It is used, for example, in polycarbonate plastic, a transparent and rigid type of plastic used to make water dispensers, food storage containers, and reusable beverage bottles. It can be found in various types of food and beverage packaging. Chemicals such as BPA used in foodstuff containers can migrate in very small amounts to the food and drinks they contain, so EFSA's scientists regularly review their safety, considering new data. BPA was eventually banned by the EU in December 2024 from food contact materials. The last tolerable daily intake (TDI) set before ban, in 2022, was significantly lowered with respect to the previous (from 4 micorgrams to 0.2 nanograms, which is 20.000 times lower). This raised the necessity by public institutions to understand how BPA was perceived in the EU and to communicate these new limits. The research exploits data from the EFSA Flashpoll dataset, a sample of 8600 respondents in 24 EU member states surveyed in December 2022, to develop two different analyses.

The first study investigates BPA generic attitudes, BPA consumers' objective knowledge, self-reported lack of knowledge, and their determinants. Associations will be examined through appropriate statistical modelling, accounting for all relevant variables, from sociodemographic to behavioral dimensions. This is complemented with descriptive analysis of key figures: Dose-response relationship knowledge and BPA Knowledge, BPA proxied consumption levels, trust in EU regulators, BPA avoidance, and chemophobia. A geographical analysis is carried out in parallel to understand if differences in BPA knowledge measures arise among EU countries.

A second study focuses more on risk perceptions and communication strategies. The primary aim is to map, among the EU population sample, levels of BPA concern, the extent to which respondents believe that BPA exposure poses a risk to their health and to the health of their children, and to analyze any parenthood effect on health risk preceptions. A secondary objective is to conduct a communication experiment about the last TDI (tolerable daily intake) of 0.2 nanograms, set before the ban by the European Commission in 2024. The sample is split into experimental groups to observe first the effect of different messages, then the role of the parenthood condition, and finally the influence of other covariates on the study's target variables. Impacts are examined through appropriate statistical modelling techniques..

The concluding chapter draws some risk communication lessons from the BPA case study. More specifically, it discusses communication on the dose-response relationship, practical guidance on safe use, and how regular public reporting can guide the population towards safer and sustainable food habits. Evidence-based guidelines for effective communication could give major support to the green transition. When institutions communicate consistently and with attention to the audiences for whom the stakes are higher, people respond with greater balance and capability. Communication, as discussed in this thesis, is not subordinate to regulation, but has a central role in protecting the public from foodborne risks.

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Foreword: Quantitative methods for “good”

This thesis—as provided by the grant that funded my PhD—examines how quantitative methods can support the adoption of effective food policies. As discussed later, the practical objective of this research is to analyze consumer knowledge and perceptions of risks related to chemical contaminants in food. While the studies presented stem from work conducted during my traineeship at the European Food Safety Authority (EFSA), they contributed to the broader debate on the need for evidence-based action in environmental protection and sustainability by quantitative analysts, which strongly motivated my PhD objectives.

Public concern and awareness about sustainability have risen sharply, and research related to Environmental, Social, and Governance (ESG) issues is growing, propelled by multiple drivers. Consider the UN 2030 Agenda for Sustainable Development and the associated Sustainable Development Goals (SDGs), as well as the incorporation of sustainability requirements into regulatory frameworks. Added to this, there is mounting pressure to address environmental challenges. Earth-system scientists warn that humanity has limited time—roughly to 2030—to change course and avoid a “Hothouse Earth” trajectory (Steffen, et al., 2018).

Against this backdrop, I believe quantitative methods can play a fundamental role—both in research and in practice. Applying statistical and mathematical methods, as well as econometrics and computer science, to generate predictions, reveal trends, explain causes, and quantify the expected impacts of interventions enables decisions to rest on numbers rather than words alone. Matched to that, I believe that the moral commitment of Quant researchers and practitioners should shift to more ethical fields of study rather than purely money-making disciplines, given current global challenges. In this respect, there is a growing set of case studies showing how quantitative methods for sustainability can move from theory to daily business and practice.

In Italy, emerging from one of the most economically challenging periods in recent history due to COVID-19, several long-term consequences are now visible. Institutions have responded to widening inequalities—especially along ESG dimensions—with recovery initiatives such as the Italian Piano Nazionale di Ripresa e Resilienza (PNRR[1]) and NextGenerationEU, which is financing this research.

Social considerations are luckily increasingly influencing finance, a domain that relies heavily on quantitative measurement. Some investors pursue blended-value strategies, seeking social returns and, at times, prioritizing them over financial ones (Boni, et al., 2021). Impact investing further reinforces this link. Quantitative approaches can support, for instance, what might be termed "good finance," an area of growing interest, as seen in the proliferation of ESG-labelled funds.

The relevance of ESG research in financial institutions and corporate decision-making is expanding (Ziolo, et al., 2019). Drivers include reputational risk, regulatory integration of ESG requirements, and the impetus from post-pandemic recovery plans. The 2030 Agenda underscores the urgency of a sustainability shift, and many sectors—finance among them—are responding via both compensatory and proactive strategies. Implementing this transition rapidly is non-trivial: it entails uncertainty, initially modest returns, and coordination within and between countries, especially through the intermediate adaptation period. Moreover, despite growing attention to sustainability, academic curricula and practical implementation still have substantial room to evolve.

This raises two questions: to what extent can quantitative methods contribute to this transition and to recovery challenges, and how broad is their scope? In financial markets, statistical, mathematical, and econometric methods are already routine when it comes to the money-making machine. Though evidence (e.g., Ziolo et al., 2019) suggests that quantitative approaches are useful for analyzing ESG factors. They also expand the analytical toolbox for sustainable portfolio construction and can harness today's data abundance to build sustainability and recovery metrics across domains. At the same time, scholars argue these methods should complement expert judgement and qualitative analysis; importantly, quantitative sustainable investing is still in its early days (Sorensen, et al., 2021) with much room for development.

[1] PNRR stands for National Plan for Recovery and Resilience, and it is the post Covid-19 Italy's strategic framework for investment and reform, financed through the European Union's *Next Generation EU* program. It aims to promote sustainable economic growth, digital and ecological transition, and social inclusion after the COVID-19 crisis. The plan outlines targeted measures and milestones to enhance productivity, resilience, and institutional efficiency within a green and innovation-driven paradigm.

Given the purpose and state of research, I see value in extending quantitative analysis beyond traditional topics to ESG themes related to the PNRR. This could unlock promising avenues for change and social improvement driven by public governance activity.

Two projects, in particular, have inspired me by illustrating practical relevance from both corporate and research perspectives.

From a corporate angle, Hera S.p.A., a major international energy firm which numerous municipality contracted for providing public energy and more services, presented a seminar in February 2022 within a UNIBO Higher Education course in Mathematical Finance on AI applied to environmental services. An engineer described a machine-learning system—an on-board neural network for waste-collection trucks—providing just-in-time assessments of waste-sorting quality. By delivering quality information before arrival at recycling plants, the system promised greater efficiency and a strengthened circular economy. Although the application was at a prototype stage with limited ex-post performance data, the early results were encouraging. On top of that, they managed to make it economically convenient: the money saved out of reduced time waste and optimization procedures fully covers the cost of applying AI on the trucks.

On the research side, during my bachelor's and master's theses I investigated whether "good businesses"—profitable firms that also maintain fair levels of worker welfare—can exist in practice. Using a sample of roughly 30,000 Italian firms, I estimated several regression models relating profitability (with multiple proxies) to human-capital welfare (also proxied). In three out of four models, welfare measures were significant and positive predictors of profitability in the sample.

These examples suggest that quantitative methods can offer fresh perspectives on sustainability-oriented interventions, challenging the presumption that socially and environmentally beneficial actions are anti-economic. Rigorous quantitative evidence can help identify win–win corporate solutions and steer business strategy by confirming or rejecting hypotheses about the most effective approaches.

In the latter example, the base was historical data; nonetheless, quantitative methods are also powerful for anticipating future events, and predictive performance has expanded with computing power.

If the notion that sustainability and social improvement benefit from quantitative methods gains traction, positive spillovers could arise beyond this field. In firms, quantitative R&D

teams may be tasked not only with analytics but with designing solutions via machine learning and other advanced modelling, as it is already increasingly happening. In higher education, where the pedagogy of sustainability increasingly appears in non-quantitative disciplines, curricula could integrate stronger quantitative perspectives. Vice versa, quantitative curricula may include subjects on how the learned techniques may serve ESG needs, in terms of applications and directions.

More generally, problem-driven, evidence-based solutions grounded in rigorous quantitative approaches can help address societal challenges beyond sustainability and beyond the post-pandemic recovery, which may catalyze infinite interdisciplinary spillovers. When it comes to Public moves, from local ESG management towards the global goals of Agenda 2030, Quantitative methods can become a powerful enabler of multidisciplinary work to address related challenges, with a broad scope for application and progress.

1. Introduction

This thesis follows from the motivation—stated in the foreword—to contribute to a problem-driven, society-oriented application of quantitative methods to support food policies. The scope of application lies within the Agrifood sector. Specifically, I explore whether—and how—institutional communication can correct or redirect population-level food consumption towards healthier, more sustainable, and more responsible eating behaviors. The present work will evaluate the food risk perceived by a sample of the European population about the presence of Bisphenol-A in food contact materials, before its ban, and will investigate the effects over concern measures of different communication formats.

Communication strategies aimed at transmitting food-safety messages and educating the public towards more conscious food habits are among the key instruments used by public institutions to achieve their goals. Understanding the design patterns and effectiveness of these strategies is essential for evidence-based policy.

Bridging communication gaps between science and citizens is a critical pathway to achieve a genuine green transition rather than leaving it as a theoretical construct. For this reason, it is essential to develop communication strategies that effectively reach people and influence attitudes and behaviors (also through organizations, lobbies, local governments, and other stakeholders).

1.1. Research on food risk communication as a current priority

In a food landscape constantly exposed to changes, ranging from cultural to the sustainability dimension (as discussed in Chapter 2), communication strategies also need to be regularly updated to maintain and possibly boost their effectiveness. Effective communication is a crucial element in the current global agenda, which demands a rapid ecological transition.

Considering food safety communication, the scope is not as limited as one may initially think. According to European authorities, it entangles consumer expectations about food production methods and the final product, information sources, responses to information about risks and on the other hand benefits, as well as related trade-off decisions, and, nonetheless, institutional trust (EFSA, 2023). Indeed, evidence suggests that effective communication strategies should build upon trust and account for personal values, cultural context, and consumer expectations to be effective. The centrality of trust emerges as the main founding element to mitigate potential concerns linked to food risk (Onyeaka, 2025; EFSA, 2023). In this regard, researchers have also developed ad-hoc tools for self-evaluation destinated to food safety authorities, so that they can identify their own gaps in food risk communication and eventually foster their improvement and preparedness, as risk communication remains a core institutional and strategic function for these bodies (Kasza, et al., 2024). According to existing research, many food safety authorities still present structural limitations and there is room for improvement.

While trust is central, there are further requirements for public food safety communication to make it *good*. Studies suggest that, for instance, in cases of scientific uncertainty, it is better to provide a transparent communication about conflicting evidence rather than avoiding communication. This strategy also works as a powerful contrast to misinformation and fake news, which in case of uncertainty or newly incoming risks, easily and rapidly spread (Onyeaka, 2025).

Previous literature also recognizes a relevant role to scientific literacy and educational approaches (intended to be multidisciplinary) when it comes to the understanding of risks and to foster adherence to healthy habits and safe behaviours (De Cunha, 2025; Yeak, et al., 2025).

Ultimately, food safety is not merely about technical and biological controls, but it is concretely made by the interaction among risk perceptions, communication, and human behavior. Thus, it is influenced by the cultural dimension, by cognitive paths, and by psychological factors, too. Heterogeneity in risk perception across people is also the result of emotional traits, familiarity and media exposure (Yeak, et al., 2025). This is why communication regarding food safety must be customized: on the basis of the risk typology, taking relevantly into account the cultural context and considering the characteristics and personal values of the targeted audience, towards a tailor-made kind of communication strategy design (Onyeaka, 2025; EFSA, 2023; De Cunha, 2025; Yeak, et al., 2025).

This thesis positions itself on the two main points referenced above, with an application to the presence of Bisphenol-A in foodstuffs in the EU, until its ban from food contact materials in December 2024. When dealing with chemicals that enters into contact with food, the path to good communication becomes even more delicate, since public perception and objective, scientifically assessed risks may be significantly misaligned , with a frequent overestimation of these risks by the public (Yeak, et al., 2025). Thus, research and careful design of communication strategies on this topic are a priority among other types of food risk, since there is a need to address biased perceptions.

The first of our analysis aims at Understanding the target audience and identifying their needs, while different communication formats will be tested in a second analysis, also considering different subgroups within the EU population.

2. Context

Food policies and related communications are operated in a current environmental and social global context that evolves at the speed of light. This already highlights the need for constant monitoring of what the public sentiment is about risks, specifically when it comes to food. On top of that, stratify the numerous urgent needs associated with the green transition planned for the Agenda 2030, where the food dimension is central, and require fast, structural, as well as behavioral changes on a global scale.

The operational context will be debriefed, with the intent to clarify what the actors involved are, the obstacles, main challenges and ultimately the power of food policies and communicative strategies in meeting the Agenda 2030 goals.

2.1. Food chain responsibility in the ecological transition

What we eat, and how that food is produced, affects both our health and the environment. Food must be grown and processed, transported, distributed, prepared, consumed, and sometimes disposed of as waste. Each of these steps generates greenhouse gases (GHG) that contribute to global warming and climate change. According to the United Nations, more than 30% of anthropogenic GHG emissions are linked to food (United nations, 2022). Researchers estimate that approximately one-third of global GHG emissions are attributable to the food chain—from farm to table—including growing, processing, transportation, energy requirements, packaging, and waste (Crippa, et al., 2021). Crippa et al. also note that countries generating larger amounts of GHG often rely heavily on the agrifood sector, such as major exporters (e.g., Brazil) or countries with relatively weaker economies (e.g., many in Africa).

Emissions from the agrifood system are sufficiently large that, on their own, they could cause the world to miss the goal of limiting the rise in global average temperature to 1.5°C above pre-industrial levels. In contrast, emissions associated with food production and agricultural activities should fall to zero by 2050 (Sutton, et al., 2024). The urgency of shifting agriculture away from fossil-fuel dependence has been recognized for decades; already thirty years ago, scholars urged action to moderate emissions related to food production as an 'insurance policy' against geophysical catastrophe (Kaiser & Drennen, 1993). Evidence for the need to transform food systems and production chains worldwide has accumulated over many years.

Figure 1 - Sustainable development goals (United Nations, 2015)

Conversely, climate change affects the food sphere along multiple dimensions: availability, accessibility, utilization, and supply-chain stability. These pressures are particularly acute in developing countries—for example, in parts of East Africa, extreme climate events jeopardize food availability through crop losses and leave around half of households food-insecure (Gebre & Rahut, 2021). This is not new to research: early environmental studies already showed that food security diminishes when food systems are stressed by multiple factors, including global warming (Gregory, et al., 2005; Betts, et al., 2018). The two themes—climate and food—are strongly interlinked; neither can be addressed in isolation.

2.2. The Agri-food dimension in Agenda 2030

The agrifood sector and related topics are addressed from multiple perspectives in the UN 2030 Agenda. Inspecting SDGs[2], several targets relate directly to agrifood (e.g., Zero Hunger; Clean Water and Sanitation). Through the spillover effect, almost all other SDGs are affected by agrifood practices.

[2] Researchers connect their analysis more and more frequently to SDGs (Figure 1), Sustainable Development Goals, which are the objectives established in the Paris Agreement of 2015: a legally binding international agreement which states, on top of many other mandatory objectives, the limit global warming to 1.5°C, greenhouse gas emissions to peak before 2025 at the latest and their decline 43% by 2030 (UNFCCC, 2015).

- No poverty: Poverty is the condition of lacking the means to satisfy basic needs—insufficient income or material resources. Poverty intersects with food availability and employment, among other aspects. In 2021, an estimated 39% of the world's population worked in the agrifood sector, according to FAO figures. A large share of agrifood workers operate in the informal economy and are thus not fully captured by official statistics. For instance, according to the report ILO/96/26, approximately 1.1 billion workers are active in agricultural production worldwide, nearly half in wage labor, many earning incomes at or below subsistence (International Labour Organization, 1996). By 2022, FAO reported that 26.6% of the global workforce was employed in agriculture (FAO, 2022).

- Good health and wellbeing: The World Health Organization recognizes that safe food and appropriate dietary habits are foundational for good health. Malnutrition remains a major threat to global health, while obesity has surpassed one billion people worldwide in 2024 (World health organization, 2024). Proper nutrition is a primary prevention lever against many chronic diseases.

- Decent work and economic growth: In Europe, by 2019 around 20% of agricultural workers were estimated to be in the shadow economy (Schneider, et al., 2021). The share of informal work is even higher in many other regions. The ILO (2018) reports that agriculture has the highest share of informal workers globally over 90% (International Labour Organization, 2018). Farm workers commonly face difficult and hazardous conditions, often with insufficient housing and health care (National center for farmworker health, 2002). Given the sector's global predominance as a source of employment, its relevance to this goal is evident.

- Industry, innovation and infrastructure: These dimensions are critical for food safety and availability. Food-system infrastructure spans the entire supply chain between producers and consumers, including inputs (seed, feed, compost), equipment services, processors, distributors, retailers, logistics, waste management, surplus-food rescue, and the workforce that enables these functions. Inadequate infrastructure hampers agrifood markets much like poor transport networks hinder mobility (Cantrell & Lewis, 2010).

- Reduced inequality: Inequalities in the agrifood sector—by gender, geography, and generation—have been recognised for over fifteen years. Allen and Wilson (2008) trace many patterns to globalisation, including policy orientations in large economies. Farmers are heavily affected by extreme climate events (e.g., droughts in India). Food availability constraints are unevenly distributed, as in many African contexts. From a gender perspective, food-related crises can disproportionately affect women, given their central roles in farming and family nutrition (Allen & Wilson, 2008).

- Responsible production and consumption: Agrifood encompasses both sides of this goal' production, farming, food processing and consumption choices as well. Sustainability of consumption is therefore crucial. For example, animal-based products (meat and dairy) generally require more resources and cause higher emissions than plant-based alternatives (Hertwich, et al., 2010). This underpins, beyond ethical considerations, the environmental rationale for plant-based diets.

- Climate action: Food systems account for more than one-third of global GHG emissions (FAO, 2021). At COP29 (Baku, November 2024), FAO and other actors highlighted farmers as agents of climate action and identified gaps and opportunities for policymaking that recognises and empowers farmers, villages, and rural communities (Climate Action, 2024).

- Partnership for the Goals: All of us are stakeholders in food systems and their impacts. Food involves international exchanges of goods and inputs as well as financial flows. Cross-national and cross-continental cooperation is key to steering global food systems—and the broader economy—towards decarbonisation.

2.3. Food issues in 2025

The 'food system' is a broad, integrative concept; consequently, current issues are multifaceted. Virtually everyone on the planet is a stakeholder, and innumerable groups are affected by sectoral shortcomings in 2025.

Globally, food production has grown over the last sixty years—more than population growth since 1961—yet food is still not sufficiently available to everybody (FAO). If there is enough food to nourish everyone, the gap is, among other reasons, largely explained by waste. According to the World Food Program and FAO, approximately 1.26 billion tons of food are wasted annually, roughly twice the amount needed to feed the undernourished population (World Food Program US, 2024).

At the country level, dependence on imports is another issue for domestic food supply. Only about one-third of countries can fulfil their food demand locally, necessitating international trade. In a study covering 186 countries, Stehl et al. report that only Guyana is self-sufficient (Stehl, et al., 2024). More broadly, proximity food is not always available in feasible terms or across the full spectrum of nutritional needs for a healthy diet. For crops, researchers show that only 11–28% of the global population can satisfy demand within a 100-km radius, with substantial regional variation; for 26–64% of the population, this distance exceeds 1000 km (Kinnunen, et al., 2020).

On a wider perspective, Earth has already crossed six out of nine planetary boundaries (Persson, et al., 2023; Steffen, et al., 2015). Previous analyses suggest that agrifood is the leading driver for five of these six boundaries, now beyond the safe operating space.

Rice, meat, and dairy products are among the most environmentally intensive foods; yet global diets, for cultural and availability reasons, still rely heavily on them. Of the world's land surface, 71% is habitable; 49% of this habitable land is used for agriculture, of which livestock occupies 73%, while crops account for 22% (UNCCD, 2019). This may appear paradoxical given that crops supply the bulk of calories, yet they occupy less than 8% of the global surface.

Agriculture—both livestock and crops—is also the largest user of global freshwater (FAO, "Water at a Glance"), one of the planetary boundaries already crossed. Better management and, where feasible, contraction of freshwater use in agrifood are urgent. In a reinforcing cycle, climate change also affects both the quantity and variety of foods, especially the kinds of crops that can be cultivated (Heikonen, et al., 2025).

These criticalities point to the need for optimized resource management—primarily land and water use. Because both are crucial for agrifood, to maximize protein and calorie availability it is reasonable to consider shifting more land to crops (Piipponen, et al., 2023). More sustainable production should be complemented by more sustainable consumption, including dietary change towards more sustainable diets. This would be facilitated, if not initialized, by food education and dissemination of more plant-based nutrition alternatives.

Overall, the above would help restore biosphere integrity: the planetary boundary most jeopardized by emissions. Given that food systems are the primary driver of GHG, pushing Earth beyond the safe operating space (Rockström, et al., 2009), it requires major moves towards the respect of planetary boundaries.

Finally, from a regulatory standpoint, shortcomings persist worldwide. Regulation, understood broadly, comprises formal law, market mechanisms (particularly relevant in Agrifood), and nonetheless, social norms. The latter are powerful levers for reducing food waste and shifting diets. Social norms are the implicit rules we learn from early life: while laws are constraints imposed by institutions, social norms are constraints imposed by people and society at large. A large share of daily food is consumed in organizational contexts (schools, workplaces): many are public. Thus, gaps exist not only in ecological regulation but also in the social-norm infrastructure, which is easily adjustable and can yield large effects. On a socio-psychological plane, a major tension arises between change and persistence. Foods with larger environmental footprints per serving (e.g., ruminant meat and pork) are often embedded in cultural identities. In Finland, for example, men have considerably higher diet-related GHG footprints than women, reflecting consumption patterns (Ylipisto University of Helsinki, 2025). Meat is often seen as a 'masculine' food, which helps, for instance, explain persistence. People are also attached to foods from their upbringing, perceived as familiar. Such factors help sustain practices that persist even when science communicates that they are unhealthy or environmentally harmful.

2.4. Actors of Change

In this context, change-management considerations raise a practical question: which actors are most relevant for advancing the Agenda 2030 objectives? While, in principle, every person is an actor and should be involved, some actors—or organized groups of actors—are more influential than others, and different groups play different roles.

Petzold et al. (2023) primarily distinguish between individuals/households and governments/institutions. The latter are typically involved in planning and funding societal adaptation responses; the former are central to coordination and implementation.

Individuals can also facilitate the transformation of institutions in participatory and inclusive ways, co-creating solutions.

Notably, researchers highlight an under-representation of the private sector in transition processes—surprising given its central role in shaping development trends and market-based interventions. They also assign academia key roles in monitoring, evaluation, and post-implementation adjustment (Petzold et al., 2023). Lesch et al. (2023) refer to sectoral structures that transcend national boundaries as potential promoters or inhibitors of sustainability transitions. They emphasize the multi-level nature of transitions and the capacity of global actors to institutionalize alternative socio-technical configurations, thereby improving current structures through the exercise of agency. Both studies underscore the networking potential among actors (Lesch, et al., 2023; Petzold et al., 2023).

3. The European Food Safety Authority and the Bisphenol-A issue

The European Food Safety Authority (EFSA) is one of the 24 agencies within the EU Agencies Network that provide scientific advice to European decision-making bodies. EFSA's mandate is to deliver independent scientific advice and to communicate clearly about existing and emerging risks along the food chain. The Authority is autonomous, independent, apolitical, and funded through the EU's central budget. Policy institutions responsible for decision-making and public policies use EFSA's work to take informed decisions in the nutrition and food-safety domains. EFSA's primary institutional stakeholders are the European Commission, the European Parliament, and EU Member States. Risk communication is a core EFSA function, addressed to both scientific and non-scientific audiences across the EU. Two main channels are used: the EFSA Journal and the institutional website. While scientific outputs mandated to EFSA are published in the EFSA Journal, the website features a selected set of risk news items through a topic-prioritization process introduced in 2023 (Vrbos, et al., 2023).

EFSA also adopts proactive surveillance of emerging risks and adapts approaches to risk assessment, which are evolving over time. The current strategy to 2027, "Science, Safe Food and Sustainability," addresses the increasing complexity of agri-food systems under climate change, biodiversity loss, demographic pressures, and digital transformation. It aligns with EU flagship initiatives such as the Green Deal and the Farm to Fork Strategy according to EFSA's mission to protect human, animal, plant, and environmental health across the food chain, guided by independence, scientific excellence, transparency, and cooperation.

The strategy is built around three objectives: (i) delivering robust scientific advice and effective, user-oriented risk communication; (ii) enhancing preparedness for emerging risks through advanced analytics, alternatives to animal testing, One Health[3] approaches, and digital tools for near real-time data; and (iii) strengthening organizational agility by investing in staff expertise, modernizing IT systems, and streamlining administrative processes. Cross-cutting priorities include integrated One Health perspectives, sustainable risk-assessment practices, AI-predictive modelling, and reinforced public trust

[3] One Health is an integrated, collaborative approach that recognizes the interconnection between human, animal, and environmental health, aiming to prevent and manage complex health threats at the interface of these domains (One Health High-Level Expert Panel, 2022).

through transparent, participatory governance. Overall, the goal is a more resilient European food-safety framework capable of preventing and managing emerging threats, supporting agricultural sustainability, and consolidating confidence in EU scientific institutions.

3.1. Food contact materials and Bisphenol-A

During production, processing, storage, preparation, and serving, foods are exposed to various external materials and means, such as packaging, containers, wraps and foils, processing machinery, kitchenware and tableware. These are collectively defined as Food Contact Materials (FCMs). Because FCMs come into contact with foods and beverages, the substances they are made of can migrate into the food (under certain conditions), potentially altering composition, taste, and quality.

EFSA provides the European Commission and national legislators with scientific assessments regarding substances that may be used safely in the manufacture of FCMs. Upon request, EFSA evaluates the safety of existing and new substances and assesses newly available scientific evidence. EFSA also maintains a dedicated panel on FCMs, with working groups tasked with monitoring and evaluating the evidence base.

In the EU, FCMs must be manufactured in compliance with applicable legislation, including Good Manufacturing Practice (Regulation EC 2023/2006[4]) and the general requirements in the Framework Regulation EC 1935/2004[5]. The overarching principle is that any transfer of chemicals into food should not raise safety concerns, must not change food composition unacceptably, and should not adversely affect organoleptic qualities (e.g., taste or odor). Specific measures exist for several material groups, notably plastics, recycled plastics, active and intelligent materials, ceramics, and regenerated cellulose film. In 2023, EFSA's work also addressed FCMs produced from mixtures of natural origin and non-fossil biological sources, reflecting growing interest in such materials for food-contact applications. Bisphenol-A (BPA) is used to produce certain plastics and resins, including polycarbonate plastics and epoxy resins. Polycarbonate is a transparent,

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[4] Regulation (European commission) Number 2023 of 2006 sets the rules for materials and articles intended to come into contact with food (FCMs). It sets for food producers the requirements for a quality assurance system, implementation of effective quality control, and records keeping to ensure materials are produced safely and consistently throughout all stages of manufacturing, processing and distribution.
To the regulation → https://eur-lex.europa.eu/eli/reg/2006/2023/oj/eng

[5] European Union law of 2004 that sets the general safety and inertness requirements for all materials and articles that come into contact with food in general terms. To the regulation → https://food.ec.europa.eu/food-safety/chemical-safety/food-contact-materials/legislation_en

rigid plastic employed in reusable products such as water dispensers, food-storage containers, and reusable beverage bottles. Epoxy resins are used in protective coatings and linings for food and beverage cans and vats. Through these uses, BPA can come into contact with food. Because substances like BPA can migrate in small amounts from FCMs into foods and drinks, EFSA used to regularly review exposure and hazard data to ensure food safety.

Compared with the initial comprehensive assessment in 2015, EFSA's expert panel has re-evaluated the tolerable daily intake (TDI) for BPA—the amount that can be ingested daily over a lifetime without appreciable health risk—substantially lowering the TDI in light of new evidence. In 2015, EFSA established a temporary TDI of 4 micrograms per kilogram of body weight per day. Following the 2023 re-evaluation, the TDI was set at 0.2 nanograms per kilogram of body weight per day, reflecting a markedly more conservative threshold. Comparing the new TDI with estimates of dietary exposure, EFSA concluded that, in all age groups, average exposures (measured back in 2015) exceeded the new TDI, indicating potential health concerns. On the basis of this scientific evidence, following public consultation and discussions with Member States, the European Commission adopted a ban on the use of BPA in food-contact materials on 19 December 2024.

3.2. Historical evolution of the use of plastics in the food industry

Plastic packaging has become integral to preserving and transporting food, ranging from the early cellophane to modern, highly specialized solutions designed for safety and freshness. The involvement of plastics in the food sector spans more than a century of innovation.

Historically, the search for flexible, practical food containers is longstanding, for example, early uses of plant-based fibers, such as mulberry bark in ancient China. A significant stimulus to food-preservation technologies came at the end of the 18th century, when Napoleon Bonaparte incentivized innovation in this direction to ensure army provisioning, catalyzing experimentation.

In 1908, cellophane was invented by Swiss chemist Jacques E. Brandenberger, with proper industrial production beginning in the 1920s due to its favorable properties. Plastics technology advanced rapidly in the 20th century, with innovations such as vapor corrosion inhibitors in the 1940s and bubble wrap in the 1950s for the protection of fragile goods, both indirectly supporting safe food transport and distribution.

From around the sixties, modified-atmosphere (gas-flush) bags extend shelf life of foods by replacing oxygen with inert gases (e.g., nitrogen or argon). This packaging helps to keep perishable ingredients such as meat, cheese, salad and vegetables leaves, crisps, pre-baked goods and cooked proteins fresh, also during long-distance transport. Hot-fill bags allow fully cooked products (e.g., industrial mono-use sauces) to be filled while hot: the self-sterilization that occurs reduces microbial risk and extends as well shelf life, before the rapid cooling of the products and their distribution (Budhram, 2025).

Global plastics production has grown markedly—from around 2 million tons in 1950 to roughly 450 million tons by 2020 (Richie, et al., 2020). While plastics have clear advantages for food preservation and logistics, single-use applications pose challenges, including potential migration of substances into food and the environmental impacts of waste generation and recycling.

3.3. Chemophobia

Some consumers exhibit or develop chemophobia—an irrational fear of chemicals—when encountering artificial, plastic, or synthetic products. It rests on the mistaken belief that anything “chemical” or “artificial” is harmful, whereas anything “natural” is inherently safe. Chemophobia is a major barrier to food policies that seek to steer consumption toward more sustainable diets, as it can skew risk perceptions and reduce public acceptance of safe reformulations and technologies. It may lead some individuals to avoid beneficial substances a priori (e.g., medicines or vaccines), while others might use natural products carelessly on the assumption that they are always safe (Saleh, et al., 2019). The phenomenon has been examined across psychology and chemistry, with recent reviews synthesizing evidence and proposing counter measures (Rollini, et al., 2022). Additionally, the public tend to generally overestimate chemical risks (Yeak, et al., 2025). To counteract chemophobia, researchers emphasize the need for multifaceted and evidence-based strategies integrating mainly education, communication and nonetheless institutional trust-building. Effective interventions should focus on enhancing basic chemical and toxicological literacy, particularly understanding the concepts of dose(exposure)-response, and potential risks, while fostering critical thinking about the natural=safe heuristic. Transparent and dialogic communication between scientists, industry, and the public is essential to rebuild trust and contrast misinformation. Moreover, attention to language is crucial: avoiding misleading labels such as “chemical-free” and reframing the term “chemical” in accurate and relatable ways can mitigate irrational fears. Myth-busting approaches and participatory activities, such as hands-on laboratory experiences in educational contexts, may further improve public perception of chemistry by concretely demonstrating its societal benefits. However, Rollini et al. (2022) highlights that these strategies require contextual adaptation, as cultural, educational, and demographic factors likely modulate their effectiveness. Future research should thus embed science communication as a structural component of chemical education and professional practice.

3.3.1. Historical track to chemophobia

Several historical episodes likely contributed to heightened risk perceptions: the thalidomide tragedy of the late 1950s–early 1960s, Rachel Carson's 1962 book **Silent Spring** on the ecological harms of pesticide misuse, scientific evidence in the 1970s on ozone depletion linked to chlorofluorocarbons and industrial disasters involving toxic releases. Among the most notable were the Seveso accident (Italy, 1976), one of the largest residential exposures to dioxins, and the Bhopal disaster (India, 1984), in which a massive release of methyl isocyanate caused thousands of deaths and long-term health impacts (Hanna, 2006).

The roots of chemophobia may be even older: World War I has been labelled the 'chemists war,' and cultural preferences for 'natural' over 'artificial' can be traced back to the medieval period, with echoes persisting today (Rollini, et al., 2022).

Evidence suggests that biases in risk perception can be mitigated through targeted communication and education that speak to audiences' values and mindsets rather than addressing a generic 'public.' In fact, in toxicology, expert communication is more effective when informational (fact-based) rather than affect-based. The Royal Society of Chemistry's 2015 report on public perceptions recommends accessible language and practical, example-driven teaching that allows students to connect chemical concepts with everyday life (TNS MRB, Royal Society of Chemistry, 2015). It further recommends teaching chemistry through hands-on, example-driven methods that let students observe and test concepts in their daily lives. Recent analyses also show that lay knowledge of chemistry and toxicology is generally limited, and greater knowledge is associated with lower chemophobia (Saleh, et al., 2019).

4. Data

This thesis comprises two studies that draw on a single primary dataset generated by EFSA via an ad-hoc survey:

BPA1_View: *Examining European consumers' perceptions and knowledge of BPA*

BPA2_Comm: *Testing alternative strategies to communicate BPA tolerable daily intakes and their effects on risk perception*

The survey was designed and administered specifically to inform the last re-evaluation of the BPA TDI. This chapter sets out the underlying assumptions, the survey design, theoretical framework, data-collection procedures and it highlights potential limitations of the survey as well. Finally, it presents the measurements—and related descriptive statistics—for variables common to both studies; constructs that are unique to either study are described in the respective Chapters.

4.1. The Survey: BPA Flash-poll

When EFSA receives a mandate to address stakeholders' information needs, primarily from the European Commission, it deploys different data-collection instruments depending on the topic, the purpose and the urgency of the request. In the BPA case, following prior consultations with the European Medicines Agency (EMA), EFSA designed a BPA survey in November 2022 to map public sentiment and concern measures across the EU. The "Flash-poll" format is developed and fielded by a contracted company, ensuring that a ready-to-analyze dataset is delivered within approximately two weeks from the point in time at which the final survey is submitted.

4.1.1. Survey design

The present study consists of 8600 respondents from 24 EU countries (i.e. the 27 EU members states, except Cyprus, Luxembourg, and Malta), all aged 18 years or older. Participants were recruited from an online research panel by the firm Teleperformance, contracted by EFSA. In this chapter, the sociodemographic characteristics of respondents, as well as behavioral and psychographic dimensions relevant to the analysis will be presented and discussed.

The survey questionnaire was structured into two main sections. The first section included questions aimed at assessing awareness of BPA, respondents' free associations with BPA and their valence, knowledge of which foodstuffs may contain BPA, of the dose-response relationship, and of BPA specifically (e.g. characteristics, exposure pathways).

The second section of the survey was aimed at administering a between-subject discrete choice experiment with three experimental groups, in order to explore how different risk communication messages about lowering of BPA's tolerable daily intake (TDI) affect risk perceptions, concerns, and trust in EU regulators. More specifically, the objective of the experiment was to test whether three different communication strategies, in relation to the same change in the TDI (sensibly lower than the previous) lead to significant differences in health risk concerns. As part of the survey, respondents reported sociodemographic information: age, gender, whether they had children aged 0–14, and education (measured as the age at which they left full-time education). As a final step, the survey included items to measure constructs such as trust in regulators, chemophobia, frequency of consumption of food in packages that may contain BPA, referred to as "consumption level" (proxy), and stated avoidance of foods or drinks products should they contain BPA (referred to as "BPA Avoidance"). As the survey covered 24 EU countries, information about the respondent country also allows exploration of geographical patterns which could be linked back to a variety of potential factors related to these patterns (e.g. culture, consumption habits, etc).

4.1.2. Data collection

Administration

The company contracted by EFSA for data collection for the BPA survey, Teleperformance, was also in charge of translation in the languages of the different surveyed member states. Each respondent thus received the survey in their own language and not default in English, to ensure full understandability. The correctness of the translation was then double checked internally in EFSA, by employees who were native born from the surveyed countries, to ensure homogeneity between the survey form in different languages.

The survey was administered online in all the European member states, except Malta, Cyprus and Luxembourg. The survey design was completed in November 2022, and responses were collected in December 2022, resulting in 8600 valid questionnaires of respondents aged 16 or more.

Quota constraints and "BPA awareness"

In order to maximize country-level representativeness, a minimum quota of respondents by country was set at 300 collected questionnaires, and as maximum a number of 500 respondents, to prevent potential underrepresentation of a member state inside the aggregate European sample within the allocated budget.

As for quotas, the initial objective was to collect information on at least 60% of individuals who were BPA aware in each country. The contractor experienced difficulties in fulfilling this quota. Therefore, a minimum quota of 1/3 BPA-aware per country was re-agreed. Post data collection, the effective quota of BPA aware respondents was 43,58%. The perception-related questions were then asked only to the subsample of respondents who stated to be BPA aware, thus 3748 individuals. Additional quotas were set for other dimensions. For example, for the discrete choice experiment on message format (built on three different formats), respondents are distributed 1/3 per message. Within each message group the overall awareness quota is also applied. The same occurs to the sub-sample of parents having children aged such that are of interest of the study (2791 out of 8600).

The collected data may be subject to potential selection biases due to the lack of a probabilistic design, which was known (and agreed) since the planning of the survey. The self-selection bias is present since the questionnaire was submitted only to people who were available to receive surveys from the contractor for investigation purposes and market research and were registered in their panel. For example, it is possible that respondents with higher education and income, as well as those with very low IT knowledge and access to the internet, are under-represented.

4.2. Variables common to both studies

Table 1 reports some descriptive statistics on the final sample for the BPA Flash-poll designed in November 2022 and administered in December 2022.

Age

The Age variable was initially collected as numeric (See Appendix #1/Q1) and will be kept numeric in the statistical analysis phase. It was grouped into four age classes, as displayed in Table 1, just for the descriptive purpose.

The vast majority of the sample is of age 25+, with one third being 55+. A minority is instead composed by youth, less than 10% are under 24. The sample is composed by 16+ respondents only.

Table 1 - BPA Flash-poll 2022

Variable	**Levels**	**Value**
Age	16-24 years-old	8.6%
	25-39 years-old	28.6%
	40-54 years-old	29.6%
	55+ years-old	33.2%
Gender	Female	52.4%
	Male	47.4%
	Non binary/NA	0.2%
Education (completion age)	No full-time education	1.3%
	15 years-old or younger	3.4%
	16 to 19 years-old	35.6%
	20 years-old or older	52.9%
	Still studying	5.5%
	Don't know	1.2%
BPA Avoidance	No	12.1%
	Yes	24.0%
	Don't check	63.9%
Trust EU regulators	No	26,9%
	Yes	73,1%
N	EU respondents	8,600 (100%)

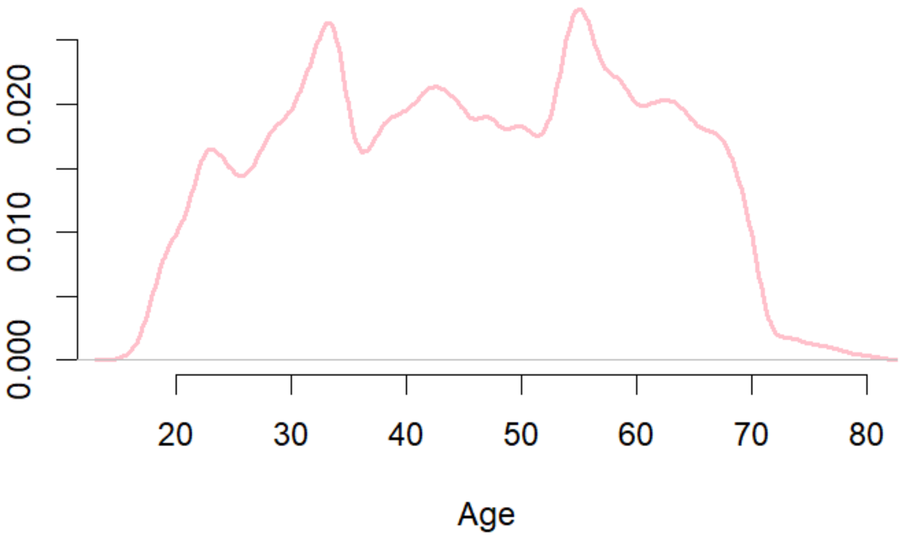
Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1)
Note:Descriptive statistics of variables which are relevant to both studies

Table 2 - Age - Descriptive statistics

Mean	45.60
Std.Dev	14.53
Min	16.00
Q1	33.00
Median	46.00
Q3	58.00
Max	81.00
CV	0.32

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q1)

Figure 2 - Density estimation of Age (Non parametric, Gaussian Kernel)



Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q1)

Age

The 50% of the sample is composed of people from 33 to 58 years old (Table 2). While the mean and the median coincide at 46, the variable shows a bimodal distribution, with peaks between age 30-35 and around age 55 (Figure 2), while few are the young respondents.

Gender

The sampled population is composed evenly of males and females. In the survey, the factor levels “non-binary” and “I prefer not to answer” were proposed as two different options of answer, though collected separately (See Appendix#1/Q2). According to EFSA’s directions, given the study purpose, these two levels could have been considered the same; therefore, they were then grouped into a unique level while pre-processing data.

Education

As for education, the variable was collected already in the classes displayed in the table, though the respondents selected what most applied to their situation (See Appendix#1/Q9).

More than 50% of the individuals declared to have stopped their education when they were older than 20, therefore in the degree age. Plus, 35.6% of the sample says to have stopped studying between age 16 and 19, in their secondary school diploma era.

Reasonably, half of the sample probably has a degree, and 90% of it reasonably has completed secondary school.

BPA Avoidance

Considering constructs related to stated behaviors, most respondents reported not checking for the presence of BPA when buying foodstuffs or drinks. This includes both those respondents that are BPA unaware (56,42%) plus some others who are aware but do not check this information, while those stating explicitly that they avoid BPA are the 24%. The variable was collected as shown in Table 1, the same three levels were presented to respondents as choice options.

Trust in EU regulators

Considering the level of trust in EU authorities when it comes to protecting EU citizens from health-related risks (i.e., the question referring to Trust), the original variable was collected with a greater level of detail (see Appendix #1/Q10.1). The original answer options consisted of a 6-level scale from “Strongly disagree” to “Strongly agree”, which did not allow for a Neutral choice.

According to the directions of EFSA given the study purpose, the first three levels were recoded and grouped into “No”, while the remaining ones into “Yes”. The majority of the sample, as shown, generally trusts EU regulators in terms of the population’s health protection.

4.2.1. Pre-processing and derived measures

For some of the variables, which are common to both studies, several major transformations and adaptations have been needed and made to both factors and quantitative measures from the raw dataset. Data manipulation and its purpose for the following analysis will be explained in this section and it mostly relates to stated behaviors and psychographic variables.

Chemophobia

Chemophobia is defined as a latent construct, which necessarily implies some manipulation during the data pre-processing stage. This measurement was based on a

Mokken scale[6], which ultimately yields a single *chemophobia score* assigned to each respondent (Saleh, et al., 2019).

The transformation of the related question (See Appendix#1/Question10.2-6) was then used as a numeric variable. To assess the unidimensionality of the five items in this sample, the Cronbach' Alpha was computed as a measure of internal consistency (Cronbach, 1951). The resulting alpha for the sample was 0.65. Although this value is below the commonly used threshold of 0.70 in the social sciences, related studies note that there is no standard criterion for the acceptability of a bundle of questionnaire items based solely on alpha (Barbera, et al., 2021). In addition, given the explorative nature of the questionnaire, the Chemophobia items may be considered acceptable (Taber, 2018) (Hair, 2010). The five Alpha-1 were also assessed for each item, each time showing a reduction with respect to the overall Alpha, proving then that every item positively contributes to the unidimensionality of the scale.

Table 3 - Chemophobia survey items – Descriptive statistics

Chemophobia score Item (Saleh et al., 2019)	Mean (SD)
[1] I believe that chemical substances are the main reason why people suffer from cancer.	3.011 (1.467)
[2] I do everything I can to avoid contact with chemical substances in my daily life.	2.964 (1.409)
[3] I would like to live in a world where chemical substances don't exist.	3.186 (1.544)
[4] Chemical substances scare me.	3.032 (1.463)
[5] I believe that chemical substances are the reason for most environmental problems.	2.967 (1.514)
Sample average score (8600 respondents)	3.032 (0.954)

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q10.2-6)

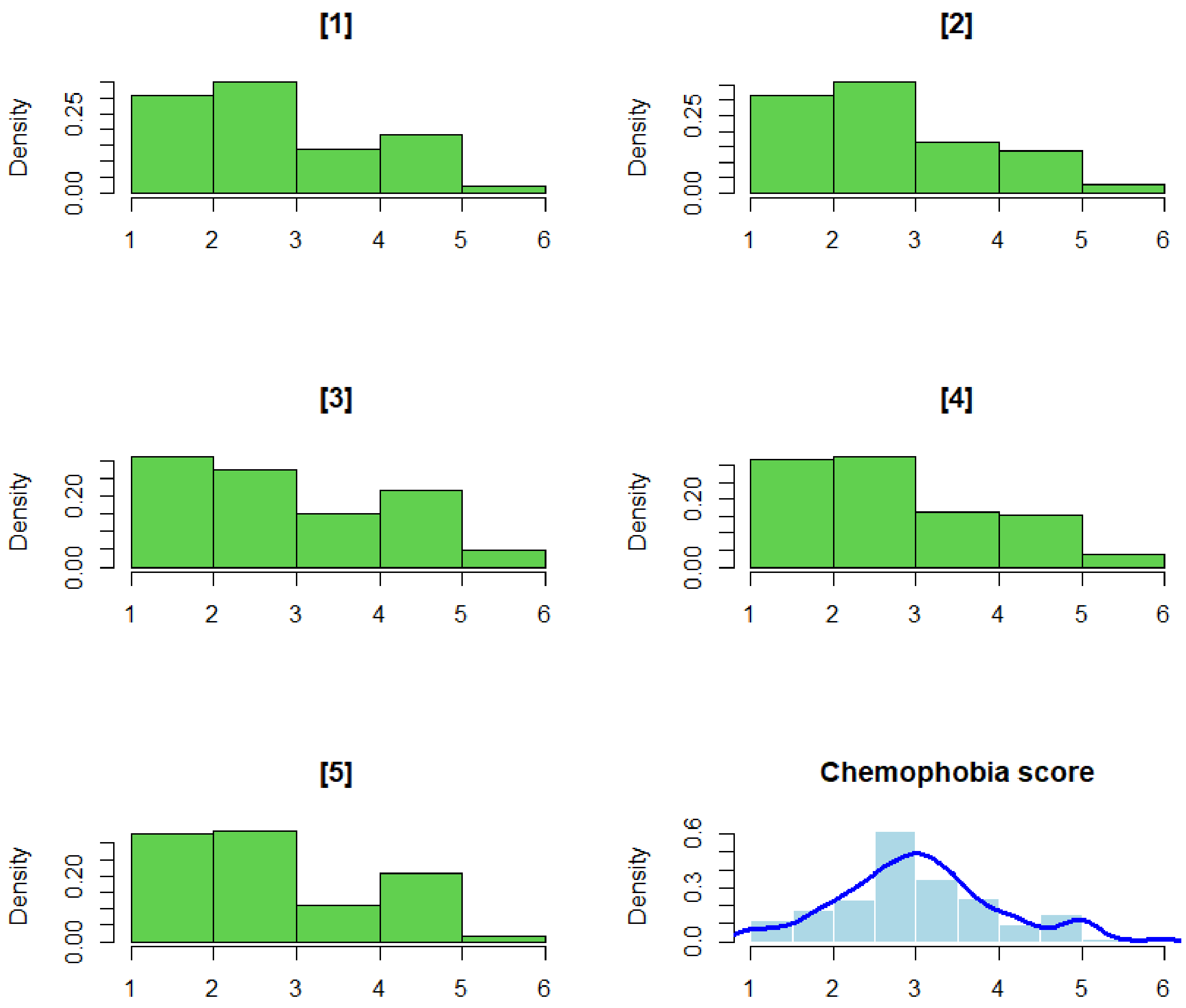
[6] A Mokken scale is a psychometric, non-parametric method that enables researchers to create uni-dimensional and hierarchically ordered (in terms of *severity*) set of items to measure a unique latent variable.

Each respondent had to answer 5 questionnaire items as shown in Table 3, which consists of statements about chemicals. Each respondent could rate each item according to 6 levels, from “Strongly disagree” to “Strongly agree”, without the possibility to opt for a neutral option.

To build the final measure, for each item, response levels were linked to a numeric score, from 1 “Strongly disagree” to 6 “Strongly agree”. Then, finally, the mean of the 5 items’ scores was computed for each respondent, obtaining the individual chemophobia score (Table 3).

Distributions of each chemophobia items (histograms) are drafted by histograms in Figure 3. Ultimately, through the non-parametric estimation method, using a Gaussian kernel, the chemophobia score density is as well displayed and presented in Figure 3.

Figure 3 - Distribution of - Chemophobia Items [1] to [5] and Chemophobia score



Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q10.2-6)
Note: for Chemophobia score the non-parametric density estimation uses a Gaussian function as kernel

Consumption (proxy)

BPA consumption was assessed through a proxy measure based on the answers provided in the relevant survey section (See Appendix#1/Q11).

The question had three response items, which were possible potential occasions of BPA intake. The respondent should reply with their consumption frequency, from “Never” to “7+ times per week”, as detailed in Table 4.

Table 4 - Consumption items (proxy) - Descriptives

Item *Consumption proxy*	*Never*	*3 times per week or less*	*4 to 6 times per week*	*7 times per week or more*	*Sample (N=8600)*
[1] Consume packaged or canned food	13.6%	67.8%	14.0%	4.5%	100%
[2] Consume drinks in plastic bottles or in cans	10.8%	56.7%	17.9%	14.6%	100%
[3] Heat food in a microwave oven by using plastic containers	4.9%	36.8%	10.5%	3.6%	100%

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1,Q11)

Table 4 reports the descriptives as measured by the questionnaire item about stated consumption. The reference is made to proxies and not to pure BPA consumption, since the items are occasions of potential BPA intake, which is thus not certain. For instance, in item [3], if a respondent consumes food heated in a microwave using a BPA-free plastic container 7 times or more per week, no BPA intake occurs.

Further processing of the consumption variable was made to generate three levels of stated (proxied) consumption, “Low”, “Medium” and “High”. The lower level was built for these respondents who, for each of the three questions’ items, replied “Never” or “3 times per week or less”. The “High” level, as opposed, was associated with those who replied “4 to 6 times per week” or “7 or more” to all the items. To any respondent whose set of answers fell outside these ranges the “Medium” level was assigned. By the end of the procedure, a new variable, Consumption level (proxy), was built (see Table 5). In subsequent analyses and for modelling purpose, we refer to the latter three-levels variable.

Table 5 – New variable for Consumption level (in proxies) - Descriptives

Consumption_level (proxy)	
Low	54.6%
Medium	41.4%
High	3.9%
Sample	N=8600

Source: our processing on data from EFSA Flash-poll on BPA, December 2022 (see Appendix#1,Q11)

4.2.2. Potential processing limitations

The pre-processing of the variables described in this section was under the control and responsibility of EFSA, based on the research needs, considering stakeholders and users of the study. Processing them according to the study objectives, however, may pose limitations in data usage and exploitation.

In particular, the consumption variable was built strictly around the extremes “Low” and “High”, to better observe the behavior of variables at the extremes. As a consequence, this also inflates variance in the “Medium” level and creates unbalances between levels.

5. Examining European consumers' perceptions and knowledge of BPA (*BPA1_View study*)

This chapter presents one of the two studies carried out during my traineeship at EFSA, developedin close collaboration with, and under the supervision of, EFSA staff[7] responsible for this project within the Strategic Communication team.

The work presented in that thesis elaborates the study's methodological foundations, reports extensions, and presents additional results and validity checks. In particular, it clarifies the treatment of scale variables and compares alternative modeling specifications to assess robustness, while discussing the implications of different underlying assumptions, while preserving the original study objectives. Finally, it extends the analysis of the related articles by exploring the possibility of alternative specifications to consider geographical heterogeneity.

5.1. Study background

Bisphenol A (BPA) is a chemical substance used in combination with other chemicals to manufacture certain plastics and resins. For example, it is used in polycarbonate plastic used to produce water dispensers, food storage containers and reusable beverage bottles. BPA is also used in foodstuff containers, as it is part of protective coatings and linings for food and beverage cans and vats, and the substance can migrate in very small amounts to the food and drinks they contain (EFSA [a], 2023). Chemicals used in foodstuff, such as BPA, undergo scientific risk assessment and maximum usage doses are set before they are approved for usage (Bearth, et al., 2016; EFSA [a], 2023). Their safety is also regularly reviewed based on new data, with the European Food Safety Authority (EFSA) being the authority responsible for evaluating risks associated with the food chain in Europe.

Following an earlier assessment in 2015, in 2023, EFSA published a risk assessment re-evaluating the risks to public health related to the presence of BPA in food contact materials (EFSA [a], 2023; EFSA [b], 2023; EFSA Panel on Food contact materials, 2023).

[7] The related article is currently under peer review, internally in EFSA. Joana S. Laurenco, quantitative psychologist working in the Communication and Partnership department of EFSA supervised the study and co-operated to the draft of the scientific manuscript, as well as Domangoj Vrbos, former team leader of the same unit and currently senior manager at CGIAR.
(Laurenco, et al., 2025)

This latest scientific assessment lowered the tolerable daily intake (TDI), from 4 micrograms, to 0.2 nanograms BPA/kg bodyweight, based on “potentially harmful health effects on the immune system” and concluded that dietary exposure to BPA is a health concern for consumers across all age groups (EFSA [b], 2023; EFSA Panel on Food contact materials, 2023). Following this assessment, in December 2024 the European Commission opted to adopt a ban on the use of BPA in food contact materials. The current ban forbids use of BPA (and other bisphenols that are harmful to the reproductive and endocrine systems) in products that come into contact with food or drink, and comprises a 18-month phase out period for most products to allow adaptation by industry and minimise disruptions in the food chain (European Commission, 2024)[8].

Underlying food risk analysis

As indicated above, EFSA’s 2023 risk assessment significantly lowered the TDI relative to the previous assessment based on all the new scientific evidence assessed. TDI refers to the amount of a substance that can be ingested daily over a lifetime without presenting an appreciable health risk (EFSA [a], 2023; EFSA [b], 2023; EFSA Panel on Food contact materials, 2023). Determining the TDI is an important part of the scientific risk assessment, which takes into consideration the dose-response toxicological principle. In other words, the notion that “the dose makes the poison” (Bearth, et al., 2016). In risk assessments, experts need to consider both risks and benefits associated with the substance, as well as factor in inherent uncertainty, owing to limitations in the knowledge and/or data available. As such, definitive statements about whether the chemical constitutes a risk to health are not possible, and safety of the substance is instead linked with the dose. As a result, citizens are then faced with inconclusive messages about risks (e.g. ‘possibly carcinogenic’) (Bearth, et al., 2016; Bearth, et al., 2021; Jansen, et al., 2020[a]) (Bearth, et al., 2021) (Jansen, et al., 2020[a]).Notwithstanding, previous research has found that the public usually perceives safety and risk in more absolute terms (e.g., (Bearth, et al., 2021; Jansen, et al., 2020[a]; Jansen, et al., 2020[b]; Siegrist & Bearth, 2019)).

Several studies have shown that a substantial share of the public tend to see chemicals as either safe or dangerous, that is, they display dose–response insensitivity (Bearth, et

[8] European Commission (2024, December 19). *Commission adopts ban of Bisphenol A in food contact materials.* European Commission News Article.
Available at → https://food.ec.europa.eu/food-safety-news-0/commission-adopts-ban-bisphenol-food-contact-materials-2024-12-19_en

al., 2016; Bearth, et al., 2019; Dickson-Spillmann, et al., 2011; Saleh, et al., 2019; Slovic, et al., 1997). Further, beyond knowledge of toxicological principles, consumers face resource constraints (e.g. lack of time) and generally have limited knowledge about risk assessment that would enable them to make more fact-based, analytical evaluation of risks posed by a given chemical (Jansen, et al., 2020[a]; Slovic, et al., 2002). As such, they may rely on other factors such as mental shortcuts (e.g. affect heuristic), level of trust in regulators, or, particularly when judging a chemical substance that is novel to them, their values, beliefs and attitudes with respect to chemicals (or to a more familiar risk that they perceive as being related) (Bearth, et al., 2016; Jansen, et al., 2020[a]; Saleh, et al., 2019). However, this can introduce bias in decisions, with research showing, for example, that the public generally has a negative attitude towards chemicals (Jansen et al., 2020a; Saleh et al., 2019), which may in turn lead to negative perceptions of chemicals and chemophobia (i.e. irrational fear of chemicals) (Saleh, et al., 2020; Saleh, et al., 2019).

The aim of the present study was to investigate consumers' perceptions about BPA, and relate this to their knowledge about BPA, toxicological principles, as well as trust in regulators and level of reported chemophobia, among others. In particular, the present study examines associations with, perceptions, and awareness of BPA through the Flash-poll in 24 countries as described in Chapter 4. Building on evidence from the food risks literature, a number of factors that might be of importance concerning the consumer's perceptions of BPA were also investigated, including knowledge of dose-response relationship, specific knowledge of BPA (e.g. characteristics, exposure pathways), chemophobia, and trust in regulators. Additional factors, such as knowledge of which foodstuffs may contain BPA, extent to which the consumer avoids food or drink products if they contain BPA in their packaging, among others, were also examined.

Overall, findings of this study could aid risk-communication efforts intended to address public perceptions and misconceptions regarding BPA, safety levels, and irrational fear of chemicals.

5.2. Theoretical background: Consumers, knowledge and risk perceptions

Slightly less than half of European consumers have heard about traces of materials that come into contact with food, e.g. plastic or aluminium in packaging (49%). Moreover, this topic is not a main concern for Europeans, with recent data from the 2022 Eurobarometer Survey on Food Safety showing that it is in the bottom five food risks concerns out of a list of 15 possible ones (EFSA, 2022). Relatedly, a recent survey with a sample of the

Dutch general population found very low awareness of BPA, with around eight in ten respondents (81%) who had never heard about it before (Jansen, et al., 2020[a]). Additionally, evidence from a qualitative study, also in the Netherlands, revealed that none of the participants had specific knowledge of BPA. Participants were provided with existing communications about BPA, mentioning that BPA in food packaging can transfer to food, thus presenting a potential health risk and that uncertainty exists about whether small amounts of BPA in food can cause (other) adverse effects. Following this, they were then asked to express their initial thoughts and associations about BPA. Results showed that potential personal exposure was the key factor in their appraisal of risk. Moreover, participants perceived uncertainty about possible effects particularly worrying in the case of BPA owing to its ubiquity. As stated by the authors, “participants referred to the many plastic products that contained the chemicals and how easy it was to get in contact with them” (Jansen, et al., 2020[b]).

Research on risk perception shows that individuals take into account several properties of risk when it comes to unfamiliar chemical substances in food, with novelty, but also unnaturalness (substance being produced by industrial process rather than nature), low perceived control (ability to avoid exposure to risk) (Bearth, et al., 2014; Jansen, et al., 2020[b]; Nardi, et al., 2020), having little knowledge about the substance (Jansen, et al., 2020[a]), or low benefits perception (Nardi, et al., 2020; Verbeke, et al., 2007) linked with chemical substances being considered more risky. In addition, findings from a recent meta-analysis revealed that several demographic characteristics also impact food safety risk perceptions, with results showing that being older, female, having children, and number of people in the in household increases risk perceptions, whereas level of education has a negative effect (Nardi, et al., 2020). Likewise, having a positive attitude or predisposition towards a food negatively affects risk perception (Nardi, et al., 2020). Trust in government has also been found to reduce risk perception (Nardi, et al., 2020; Saleh, et al., 2020; Tonsor, et al., 2009). In particular, when individuals lack sufficient technical knowledge for judging a certain risk, trust in risk regulation bodies is associated with lower perceived risks and reduced concerns (Saleh, et al., 2019; Siegrist & Cvetkovich, 2020).

Research on consumers’ risk perceptions and decision-making about chemical substances also indicates that chemophobia is a significant driver. Chemophobia refers to the irrational fear of chemicals (Gribble, 2013; Michaelis, 1996; Saleh, et al., 2020). It can affect people’s decision-making and behavior, such that those with high levels of chemophobia endeavor to avoid contact with synthetic chemicals (Saleh, et al., 2021; Siegrist & Bearth, 2019; Saleh, et al., 2019). Studies show that chemophobics tend to be overly concerned with the risks of chemicals and that chemophobia is more strongly related with fear of exposure to synthetic rather than natural chemicals. This is despite origin not being an indicator of a chemical's toxicity (Rozin, et al., 2004; Saleh, et al., 2019; Saleh, et al., 2020; Saleh, et al., 2021). Further, research shows that a significant proportion of the public displays dose–response insensitivity, that is, they tend to see chemicals as either safe or dangerous. In other words, there is the perception that even minor doses of, and exposure to, chemicals are likely to cause harm, resulting in the belief that all chemicals are (equally) harmful (Bearth, et al., 2016; Bearth, et al., 2019; Dickson-Spillmann, et al., 2011; Saleh, et al., 2019; Slovic, et al., 1997). In effect, however, "the dose makes the poison", such that there are safe limits of exposure to chemical substances (Bearth, et al., 2016; Rollini, et al., 2022). Importantly, recent evidence suggests that lack of knowledge about basic toxicological principles (e.g., dose-response mechanisms) is associated with higher levels of concern, and with higher levels of chemophobia (Bearth, et al., 2021; Bearth, et al., 2019; Saleh, et al., 2019). Relatedly, Jansen et al. (2020a) found that dose–response insensitivity was positively correlated with worry about the presence of the substance in food, worry about the health risk and perceived magnitude of the health risk.

On a different aspect, a recent study found a weak, but positive association between knowledge and affect toward "chemical substances (Saleh, et al., 2019). The expression "risk as feelings" (vs. "risk as analysis") has been used to describe the fact that, to judge risks, the public tends to rely both on more rational (e.g. available data) and affective evaluations. The latter encompasses the use of heuristics or other decision strategies that allow individuals to cope with existing resource constraints (e.g. limited time, knowledge, etc (Bearth, et al., 2019; Jansen, et al., 2020[a]). For example, consumers tend to judge risks as low and benefits as high if their feelings regarding a given product are positive (and vice-versa). This tendency to rely on feelings towards a product, based on images or associations that it triggers, is referred to as the effect heuristic. While it deems judgement faster, it can introduce bias and drive irrational fear or negative perceptions of chemicals. In addition, consumers may rely on other strategies, such as the level of trust they have in risk assessors and regulators as a basis for establishing their worry, rejection, etc. of foods (Jansen, et al., 2020[a]; Rollini, et al., 2022; Saleh, et al., 2019).

5.3. Measures

Chapter 4 introduced the variables from the EFSA BPA Flash-poll that are common to both studies. This following section presents additional Flash-poll variables specific to the current study BPA1_View. The key outcome is risk perception, which was measured only among respondents who reported being aware of BPA. Consequently, the analytic subsample for risk perception comprises 3,748 respondents out of 8,600.

5.3.1. BPA awareness (filter question and quota constraint)

Awareness of BPA was measured on a four-levels scale, consisting of (1) "Never heard of it"; (2) "Heard of it, but do not know much about it"; (3) "Heard of it, and feel I am reasonably well informed"; and (4) "Heard of it, and feel I am very well informed" (See Table 6). A binary variable on awareness was built combining the last three items. The derived awareness item was used by the field work contractor to meet a quota constraint.

Table 6 – Filter question on Awareness - Descriptive statistics

Awareness Item	Count	Freq	Derived binary variable
(4) "Heard of it, and feel I am very well informed"	255	2.97%	Yes
(3) "Heard of it, and feel I am reasonably well informed"	836	9.72%	Yes
(2) "Heard of it, but do not know much about it"	2657	30.9%	Yes
(1) "Never heard of it"	4852	56.42%	No

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1,Q0)

5.3.2. Generic attitude towards BPA

A measure of overall attitudes toward BPA was elicited through the survey to serve as the target variable and to examine its underlying determinants. Respondents rated BPA on an 11-point scale (0 = "extremely negative," 5 = "neutral," 10 = "extremely positive").

For questionnaire clarity, the item included descriptive labels, but the analysis used only the numeric values. A “Don’t know” option was intentionally omitted to elicit a directional assessment. During this phase there came the need to map general attitude towards Bisphenol-A among the sample, with the objective of assessing what the drivers of such attitudes may be.

Table 7 – Generic attitude towards BPA – Frequency distribution

Level	Freq
0 - “Extremely Negative”	15.07%
1	6.80%
2	10.30%
3	9.71%
4	5.44%
5 - “Neutral”	32.50%
6	4.72%
7	5.50%
8	4.90%
9	2.11%
10 - “Extremely positive”	2.85%
N (BPA-Aware respondents)	3748 (100%)

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1,Q5)

As can be observed in Table 7, the highest frequencies are observed in correspondence to negative attitudes, although 32%, of the sub-sample of those reporting awareness of BPA stated to have a neutral attitude.

The EFSA research team decided to transform the original variable into a 3-levels ordered variable. The responses were recoded into: negative (values 0-4), neutral (values 5 or 6), and positive (values 7-10). These breakpoints were set following the ratio of avoiding classes with an excessively small number of respondents relative to other classes, in the subsequent analysis, and the aggregate classes range from 15% of responses classified as “positive perception” and 47% as “negative perception” (See Table 8).

Free associations with BPA and their valence were also measured using an adapted version of the procedure used by Saleh (Saleh, et al., 2019), again only on those respondents who stated to be BPA-aware.

Table 8 – Generic attitude towards BPA: Transformation into a 3-levels factor

Generic attitude *(Raw)*	Derived variable *(3-levels)*
0- "Extremely Negative"	Negative
1	Negative
2	Negative
3	Negative
4	Negative
5 - "Neutral"	Neutral
6	Neutral
7	Positive
8	Positive
9	Positive
10 - "Extremely positive"	Positive

Attitude levels (Grouped Variable)	Count (Freq) [N=3748]
Negative	1774 (47.33%)
Neutral	1395 (37.22%)
Positive	592 (15.45%)

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q5)

Respondents were asked to indicate the first association (word, image, or thought) that came to mind when thinking of BPA (Figure 4,5,6) (See Appendix#1/Q4).

Figure 4 - Word cloud diagrams for Neutral[9] BPA Attitudes

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q4)

[9] Neutral perceptions are intended as respondents who replied to Q4 (See Appendix#1) from 4 to 6, thus this diagram refer to 1599 respondents. This split is made only for descriptive purposes.

Figure 5 - Word cloud diagrams for Positive[10] BPA attitudes

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q4)

Figure 6 - Word cloud diagram for Negative[11] BPA attitude

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q4)

Figures 4, 5 and 6 below show the cloud diagrams derived from free associations for the neutral, positive, and negative attitudes, respectively.

As all of the diagrams above show, the two main words presented by respondents when asking about their first association with Bisphenol-A are *plastic* and *chemical*, for all of the three categories of attitudes.

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[10] Positive perceptions are intended as respondents who replied to Q4 (See Appendix#1) from 7 to 10, thus this diagram refer to 472 respondents. This split is made only for descriptive purposes.

[11] Negative perceptions are intended as respondents who replied to Q4 (See Appendix#1) from 0 to 3, thus this diagram refer to 1677 respondents. This split is made only for descriptive purposes.

5.3.3. (Objective) Knowledge of BPA

The second key measure in this study captures objective knowledge about Bisphenol-A (BPA). Accordingly, the questionnaire included two sections with knowledge items, and responses were evaluated for their correctness (Appendix #1: Q6; Q7.1–2; Q7.3–6). The survey distinguishes three knowledge domains: (1) the dose–response relationship; (2) BPA-specific facts (e.g., characteristics and exposure pathways); and (3) knowledge of which food products may or may not contain BPA.

Figure 7 - BPA Definition provided in the BPA Flash-poll

Bisphenol A, 'BPA' for short, is a chemical used to make certain types of plastics and can be found in numerous consumer products. For example, it is one of the substances used in some food packaging.

The knowledge measure was collected for the entire BPA Flash-poll sample. To ensure coverage of respondents who reported no prior awareness, the survey provided a brief introduction to BPA immediately before Question 6 (see Appendix #1 and Figure 6), consisting of a short sentence describing what Bisphenol-A is. On the basis of this definition, BPA-unaware respondents could still form an initial understanding of the concept and answer the knowledge items. Including non-aware respondents is justified by the possibility that, even without explicit awareness of BPA's technical aspects, they may possess relevant knowledge related plastics, chemicals and food packaging.

Dose-response relationship

Two question items were dedicated to the assessment of respondents' knowledge about the dose-response relationship. The two statements on the dose-response relationship (one correct, one incorrect) were adapted from the knowledge of basic toxicological principles scale by Saleh (Saleh, et al., 2019), as shown in Table 9(1).

BPA-specific statements

The four BPA-specific statements (two correct, two incorrect, see Table 9(2) aimed at measuring people's knowledge of BPA characteristics and were designed based on literature, followed by expert review by BPA experts at EFSA and academics with specialized expertise in social sciences. Respondents were asked to reply to each statement with "True", "False", or "I Don't know". Similarly to the above, all responses were recoded, so that 'correct' responses were given 1 point and 'incorrect' and 'don't know' responses were given 0 points.

Knowledge of products that may contain BPA

Table 9 - BPA Objective Knowledge - Domain, Item evaluation - Descriptive statistics

Domain	Statement	Correct	Incorrect (Wrong answer)	Explicit "Don't know"	N (8600)
(1) Dose response	Being exposed to a synthetical chemical substance always has a serious impact on health, no matter what the level of exposure is. **[FALSE]**	15.9%	58.3%	25.8%	100%
	Having a small amount of BPA in a consumer product, does not mean that it has a serious impact on health in the amount present. **[TRUE]**	36.1%	26.8%	37.2%	100%
(2) BPA specific	Using plastic bottles or food storage containers which contain the label "BPA free" is safer for humans than similar products that do not contain this label **[FALSE]**	11.0%	62.5%	26.5%	100%
	BPA cannot transfer from the plastic lining of canned foods into the food stored inside **[FALSE]**	34.4%	24.0%	41.6%	100%
	Food is the major source of exposure to BPA in humans **[TRUE]**	40.6%	17.9%	41.5%	100%
	If a plastic container contains BPA, heating food in the microwave inside that container can increase the transfer of BPA into the food **[TRUE]**	61.5%	8.8%	29.7%	100%
(3) BPA Products	Bottles and food storage containers for infants/children up to 3 y.o. **[FALSE]**	27.1%	42.8%	30.1%	100%
	Beverage and food cans **[TRUE]**	42.0%	27.3%	30.7%	100%
	Polycarbonate plastic bottles, e.g. some reusables water/sports bottles **[TRUE]**	62.9%	12.1%	25.0%	100%
	Thermal paper, e.g. used for receipts in cash registers **[FALSE]**	25.1%	37.5%	37.4%	100%

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q6,Q7)

The definition was followed by a question asking whether the four listed products could contain BPA or not according to what the respondent thinks. Surveyed poeple were asked to respond to each item with “yes”, “no”, or “Don’t know”: the correct answer was yes for two of the items (Canned Food, Reusable plastic bottles), and no for the remaining two (Infant products, Thermal paper) (see Table 9(3)). The responses were recoded, such that ‘correct’ responses were given 1 point while ‘incorrect’ and ‘don’t know’ responses were given 0 points.

5.3.4. Measuring lack of knowledge

A further step aimed to capture “lack of knowledge,” understood as not knowing rather than holding incorrect beliefs. The goal was to assess respondents’ meta-knowledge, their self-awareness about the correctness of their beliefs. Some respondents may attempt an answer despite uncertainty, whereas others may explicitly acknowledge insufficient knowledge and opt for replying “I don’t know.” Because it relies on self-report, the lack of BPA knowledge is a subjective knowledge measure. Keeping this construct separate from objective knowledge, while comparing them, is informative, as the two can influence food-related attitudes differently (Aertsens, et al., 2011). In Table 9, this measure corresponds to explicit “Don’t know” responses.

5.4. Methods

Upon processing of the BPA Flash-poll raw data, and based on the knowledge and lack of knowledge, it is possible to explore their role in explaining respondents' attitudes towards BPA.

5.4.1. Derivation of a Knowledge Index

Given the multiplicity of knowledge variables seen above available to the analysis, as well as the centrality of that aspect to the means of the analysis, to better group, synthesize and express knowledge of BPA, a suitable Knowledge Indexing was investigated. There is a relatively rich literature on assessing objective knowledge in relation to agricultural and food dimensions. Mc Carthy et al. (2005) developed a scoring system which had as objective the assessment of levels of food knowledge in Ireland. Within their questionnaire, each correct reply to a specific knowledge item was assigned a predetermined score, which cumulated over all knowledge questions. In this case, the possibility of replying “Don’t know” was allowed in the questionnaire, but only for descriptive purposes, without being explicitly considered into the scoring system in any manner (McCarthy, et al., 2005). More straightforward methods exist and have been applied in previous works for objective knowledge assessments. Pienak et al. (2010)

assessed food knowledge, to be then used as a determinant of organic vegetables consumption in the Belgian population. In this study, the final index consisted of a simple count of correct answers, “Don’t knows” were not allowed in the questionnaire (Pieniak, et al., 2010), though the knowledge index was itself the count of the total statements answered correctly.

In the context of the Swiss Panel, for the investigation on how nutrition knowledge and psychological traits influence risk perception, Siegrist et al. (2016) proposed an alternative approach. Four different knowledge items were administered in the questionnaire, and respondents were given the “Don’t know” option while replying. The overall index consisted of the number of correct responses (i.e. a score between 0 and 4), and “Don’t knows” were considered null, analogously to incorrect responses (Michael Siegrist, 2016). Piha et al., (2018) explored how consumer knowledge influences the willingness to buy insect-based foods in Northern and Central Europe. This survey allowed for explicit recommendations to respondents, aiming at reducing the potential tendency to guess an answer even if they are uncertain. This recommendation was matched to the possibility of replying “Don’t know” to questions. At the beginning of the survey, thus, respondents were encouraged to reply “Don’t know” when they were uncertain about the response, to prevent guessing. As for the other indices, the final knowledge score consisted of the count of correct answers and ”Don’t know” were again treated identically to incorrect answers.

The BPA Flash-poll was designed to allow for “Don’t know” answers and the only reminder (though not a recommendation) that was given was precisely: “If you don't know, you can just indicate so”. Given the survey flow, which was given, and examining the studies mentioned above, the final decision about the main knowledge index to be built consisted of the net count of correct answers. Beyond the overall knowledge indicator, which was kept just for descriptive purposes, three separate indicators were also built for each of the respective domain, as listed in Table 10. Therefore, for Knowledge, three will be the domains: Dose-response (can take values 0, 1 or 2), BPA specific (can take values 0,1,2,3 or 4) and BPA products (0,1,2,3 or 4). The reference variable for these three measures will be onwards called *knowledge counts*. For the sake of comparability, the three indicators (hereafter referred to as *knowledge scores*) were built by dividing the knowledge counts by their maximum value (i.e. the dose-response indicator was obtained by dividing the knowledge count by 2, the two other indicators by 4). The knowledge scores are summarized in Table 10.

Finally, the overall knowledge count (between 0 and 10) was also transformed into a score by dividing the resulting count by 10. This measure – referred to as an additional domain "*knowledge overall*" – is also described in Table 10, both in its count and score form.

A similar procedure was applied to capture what we termed as Self-reported Lack of knowledge, by counting the number of times a respondent clicked the "Don't know" option. Again, count measures were also split into the three domains (+ *knowledge overall*) and transformed into scores by dividing them by their maximum value.

Table 10 - Knowledge Indexes – Descriptive statistics

KNOWLEDGE		***Domains***			
		Dose response	*BPA Specific*	*BPA products*	*Overall*
Mean (SD)	Knowledge scores	0.26 (0.33)	0.37 (0.27)	0.39 (0.26)	0.357 (0.200)
	Knowledge counts	0.52 (0.66)	1.48 (1.09)	1.57 (1.05)	3.57 (2.00)
	Lack of knowledge (scores)	0.31 (0.39)	0.35 (0.36)	0.31 (0.38)	0.325 (0.317)
	Lack of knowledge (count)	0.63 (0.77)	1.39 (1.43)	1.23 (1.51)	3.25 (3.17)

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q6,Q7)

Table 10 shows that the knowledge indicators capture relatively low levels of objective knowledge in all domains, as none of the knowledge score exceeds 40% on average for that sample. Lack of knowledge scores are also relatively large. As displayed in Table 10, all of the knowledge measures that were set are relatively small (none of the scores above 40%) and bear large variability.

5.4.2. Statistical analysis

The purpose of BPA1_View is to map overall BPA Attitudes among the EU population and to investigate its drivers, primarily the effect of knowledge of BPA and its lack on Attitudes. To facilitate the interpretation of the following statistical analysis' procedure and the presentation of the specified formulae for modeling, available relevant variables were split per domain and reported in Table 11.

5.4.2.1. Model specifications

The key dependent variable for the analysis of objective knowledge is the BPA-specific knowledge domain, along with its corresponding indicator for the modeling formula of lack of knowledge.

Ordered Logit Specification

The ordered logit regression model generalizes the binary response logit, allowing for more categories in the output if they are ordered. An ordinal response Y_i with C categories is defined by a set of *C-1* equations where the cumulative probabilities are related to a linear predictor, with the constant dropped or set to 0, through the *logit* function. In particular, the logit of each cumulative probability is assumed to be a linear function of the covariates with regression coefficients constant across response categories (Greene, 2018).

Borooah (2001) also presents the ordered logit model for dependent variables with more than two ordinal categories, distinguishing it from multinomial model specification for nominal outcomes, which does not treat the ordinality characteristic. The model posits a latent continuous variable y^*determined by regressors X and a logistic error term ε, with observed outcomes y mapped to categories via threshold ordered parameters. Cumulative probabilities are modeled using the logistic CDF: $P(y \leq j) = \Lambda(\tau_j - X\beta)$. A typical assumption is proportional odds, implying constant effects of regressors across thresholds (Borooha, 2001).

Questions relating to satisfaction with life assessment or beliefs, typically measured through Likert scales, are usually ordinal in nature. This is the case of BPA attitude: “Negative”, “Neutral” and “Positive”. When the response variable of interest is ordinal, as in this situation, the ordered logit model is the appropriate approach.

A secondary objective is to assess whether a solid understanding of the dose–response relationship helps explaining BPA-specific knowledge. The aggregated measure (the overall knowledge indicator) was not taken into consideration while specifying the models because it would bear endogeneity. That would occur because BPA-specific knowledge is one of its components and, as a separate regressor, it would have been collinear with any other knowledge domain.

Table 11 - Relevant variables for statistical analysis for the BPA1_View study

Vector	Domain	Covariate
D	**Sociodemographic**	Gender → *Gender*
		Age → *Age*
		Education completion age → *Education*
B	**Behavioural**	BPA Consumption (proxy) → *Consumption*
		BPA Avoidance → *Avoidance*
P	**Psychographic**	Chemophobia → *Chemoph_score*
A	**Attitudinal**	BPA Attitude → *Attitude*
		Trust in EU regulators → *Trust*
K	**Knowledge**	BPA knowledge → *Knowl_BPA*
		BPA knowledge → *Knowl_BPA_score*
		BPA knowledge → *Lack_knowl_BPA*
		BPA Lack of knowledge → *Lack_knowl_BPA_score*
		Knowledge of Dose-response relationship→*Knowl_DR*
G	Geographical Fixed Effects (See Chapter 5.4.2.2.)	

Regarding covariates, dose–response knowledge is treated as a categorical factor and will be included in all models: the one predicting BPA-specific knowledge, the one predicting lack of knowledge, and the BPA attitudes model. The coding distinguishes respondents who answered none of the dose–response items correctly (baseline) from those who answered only one correctly and eventually those who answered both correctly.

Knowledge of products that may or may not contain BPA (not shown in Table 10 and not used in the statistical analysis phase) was deemed ineligible as a covariate for BPA-specific knowledge due to substantial correlation with that outcome (See Appendix#2), which would raise clear endogeneity concerns and would be multicollinear with other regressors as well. In any case, this variable appears almost independent of attitudes (Pearson r = 0.02), thus it was not included as a regressor.

<u>*Model 1: Knowl_BPA*</u>

$$Knowl_{BPA} = \theta Knowl_{DR} + \gamma D + \delta B + \kappa P + \lambda\, Trust + \varphi G + \varepsilon \qquad (1)$$

Model (1) attempts at explaining the BPA specific knowledge (measured as count of correct answers) as a function of knowledge of generic dose-response relationships, also controlling for sociodemographics characteristics, behavioural and psychographic covariates and trust towards EU regulators. The model includes geographical fixed effects, as discussed in Section 4.4.2.2.

Model 2: Lack_knowl_BPA

$$Lack\_knowl_{BPA} = \theta Knowl_{DR} + \gamma D + \delta B + \kappa P + \lambda\, Trust + \varphi G + \varepsilon \qquad (2)$$

Model (2) investigates BPA specific self-reported lack of knowledge (measured as count of Don't knows), using the same covariates as in Model 1, i.e. knowledge of generic dose-response relationship, sociodemographic controls, behavioural and psychographic variables and trust in EU regulators, controlling for geographical fixed effects.

Model 3: Attitude

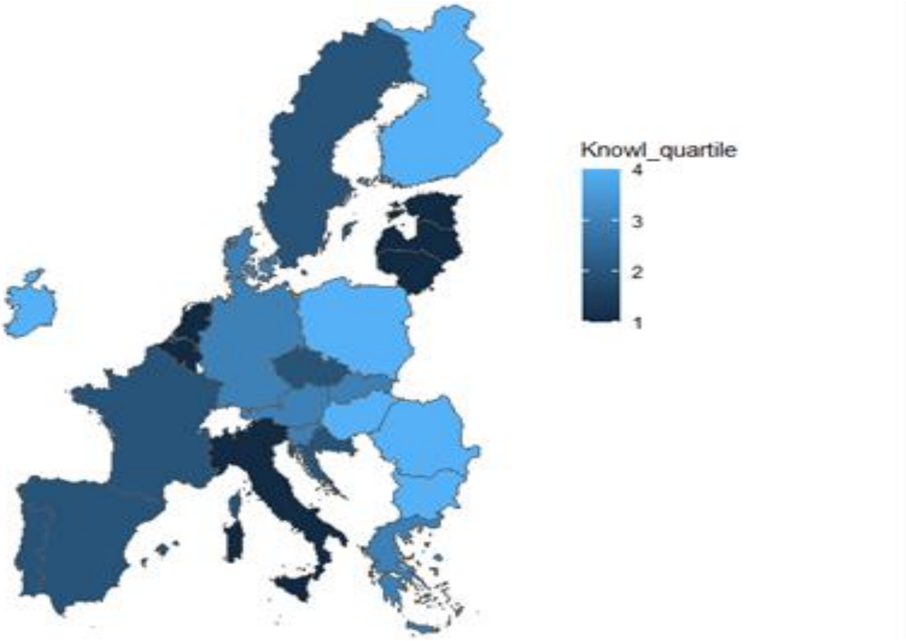
$$Attitude = \theta_1 Knowl_{BPA_{SCORE}} + \theta_2 LackKnowl_{BPA_{SCORE}} + \theta_3 Knowl_{DR} + \gamma D + \delta B + \kappa P + \lambda\, Trust + \varphi G + \varepsilon \qquad (3)$$

Model (3) aims at inspecting drivers of generic attitude towards BPA. As for previous models, we consider sociodemographic, behavioural and psychographic covariates, knowledge about the dose-response relationship and trust in EU regulators, and geographic fixed effects. Additionally, we include two further covariates related to BPA knowledge: *BPA specific objective knowledge* and *BPA Specific self-reported Lack of knowledge*, both included as scores rather than counts.

5.4.2.2. Exploring country-level heterogeneity

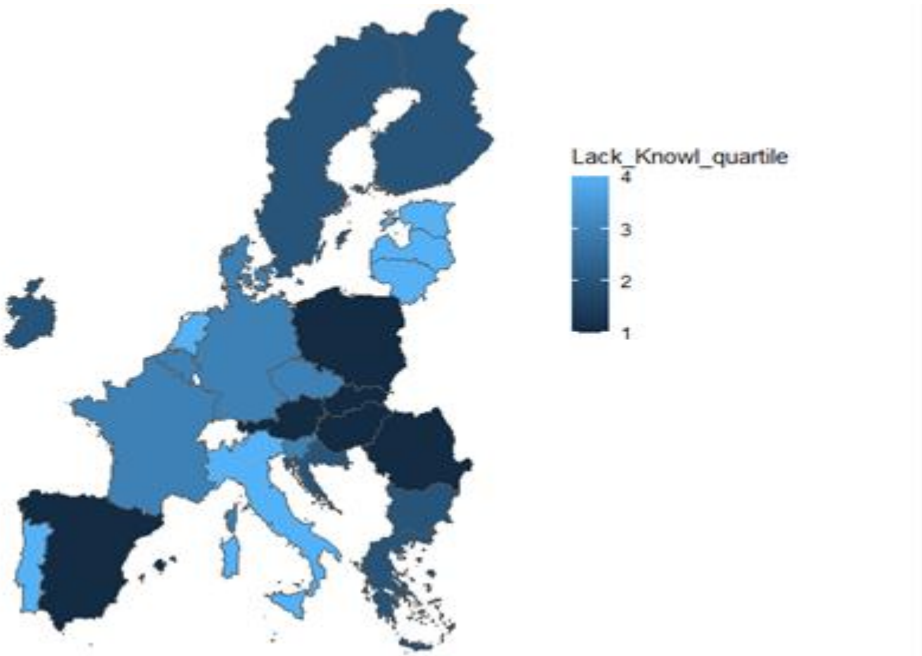
As discussed in Chapter 4, the BPA Flash-poll was administered in 24 member states, with a minimum of 300 respondents per country, while ensuring that at least 33% of respondents reported to be BPA aware, again, in each country.

Figure 8 - EU countries by BPA-specific Knowledge quartiles (1 to 4)



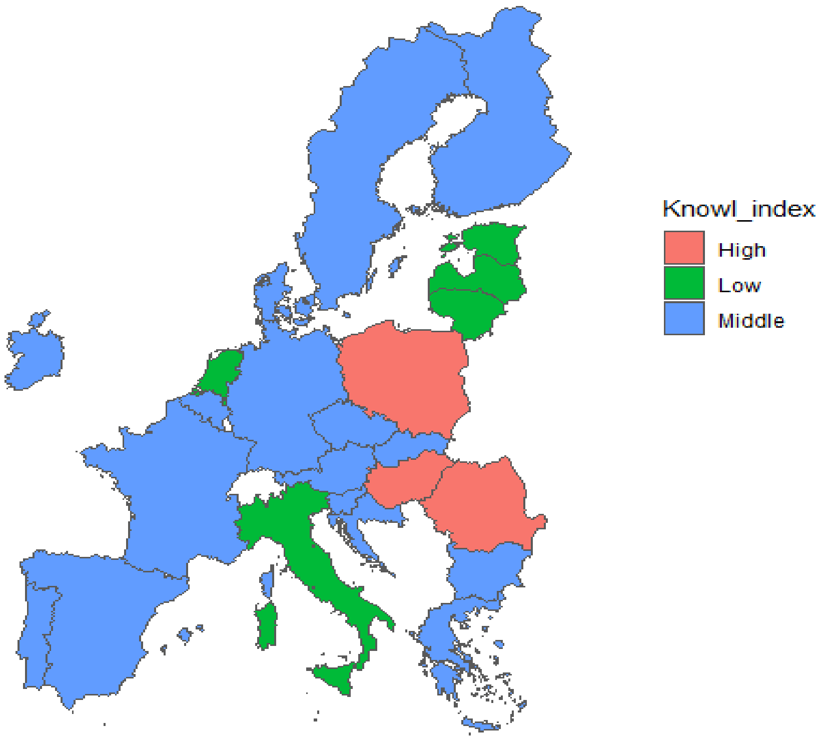
Thus, in order to explore potential unexplained geographical heterogeneity in terms of knowledge and attitudes, additional variables were included to capture geographical fixed effects. More specifically, the 24 countries were grouped into four quartiles based on country averages for BPA-specific knowledge (Figure 8) and BPA-specific lack of knowledge (Figure 9).

Figure 9 - EU countries by BPA-Specific Lack of knowledge quartiles (1 to 4)



A single variable was then built by combining the classification of countries in terms of objective knowledge and self-reported lack of knowledge. Specifically, countries at the bottom quartile for BPA knowledge and at the top quartile for lack of knowledge were classified as “low”; those at the top quartile for BPA knowledge and at the bottom for lack of knowledge were labelled as “High”, and the remaining 12 countries outside this specification were labelled as “Medium” (Figure 10).

Figure 10 - EU countries by BPA-Specific Lack of knowledge quartiles (1 to 4)



These groups were then tested in pair (Low and Medium, Medium and High) to see if they showed statistically different means for the original indicators. As one would expect, the t-tests confirmed the three groups are statistically different among them when it comes to knowledge and lack of knowledge.

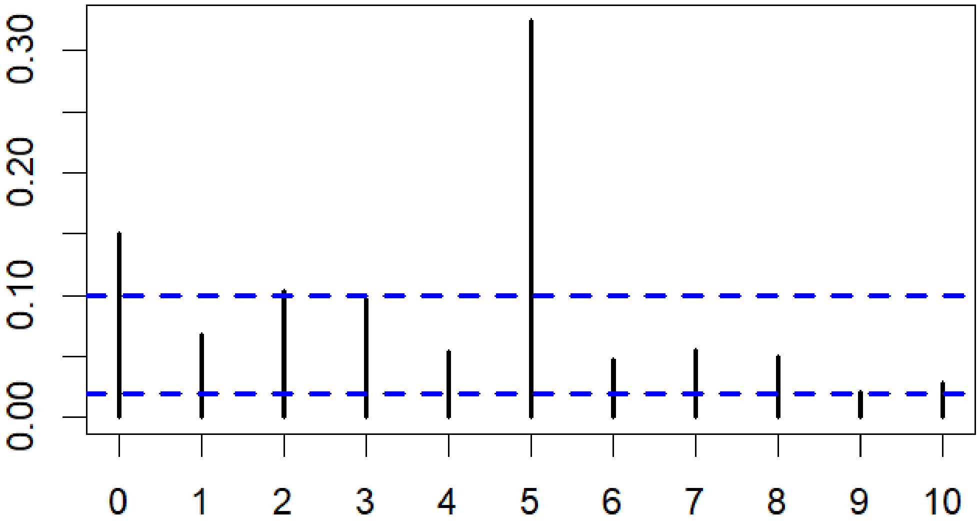
Finally, models allowing for all country-level fixed effects were estimated, without any grouping, although these are not reported in the output tables.

5.4.2.3. Alternative specifications

<u>*Attitudes towards BPA: original versus transformed variable*</u>

Considering the sample of 3748 respondents (those respondents who were BPA aware), as shown in Figure 9, the absolute mode of the variable is 5, which was the response chosen by 32.5% of respondents. Further, responses are highly concentrated on the levels between 0 and 4 (almost half of responses), with 0 as the second most chosen option, with around 15% of answers. All the other levels, between 1 and 4, and between 6 and 10, the rate of respondents ranged between 2% to 10% (blue lines in Figure 11).

Figure 11 - Bar plot Attitude rating "Rate your perception of BPA"



Note: blue lines represent 0.02 and 0.1 relative frequencies
Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q6,Q7)

As discussed in this Chapter, EFSA experts chose to categorize the raw response on attitudes into "Negative", "Neutral" and "Positive", because of a preference towards more homogeneous, fewer levels. In general, categorizing variables that could be potentially treated as continuous implies subjective choices on the number of cut points and where to place them (Altman, 1994; Greenwood, et al., 2006). In addition, this procedure leads to a non-negligible loss of available information.

By maintaining the 10 original levels, it is also possible to relax the assumption of an ordinal dependent variable and rely on ordinary least square regressions and exploit its properties, given the number of categories. Dosman et al. (2001) argue that low-level ordinal scales (e.g., 0–3) are imperfect proxies for underlying perceptions, which are better represented along a continuum continuum (Dosman, et al., 2001). Accordingly, models that avoid collapsing response categories may preserve more information. Moreover, outside the food domain, such scales are often analyzed with linear regression: Didino et al. (2018) model life satisfaction and happiness measured on a 0–10 scale (Didino, et al., 2018), and medical studies use 0–10 (and −10–0 for relief) scales to rate pain and pain relief, estimating linear models (Farrar, et al., 2010; Tin, et al., 2023).

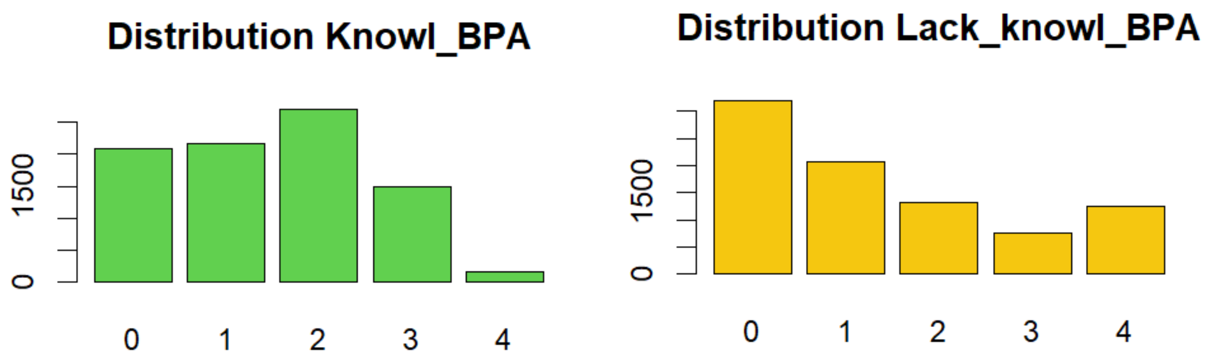
Since the number of levels for this variable is high (11), larger than typical Likert scales, and given past application of this procedure in research, it was envisaged that ordinary least squares regression could perform well. In the workflow, the results from the two different model specifications will be compared to assess whether the two both provide consistent results.

BPA Knowledge and Lack of knowledge: Considering alternative specifications

To provide further support for ordered logit as the most appropriate specification for knowledge measures, it is useful to examine the dependent variables more closely, focusing on their properties and empirical distributions.

A plausible alternative for modelling these variables when considering them as the count of correct answers out of four questions for each measure, would be a Poisson count model This approach assumes, among other conditions, that the dependent variable follows a Poission distribution and is equidispersed (SAS Institute Inc, 2026; Hilbe, 2011).

Figure 12 - Bar plots of knowledge variables of interest



Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q7)

As a first step, the distributions of the two variables were inspected. Two bar plots were produced to assess whether a Poisson-like shape could plausibly fit the data. For *Knowl_BPA*, the distribution does not clearly contradict a Poisson pattern and could therefore be considered potentially compatible at this stage (Figure 12). Instead, *Lack_Knowl_BPA* shows decreasing frequencies from 0 to 3 and then an increase at 4, which is not consistent with a Poisson probability mass function (Figure 12).

As a second step, equidispersion was tested for the variable *Knowl_BPA,* by computing the mean and variance while treating the variable as numeric. The mean is 2,476 , whereas the variance is 1,193 , indicating that the variable is not equidispersed and that the Poisson assumption is violated..

Another potential alternative to the ordered logit specification is the negative binomial (Pascal) model, which accommodates overdispersion of the underlying data. However, or *Knowl_BPA* the variance is lower than the mean, and for *Lack_knowl_BPA* the mean is 2.392 and the variance 2.031, again indicating no overdispersion. Moreover, while each item could be interpreted as a Bernoulli trial, other assumptions behind the negative binomial model (independence, constant probability of success over trials) are difficult to justify in this setting.

Finally, both Poisson and negative binomial specifications are typically derived for counts on the non-negative integers without an upper bound. In the present case, both *Knowl_BPA* and *Lack_knowl_BPA* are bounded between 0 and 4, which further weakens the theoretical suitability of these models.

5.5. Results

Our study investigates the themes of EU citizens' attitudes towards BPA and knowledge of BPA, as well as the factors shaping both. Knowledge was proxied using a composite knowledge index, which was first used as dependent variable, to examine its determinants, and then as a covariate, to eventually assess its role as a driver of BPA Attitude. We also explore a geographical dimension—mapping patterns, trends, and outliers in BPA knowledge and attitudes across Europe.

Results from the ordered logistic regression models are reported in Table 12. Models (1) and (2) use the full sample of 8,600 surveyed EU citizens; model (3) is estimated on the subset of respondents aware of BPA, i.e., those who already had a perception of BPA in mind, who could have provided a meaningful evaluation. As a methodological alternative, Table 15 reports a linear model specification in which Perception is treated as a numeric variable on the 0–10 scale rather than recoded into a three-level ordered factor. The model was passed to the heteroskedasticity test, which rejected the null hypothesis of homoskedasticity of the errors, which violates OLS assumptions. For that reason, Table 15 directly reports the robust standard errors (White's).

Table 12 - Coefficients from the ordered logit models for BPA Knowledge, Lack of Knowledge and BPA Attitudes

	Knowl_BPA (1)	Lack_knowl_BPA (2)	**Attitudes (3)**
Knowl_BPA_score			-1.442*** (0.178)
Lack_knowl_BPA_score			-0.342** (0.158)
Knowl DR → 1 correct	0.588*** (0.043)	-1.105*** (0.046)	0.437*** (0.072)
Knowl DR → 2 correct	0.516*** (0.070)	-1.210*** (0.073)	0.087 (0.108)
Age	-0.005*** (0.001)	0.009*** (0.002)	-0.016*** (0.003)
Gender → Male	-0.083** (0.040)	0.040 (0.041)	0.361*** (0.065)
Gender → Non binary/NA	-0.335 (0.407)	0.601 (0.415)	-0.060 (0.780)
Education → 15 years-old or younger	-0.328* (0.197)	0.284 (0.208)	0.451 (0.385)
Education → 16 to 19 years-old	0.069 (0.169)	-0.013 (0.179)	0.049 (0.340)
Education → 20 years-old or older	0.251 (0.167)	-0.178 (0.178)	-0.465 (0.339)
Education → Still studying	0.019 (0.186)	0.064 (0.197)	-0.359 (0.363)
Education → Don't know	-0.761*** (0.250)	1.138*** (0.257)	0.032 (0.486)
Trust → Yes	-0.257*** (0.046)	0.084* (0.046)	0.432*** (0.076)
Chemoph_score	0.010 (0.021)	0.013 (0.022)	-0.029 (0.035)
Consumption level → Medium	0.095** (0.042)	-0.146*** (0.043)	0.061 (0.069)
Consumption level → High	-0.282*** (0.103)	-0.094 (0.111)	0.807*** (0.158)
Avoidance →Yes	0.712*** (0.070)	-0.663*** (0.076)	-0.530*** (0.103)
Avoidance → Don't check	-0.203*** (0.063)	0.671*** (0.067)	-0.533*** (0.098)
Observations	8,600	8,600	3,748

Note: *p<0.1; **p<0.05; ***p<0.01
Note: (1) (2) (3) are controlled for geographical fixed effects (not displayed)
Note: Nagelkerke Pseudo–R2 (1)0.099 (2)0.206 (3)0.156

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1)

Table 13 - Marginal effects, BPA Attitude (3)

		BPA Attitude		
Covariate	**Contrast**	**Negative**	**Neutral**	**Positive**
Knowl_BPA (score)		0.317*** (0.038)	-0.143*** (0.018)	-0.174*** (0.022)
Lack_knowl_BPA (score)		0.075** (0.035)	-0.034** (0.016)	-0.041** (0.019)
Age		0.004*** (0.000)	-0.002*** (0.000)	-0.002*** (0.000)
Knowl_DR	1-0	-0.097*** (0.016)	0.043*** (0.007)	0.054*** (0.009)
	2-0	-0.019 (0.024)	0.010 (0.012)	0.010 (0.012)
Gender	Male - Female	-0.080*** (0.014)	0.036*** (0.007)	0.044*** (0.008)
	Non binary/NA - Female	0.013 (0.173)	-0.007 (0.092)	-0.006 (0.081)
Trust	Yes-No	-0.096*** (0.016)	0.047*** (0.008)	0.049*** (0.008)
Consumption level	High-Low	-0.172*** (0.031)	0.053*** (0.006)	0.118*** (0.027)
	Medium-Low	-0.0136 (0.015)	0.006 (0.007)	0.007 (0.008)
Avoidance	Yes-No	0.116*** (0.022)	-0.044*** (0.008)	-0.071*** (0.015)
	Don’t check - No	0.116*** (0.021)	-0.045*** (0.007)	-0.072*** (0.014)
Note: *p<0.1; **p<0.05; ***p<0.01				

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1)

Table 14 - Baseline frequencies, BPA Attitude (3) Variables

Covariate	**Base level**	**Baseline**
Knowl_DR	0	57,37%
Gender	Female	52,38%
Trust	No	26,86%
Consumption level	Low	54,64%
Avoidance	No	12,11%

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1)

Table 15 - OLS regression Model for BPA Attitudes - Modelling alternative

	Attitudes (OLS - Treated as continuous)	Attitudes (Ordered logit)
Knowl_BPA_score	-2.004*** (0.220)	-1.442*** (0.178)
Lack_knowl_BPA_score	-0.553*** (0.187)	-0.342** (0.158)
Dose-response → 1 correct	0.737*** (0.088)	0.437*** (0.072)
Dose-response → 2 correct	0.383*** (0.126)	0.087 (0.108)
Age	-0.025*** (0.003)	-0.016*** (0.003)
Gender Male	0.455*** (0.080)	0.361*** (0.065)
Gender → Non binary/NA	0.240 (0.785)	-0.060 (0.780)
Education → 15 years-old or younger	0.575 (0.575)	0.451 (0.385)
Education → 16 to 19 years-old	-0.101 (0.523)	0.049 (0.340)
Education → 20 years-old or older	-0.691 (0.521)	-0.465 (0.339)
Education → Still studying	-0.468 (0.543)	-0.359 (0.363)
Education → Don't know	-0.214 (0.656)	0.032 (0.486)
Trust → Yes	0.705*** (0.091)	0.432*** (0.076)
Chemophobia score	-0.081* (0.047)	-0.029 (0.035)
Consumption level → Medium	0.085 (0.084)	0.061 (0.069)
Consumption level → High	1.055*** (0.210)	0.807*** (0.158)
Avoidance → Yes	-0.796*** (0.130)	-0.530*** (0.103)
Avoidance → Don't check	-0.718*** (0.118)	-0.533*** (0.098)
Constant	5.341*** (0.635)	/
Observations	3748	
R2	0.173	
Adjusted R2	0.164	
Residual std error	2.401 (df = 3706)	
F Statistics	18.895*** (df = 41; 3706)	
Note: *p<0.1; **p<0.05; ***p<0.01 Note: The model has been controlled for geographical fixed effects (not displayed) Note: White's Robust standard errors		

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1)

5.6. Discussion

BPA Knowledge

Results for the BPA-knowledge model (Table 12, model (1)) show that, as expected, the coefficients for dose–response knowledge (Knowl_DR1, Knowl_DR2) are positive and statistically significant: better understanding of dose–response is associated with higher BPA-specific knowledge. The estimates also indicate that older respondents (≥40 years) and males exhibit, on average, lower BPA knowledge.

Several behavioral covariates are relevant as well. Lack of trust in EU regulators (Trust = No, aggregating “No” and “Strong no”) is associated with lower BPA knowledge. Higher BPA consumption (proxy measure) is negatively related to knowledge, consistently with lower attention to BPA or non-awareness. Regarding BPA avoidance paths, relative to non-avoidance (baseline), actively avoiding foods or drinks that contain BPA is associated with higher knowledge, whereas not checking the label for the presence of bisphenol A is associated with lower levels of knowledge.

For the lack-of-knowledge model (Table 12, model (2)), results largely mirror previous findings. In particular, age shows a positive and significant association with self-reported lack of knowledge. An exception is gender, whose coefficients are not significant in (2).

BPA Attitude

Results from the ordered logit model on BPA perception (Table 12, model (3)) indicate that dose–response knowledge and BPA-specific knowledge are both significant predictors of attitudes, but with opposite signs. Greater BPA-specific knowledge is associated with more negative perceptions, whereas better dose–response knowledge is associated with more positive attitudes toward BPA. In fact, the most relevant finding from the inspection of the marginal effects (Table 13, Table 14) is associated to the role of the ”dose-response” knowledge (Knowl_DR). When a respondent replies correctly to 1 of the 2 dose-response related knowledge questions, its probability of having a Negative attitude towards BPA decreases by 9.7 percentage points, while it raises the probability of a Neutral attitude by 4.3 points as well as the probability of a Positive attitude, by 5.4 points. Instead, Switching from 0 to 2 correct answers in the dose-response domain question does not generate significant changes in probabilities, in line with the estimated coefficients. This most likely depends on the fact that only 9.3% of the respondent sample replied correctly to both questions.

As with knowledge outcomes, age is negatively related to attitudes: older respondents tend to report about more negative BPA attitudes. By contrast, males, those who trust EU regulators, and respondents with higher proxied BPA consumption tend to report more positive attitudes. When the Age of the interviewee increases by 1 year, the probability that a negative attitude towards BPA is reported increases by 0.4 percentage points, which is a non-negligible effect when considering cumulative effects over several years. Male gender reduces the probability of having a negative attitude towards BPA by 8 percentage points, in line with previous evidences showing on average more positive attitudes for male respondents. Considering trust in EU regulators, the probability of having a negative attitude shrinks by almost 10 percentage points, equally shifting towards the probability of having neutral and positive attitudes. Those reporting high levels of (proxied) BPA intake, compared to respondents consuming at a low frequency, reduce the probability of a negative attitude by 17.2 points, with a major shift in positive attitudes (+11.8 percentage points), as one would expect. When looking at avoidance patterns, those actively avoiding BPA increase the probability of a negative attitude by 11.6 percentage points. Interestingly, similar effects are observed on those who declare not to check for BPA presence in foodstuffs.

Conversely, some behaviors are associated with negative attitudes: higher BPA-specific knowledge and the Avoidance levels “avoid” or “do not check” (relative to non-avoidance). The expectation that chemophobia depresses attitudes aligns with prior literature (Rollini, et al., 2022). However, in this ordered-logit specification its coefficient is not statistically significant.

Treating perception as a continuous 0–10 variable and estimating via ordinary least squares (Table 15) yields coefficient signs consistent with the ordered-logit results. In this specification, both dose–response knowledge levels are significant (including the “both correct” category, which was not significant in the ordered-logit model) and chemophobia exhibits a very small but statistically significant coefficient.
Overall, under these data and modelling choices, using a continuous dependent variable with OLS appears to offer greater power without introducing major biases, while also preserving information inherent in the original 0–10 attitude scale.

5.7. Limitations and potential extensions

Even though the present study provides some insightful hints about what the drivers of BPA knowledge and attitudes in the population would be, further study options are available. In addition to this, the work is subjected to

, given some structuring choices and constraints implicit in the original study, made necessary by the research design, but still posing some limits to the external validity of our results.

Risk of sample self-selection bias

Given the data collection technique, when it comes to respondents seeking and reaching, as well as the forced imposition of quotas by the data collector, the sample cannot be demonstrated to be statistically representative of the EU population for many unobserved variables. Only probabilistic sampling ensures that randomization occurs on both observable and unobservable variables, and quota sampling poses risks of sample selection biases.

Data was collected by a marketing research company, that was contracted by EFSA through a procurement for data collection. This company then contacts consumers that have declared themselves to be open to receiving surveys for marketing purposes, and if they do agree, a survey is sent to them, to be completed via laptop. This also generates some risk of self-selection biases.

Matched to that, due to the necessity to impose quota, most importantly the one on BPA awareness, the contractor for data collection needed to force respondents out of the survey, again making it clear the distance from a probabilistic survey. There were no alternative routes for sample collection, because the imposed quotas guaranteed more informative analyses, although it must be acknowledged that under this constraint, the external validity of the results cannot be demonstrated.

Limitations in the survey design

Other potential limitations in the analysis stem from the presence of the “don’t know” option in questions where such option was not strictly necessary, or even redundant. This resulted in a loss of observations, due to missing values in explanatory variables. While for knowledge items, also considering the objective to measure lack of knowledge as opposed to wrong knowledge, the “Don’t know” item was needed and functional, for other variables it could lead respondents to opt for the ”don’t know” option merely to limit their effort in answering. For example, such issue is evident when considering the age at which education was completed. It is not unlikely that respondents are unaware of their education completion age, and it's likely that these don't know lead to non-random missing values and potential selection biases.

BPA awareness requirements and quota

Considering awareness of BPA, the final actual quota was 43,58%, lower than the initial planned requirement of 60%. Due to the difficulties in sampling a sufficient number of BPA-aware respondents, the quota was lowered to a minimum of 33% BPA-aware respondents per country.

Only one model was estimated on the sample of BPA-aware respondents was the one with BPA attitudes as the dependent variable, while the other models on BPA knowledge were estimated on the full sample.

In any case, a trial was done splitting the BPA knowledge and BPA lack of knowledge models by BPA Awareness (results are available in the Appendix#3).

5.8. Concluding remarks

Exposure from diet is the primary manner through which BPA enters the human body. BPA intake may be increased by foodstuff temperature when food is contained in boxes fabricated with BPA and nonetheless by food packaging (Khalili, et al., 2023). In addition to that, the increasing presence of chemicals in the environment has caused the problem of chemophobia to arise (Tarasova & Макарова, 2020), sustained by insufficient levels of chemical literacy in the population. Increasing concerns associated to BPA led science to investigate for alternatives, for instance, it was considered shifting to Bisphenol-S as the main substitute (Rochester & Bolden, 2015; EFSA, 2020; Food Packaging Forum, 2024) or even turning to green chemistry options (Liguori, et al., 2020).

This study gives support to the previously identified relationship between chemical product perceptions and level of BPA chemistry literacy in humans, while it maps BPA attitude-related variables across the European countries involved.

Dose-response knowledge in the EU was for the large majority (64% to 84%) incorrect or lacking, the same occurs for BPA-specific knowledge: 38.5% to 89% of respondents lacked the knowledge to reply to the questionnaire, or replied incorrectly. The shown levels

of BPA literacy are associated with a behavioral impact, in terms of consumption and avoidance of products that may contain BPA, as well as with increasing age ranges.
Our analysis also finds that those who have better dose-response knowledge scores, as a primer, also show better BPA-specific literacy.

Instead, attitudes are negatively impacted by BPA-specific knowledge, while dose-response literacy is associated with a positive effect on BPA attitudes.
Older respondents also tend to perceive BPA negatively, and males have on average better attitudes towards it. The latter also occurs for those who are expected to consume higher levels of BPA-related foodstuffs. Negative attitudes limit consumption and lead to avoidance paths. Trusting EU regulators on food safety is relevant to the BPA population's attitudes as well. When trust is strong, the coefficient increases consistently, showing even more positive BPA attitudes. In condition of lack of trust, BPA attitudes worsen.

The psychometric dimension of chemophobia, as expected, negatively impacts attitudes towards BPA, even though its effect is not large.
Understanding public sentiment and behaviour around chemicals in food is essential to creating a safe, responsible production-and-consumption ecosystem in the EU given the sensitivity of the population to chemical risks, which is not in line with the true scientific risk and overperceives it (Yeak, et al., 2025). To strengthen the evidence base for public institutions, a psychographic profile of Europeans' perceptions—paired with measures of objective knowledge—could help policymakers identify and bridge knowledge gaps. This, in turn, would improve the effectiveness of public communication about chemicals in food and food-contact materials and support the uptake of safer, more sustainable eating habits.

6. Testing alternative strategies to communicate BPA tolerable daily intakes and their effects on risk perception (*BPA2_Comm*)

This Chapter reports the findings of an additional study on Bisphenol-A . This work has been developed in parallel with the one on BPA perceptions (BPA1_View) described in Chapter 5, and relies on the same survey data from the 2022 BPA Flash-poll (see Chapter 4). This study was also conducted in collaboration and under the guidance of EFSA researchers[12]. The present chapter reports the main results of the study, extending the discussion on methodological aspects and providing additional analyses with respect to the original manuscript.

This study aims at assessing the effects on consumer risk perceptions of communicating about the updated tolerable daily intakes (TDI) for Bisphenol-A (BPA) through different message formats. Furthermore, the study explores changes in BPA risk perception measures when the respondents focus is shifted from own health to their children's health.

6.1. Introductory background

Communications about BPA affect risk perceptions of food-contact materials, in this specificity chemicals, the aim is to gain a better understanding about how institutional messages should be shape to calibrate the EFSA risk communication strategies. By extension, strategies of other local public institutions may more in general benefit from the arising hints. The purpose of this study represents a specific case for a wider research theme: the assessment of different formats of institutional communication and their effects on the consumer sentiment about food safety. As for this work, with a specific focus on food contact materials, in particular chemicals such as BPA. In particular, given the reduction in the BPA tolerable daily intake occurred after the 2022 EFSA evaluation, two different experimental message were proposed to the sample examined: one through the usage of a verbal qualifier and one through the presentation of the calculated reduction of the TDI.

[12] The related article is currently under peer review, internally in EFSA. Joana S. Laurenco, quantitative psychologist working in the Communication and Partnership department of EFSA supervised the study and co-operated to drafting the scientific manuscript. The paper is expected to be submitted by the end of 2025 (Laurenco, et al., 2025).

The usage of these two possible formats is yet discussed, almost always in comparative terms. A first main takeaway from present literature reports that using a qualifier (i.e. “significantly higher”) is purely of directional nature, thus it leaves room for interpretation to the users. Receivers of news bear enormous variability, and words/terms’ meaning is not universal, not only among laypeople but often also within statisticians. For that reason, the verbal format usage may represent a risk of bias for perceptions and decisions, though for miscommunication (Willems, et al., 2020; Collins, et al., 2024). On the other hand, especially if, as in this case, the target audience is the whole population, numberless qualifiers are flexible and afford ease of expression, even in crucial science domains. Anyhow, while the addition of words enriches the communicative message, when it stands per se may give the impression to hide uncertainty or approximated or wrong predictions (Dhami & Mandel, 2022; Teigen, 2022). When it comes to communication through numeric element, (i.e. “40 times lower”, “75% more probable”) is then precise and does not leave any room to the receiver for interpreting the reported data. As well as that, such format is apparently preferred by users, especially when they neet to take decisions (Dhami & Mandel, 2022), in this specificity about food consumption. Anyhow, pure presentation of numbers may be ineffective if the receiver lacks numeric literacy or if not enough context and/or intention is transmitted to the target audience. Plus, without explanatory framework, even numeric literacy values may fail in correctly communicating the risk (Willems, et al., 2020; Dhami & Mandel, 2022).

The available scientific evidence already shows how public authorities in charge for food safety should adjust to the evolving communication needs of the population in terms of channels, content framing and stakeholders. This study will then assess, through experimenting different message formats about new scientific evidence related to a food hazard, how to best communicate about the new Bisphenol-A TDI to properly redirect concern measures among the EU population.

Food risk communication is fundamental not only to prevent food-related illness, but also to build trust in public and scientific institutions, which is central, as discussed in Chapter 1. Ultimately, it is important to progressively shape a culture, also through the educational path, of safer and more sustainable food habits in the European population. For that reason, investigating communication formats and channels, as well as the final effects and drawbacks of communication activities, is valuable.

6.2. Data

The study relies on the the same dataset presented in Chapters 4 and 5 in relation to the BPA1_View study, i.e. data collected through the BPA Flash-poll survey administered by EFSA in December 2022. Thus, the socio-demographic variables considered in the present study are those reported in Table 1, Chapter 4.

More specifically, the gender and education variables, as well as the BPA avoidance measure, were treated and processed the same. Thus, the gender variable consists in the same three categories (Female, Male and a single category for Non-binary/Prefer not to answer). For chemophobia, the derived score based on Saleh et al. 2019 score was also used without modifications (See Table 3). Similarly, we used the same grouping ratio to proxy BPA Consumption frequency (Low, Medium, High), as reported in Table 5. Among the variables already discussed in Chapter 4, the only adjustments relates to *Trust in the EU*, where formats more functional to the aims of the present study were adopted.

<u>*Knowledge of children's products that may contain BPA*</u>

Table 16 - Knowledge Infant/Children BPA products - Assessment descriptives

"Please indicate whether you think the following product can contain BPA or not. If you don't know, you can just indicate so."	Replied "No" (Correct)	Replied "Yes" (Incorrect)	Replied "I don't know"
Bottles and food storage containers for infants/children up to 3 y.o. (False)	27.1%	42.8%	30.1%

Know_child_BPA	Freq
1	2331 (27.10%)
0	6269 (62.90%)

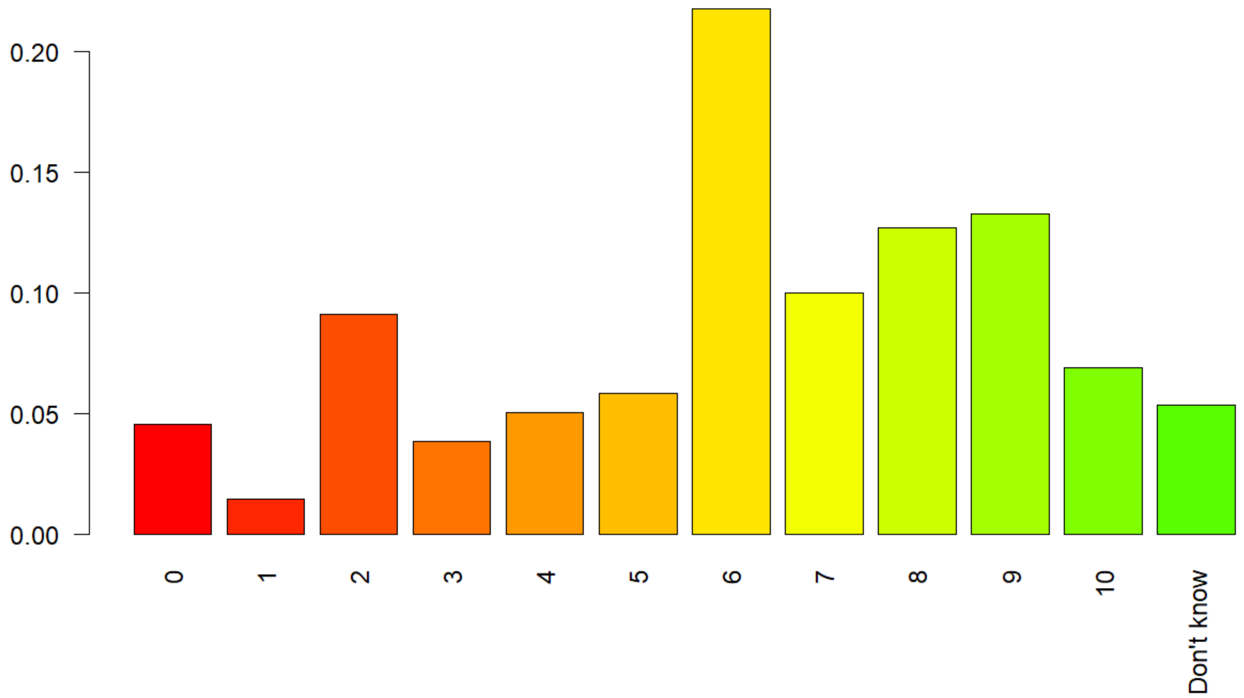
Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q6.1)

As part of the objective knowledge variables, examined in BPA1_View (Table 9), within the domain of products that can potentially contain BPA, one of the items was related to baby children's and infants' products (See Appendix#1/Q6.1). Thus, for the purpose of this study it was eventually built a binary variable on knowledge, relevant to children health, based on this individual item. The variable *Know_child_BPA* (see Table 16), takes value 1 for correct responses. The variable takes a value of 0 both for incorrect responses and "I don't know" answers.

Trust in EU regulators in relation to the evaluation of BPA risk in Food packaging

For the purpose of this study, respondents' trust in EU regulators was measured with a specific reference to BPA and with greater detail, through a different question in the survey with respect to the institutional trust measure considered for BPA1_View.

Figure 13 - Trust in EU regulator to evaluate risks of BPA – Color Scale Bar chart



Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q8.4)

Specifically, while the trust measure in the BPA-Perc study was drawn from Q6.1 (see Appendix#1/Q6.1), BPA2_Comm rely on Q8.4 (Appendix#1/Q8.4).

Within the trust-related question' structure, respondents could state to what extent – on a scale from 0 to 10 –they trust EU regulators specifically in relation to their ability to assess risks of BPA in food packaging. Within the questionnaire, levels 0, 5 and 10, were attached with the labels "Not at all", "Neutral", "To a great extent", respectively. Respondents were also given the possibility to reply "I don't know". Thus, the raw variable has 11 levels, ranging from no trust to total trust, plus a no-reply option ("I don't know") (See Figure 13, Table 17).

Table 17 - Stated trust in EU regulators evaluating BPA risks - Descriptive Statistics

Trust EU for BPA	Freq	
0 – Not at all	392	4.56%
1	125	1.45%
2	331	3.85%
3	434	5.05%
4	505	5.87%
5 – Neutral	1874	21.80%
6	862	1.00%
7	1095	12.73%
8	1141	13.27%
9	594	6.91%
10 – To a great extent	786	9.14%
Don't know (set to missing)	461	5.36%
Sample (N=8600)	8600	100%
Mean (SD)	7.25	(2.75)

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q8.4)

Children

Given the emphasis of this study on comparing respondents' perceptions when the focus is on children's health risks, the BPA Flash-poll was composed of also an item specifically meant to collect information about children (See Appendix#1/Q3). Respondents were first asked whether they had children or not, and those who responded positively were asked their children's age, in classes.

For the purpose of subsequent analysis, it was decided to consider as a target only those parents with children aged 14 or below. In contrast, respondents with no children or with children above 14 were grouped in a single category. People with more than one child were permitted to answer up to three times the same question, thus to select multiple question items. As a consequence, the sample of children of the survey respondents will be higher than the sample of respondents with children (See Table 18). For instance, if a respondent has a 2-year-old child and a 7-year-old child as well, he/she will indicate “Have a child/children aged 0-3 years old” and “Have a child/children older than 3 but younger than 10 years old”. Only in case the first answer was “Have no child/children aged 0-14 years old”, there was no possibility provided in the survey to reply twice.

Table 18 - Dummies "Have/Have not a child/children in that age range"

	Have a child/children in that age range [0/1]	
Child age	**NO**	**YES**
0-3	7716	884
4-9	7448	1152
10-14	7084	1516
Sample of Children in the survey (minimum)		3552
Sub-sample of Respondents with Children		2968

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q3)

6.3. Target variables

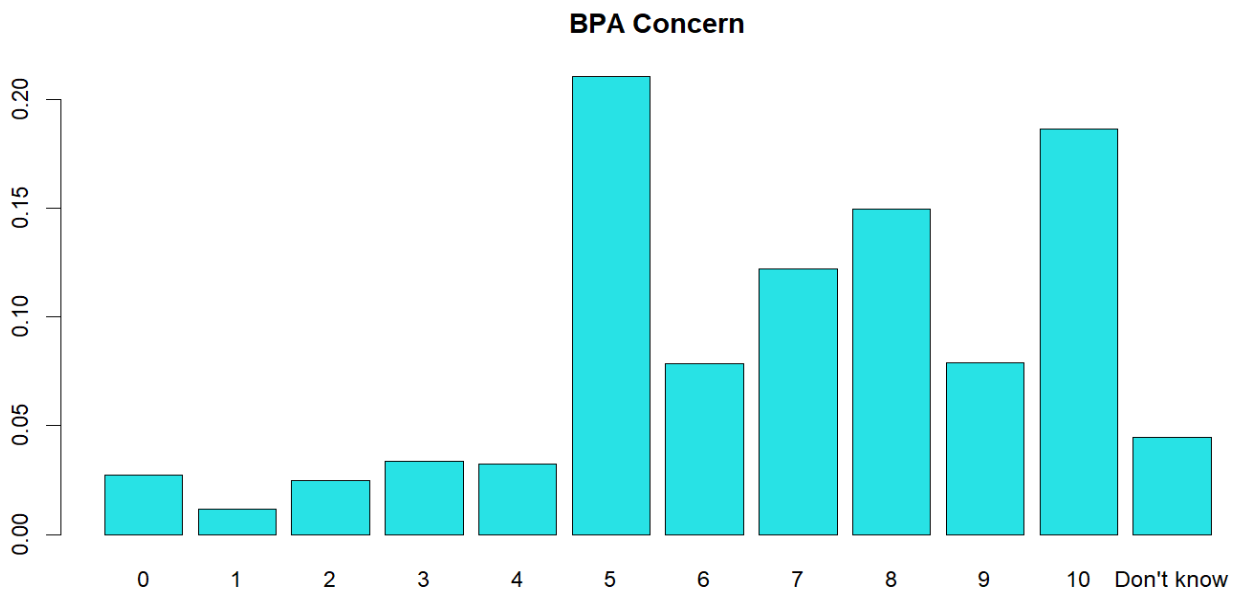
Further data processing targeted some of the key variables of interest for this study. We will refer to these measures as *target variables: concern about BPA, perceived health risk (own health), perceived health risk (children's health)*. In the survey section relevant to BPA2_Comm, respondents were asked to rate their levels of concern about BPA and perceived health risk associated with BPA.

These target variables were collected through three separate questions (see Appendix#1, Q8.1-3). All of the three variables were collected using a scale of discrete ordinal values between 0 and 10, plus a 12th category for the "Don't know" option. Similarly to the survey item on trust, three labels were attached to the levels "0 – Not at all", "5 – Neutral", and "10- To a great extent" as facilitator.

To allow for the numeric treatment of the target variable, labels were dropped and "I Don't know" replies were forced to NA.

BPA Concern

Figure 14 - BPA Concern - Bar chart



Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q8.1)

Concern for BPA is the first item of the related question in the BPA Flashpoll (See Appendix#1/Q8.1). The item responses are distributed as displayed in Figure 14 and described in Table 19.

Table 19 - BPA Concern - Descriptive statistics

BPA Concern	Freq	
0 – Not at all	234	2.72%
1	101	1.17%
2	213	2.48%
3	290	3.37%
4	277	3.22%
5 – Neutral	1811	21.06%
6	675	7.85%
7	1049	12.20%
8	1286	14.95%
9	679	7.90%
10 – To a great extent	1601	18.61%
Don't know	384	4.47%
Sample	8600	100%
Mean (SD)	6.74	(2.54)

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q8.1)

Perceived health risk (own health)

Perceived BPA risk for own health is the second item of the related question in the BPA Flash-poll (See Appendix#1/Q8.2). The item responses are distributed as described in Table 20 and displayed in Figure 15.

Table 20 – Extent BPA risk on Own health - Descriptive statistics and transformation

BPA risk Own health	Freq	
0 – Not at all	155	1.80%
1	72	0.84%
2	188	2.19%
3	251	2.92%
4	303	3.52%
5 – Neutral	1462	17.00%
6	827	9.61%
7	1218	14.17%
8	1346	15.65%
9	811	9.43%
10 – To a great extent	1,487	17.29%
Don't know	480	5.58%
Sample	8600	100%
Mean (SD)	6.91	(2.39)

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q8.2)

Perceived health risk (childrens' health)

Perceived BPA risk for children health is the third item (See Appendix#1/Q8.3). The item responses are distributed as described in Table 21 displayed in Figure 15. This variable was only collected on the subsample of those respondents having at least one child in an age relevant to the analysis, i.e. aged 14 or below(N=2968).

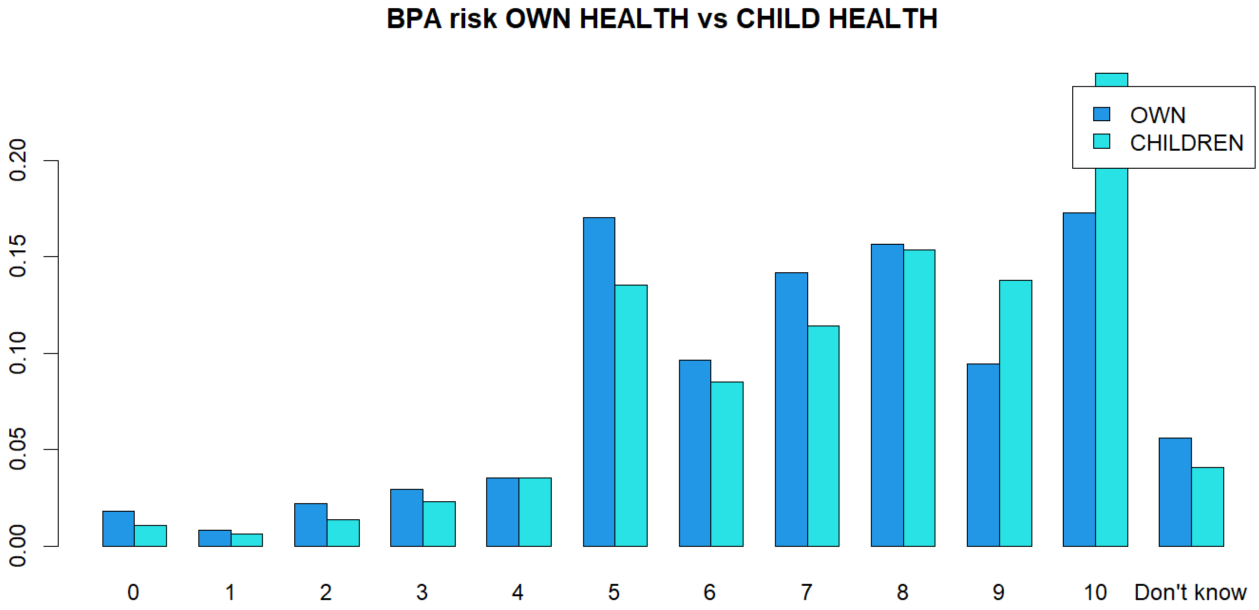
Table 21 – Extent BPA risk on Children's health - Descriptive statistics and transformation

BPA risk Children's health	Freq	
0 – Not at all	32	1.08%
1	18	6.06%
2	41	1.38%
3	68	2.30%
4	104	3.50%
5 – Neutral	402	13.55%
6	252	8.49%
7	338	11.39%
8	455	15.33%
9	409	13.78%
10 – To a great extent	728	24.53%
Don't know	121	4.08%
Sample	2968	100%
Mean (SD)	7.45	2.31

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q8.3)

As shown in Figure 15, there is a general increase in health risk concerns when children are considered, and the difference is especially large for the highest levels of concern (9 and 10). As opposed, for neutral and low levels of perceived health risk, instead, frequencies are higher when respondents report about their own health.

Figure 15 - Extent BPA Risk on Own health vs Children's health - Comparative Bar chart



Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q8.2-3)
Note: the light blue bars (Perceived BPA health risk on Children health) is drawn on the subsample of parents

6.4. Methods

The study aimed at assessing the relevance of adopting different message formats when communicating a change in risk-related data, in this case the Bisphenol-A tolerable daily intakes (TDI). For this purpose, the survey involved the presentation of a message in different formats to different subsamples of respondents. These messages preceded a question about BPA beliefs.

The statistical analysis explored the association between the message kind and the above defined target variables, while controlling for socio-demographic characteristics and considering explicitly the effect of the parenthood condition (defined as being a parent of at least one child aged 14 or less).

The hypothesis being tested is whether different message formats in communicating the update on TDI lead to differences in levels of concern about BPA and BPA health risk perceptions.

6.4.1. Experimental treatment and control groups

At the early stage of the present study, in 2023, the BPA Tolerable Daily Intake was 0.2 nanograms, 20000 times lower than the previous one, which was 4 micrograms.

To test the effect of different message formats used to communicate the new TDI of BPA to the EU citizens, three different message formats (2 + control) were presented to three different sub-samples. The assignment to each group was randomized, and each group consisted of about 1/3 of respondents (Table 22). Given the randomization, the Awareness quota should be in place for all the three groups, together with, theoretically, the stratification about the parenthood condition and other sociodemographics to safeguard within-group representativeness of the overall sample.

Table 22 - Experimental groups - Sample splitting

group_msg	*Sample splitting*	
[Group 1] **None**	2851	33.15%
[Group 2] **Qualifier**	2796	32.51%
[Group 3] **Value**	2953	34.34%

Table 23 - Introductory messages to experimental groups

[Group 1 /NO INTRO]
[Group 2 /INTRO1] **Please read the following text carefully.** **Scientists working with the organization responsible for food safety in the EU have assessed possible health risks associated with daily ingestion of bisphenol A (BPA). They proposed that the amount of BPA that an individual can ingest daily over a lifetime without health risk is 0.2 nanograms (= 0.0002 micrograms) per kilogram of bodyweight per day.** **This new value of 0.2 nanograms is <u>significantly lower</u> than the temporary value established in 2015, as scientists established based on new evidence that the old value posed a health concern. The 2015 value was 4 micrograms per kilogram of body weight per day.**
[Group 3 /INTRO2] **Please read the following text carefully.** **Scientists working with the organization responsible for food safety in the EU have assessed possible health risks associated with daily ingestion of bisphenol A (BPA). They proposed that the amount of BPA that an individual can ingest daily over a lifetime without health risk is 0.2 nanograms (= 0.0002 micrograms) per kilogram of bodyweight per day.** **This new value of 0.2 nanograms is <u>20,000 times lower</u> than the temporary value established in 2015, as scientists established based on new evidence that the old value posed a health concern. The 2015 value was 4 micrograms per kilogram of body weight per day.**

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q8 INTRO)

The questions related to the target variables for the control group, Group 1, were posed without any introduction. For the other two groups, an introductory paragraph was included in the questionnaire (See Table 23). Both messages reported the last TDI as well as the previous one set in 2015. They differ in how the extent of the TDI reduction is explained in each message. For Group 2, the reduction was defined through a verbal qualifier (i.e. "significantly lower"), while for Group 3 the reduction was communicated as the calculated value of the reduction itself (i.e. "20 000 times lower").

6.4.2. Models

The primary of BPA2_Comm is to measure levels of BPA Concern, perceived health risk from BPA on own health and perceived BPA health risk on children's health (when it applies) among the EU population. At the same time, a communication experiment is done about three (2+ control) different communication formats about TDI and their effect on target variables. To facilitate the interpretation of the following modeling procedure and the analysis. Available relevant variables were split per area and reported in Table 24.

Table 24 - Relevant variables for statistical analysis of BPA2_Comm

D	***Sociodemographic***	*Gender* → Gender
		Age → *Age*
		Education completion age → *Education*
		Age of child/children (3 dummies)→ *Children age*
B	**Behavioural**	BPA Consumption (proxy) → *Consumption*
		BPA Avoidance → *Avoidance*
P	**Psychographic**	Chemophobia → *Chemoph_score*
A	**Attitudinal**	BPA Concern → *Attitude*
		Perceived BPA Helath risk (Own) → *HR*
		Perceived BPA Helath risk (Children) → *HR_child*
		Trust in EU for BPA protection → *Trust EU (BPA)*
K	**Knowledge**	Knowing infant/children products that may contain BPA → *know_child_BPA*
E	**Experimental dummies**	Verbal qualifier group → Qualifier
		Calculated reduction value → Value
G	Geographical Fixed Effects (See Section 4.4.2.2.)	

The primary dependent variables for this analysis are the attitudinal measures reported in Table 24, except Trust, alongside the outcomes of the communication experiment. Among the regressors, knowledge about whether infant/child products may contain BPA will e included, which is potentially relevant to attitudes. The control for the age of children in the household/sample to assess whether it influences the target outcomes will be specified as well. All specifications include a vector of geographical fixed effects.

As discussed earlier, the target variables can be treated as numeric. Although response labels were provided to aid respondents, the scale was explicitly defined on a 0–10 continuum. Accordingly, our empirical strategy relies on ordinary least squares (OLS) regression. Responses of “I don’t know” are treated as missing values and excluded from the analysis (see Section 4.4.2.3.).

Robust standard errors formula will be used for all models.

Model 1: BPA Concern

$$BPA\ Concern = \eta E + \theta Know_{child_{BPA}} + \gamma D + \delta B + \lambda Trust_{EU_{BPA}} + \kappa P + \varphi G + \varepsilon \quad (1)$$

Model (1) attempts at explaining BPA concern, modelled as a function of the TDI message’ format received (as captured by the vector *E*), the binary variable about children’s BPA products knowledge, controlling for sociodemographic covariates, behavioural and psychographic characteristics as well as trust in EU regulators in relation to protection from BPA related risks.

Model 2: HR_own

$$HR = \eta E + \theta Know_{child_{BPA}} + \gamma D + \delta B + \lambda Trust_{EU_{BPA}} + \kappa P + \varphi G + \varepsilon \quad (2)$$

Model (2) attempts at explaining the extent to which respondents think that BPA poses a risk on their health. The model follows the same specification as (1) in terms of covariates.

Model 3: HR_child

$$HR\_child = \eta E + \theta Know_{child_{BPA}} + \gamma D + \delta B + \lambda Trust_{EU_{BPA}} + \kappa P + \varphi G + \varepsilon \quad (3)$$

The last model (3) aims at inspecting drivers of perceived health risk from BPA on children’s health. The specification of covariates is the same as in (1) and (2), but the estimation sample is restricted to parents with a child/children in the relevant age range.

6.5. Results

Table 25 - LM for BPA Concern, risk extent on Own Health, risk extent on Children's health

	CONCERN (1)	**HR_own** (2)	**HR_child** (3)
value	0.177*** (0.064)	0.259*** (0.061)	0.179* (0.097)
qualifier	0.223*** (0.064)	0.264*** (0.061)	0.239** (0.100)
know_child_bpa	0.007 (0.059)	0.020 (0.055)	0.090 (0.094)
Children age → 0-3	0.047 (0.091)	0.067* (0.041)	0.013 (0.063)
Children age → 4-9	0.028 (0.038)	0.039 (0.035)	-0.0004 (0.053)
Children age → 10-14	0.076** (0.034)	0.51 (0.033)	-0.016 (0.061)
Gender→ Male	-0.365*** (0.053)	-0.338*** (0.050)	-0.350*** (0.082)
Gender → Non binary/NA	-0.707 (0.793)	-0.790 (0.650)	-1.615 (1.348)
Age	0.017*** (0.002)	0.008*** (0.002)	0.013*** (0.005)
Education → ≤15 years-old or younger	0.702** (0.309)	0.621** (0.286)	0.801* (0.458)
Education→ 16 to 19 years-old	0.875*** (0.271)	0.641*** (0.249)	0.664 (0.420)
Education → 20 years-old or older	1.061*** (0.270)	0.778*** (0.248)	0.895** (0.418)
Education → Still studying	0.706*** (0.292)	0.448* (0.267)	0.608 (0.464)
Education → Don't know	0.638* (0.351)	0.291 (0.357)	-0.021 (0.576)
Avoidance → No	-0.888*** (0.084)	-0.742*** (0.083)	-1.137*** (0.133)
Avoidance → Yes	0.804*** (0.063)	0.875*** (0.058)	0.434*** (0.090)
Consumption level → Medium	-0.140** (0.055)	-0.073 (0.053)	-0.086 (0.086)
Consumption level → High	-0.216 (0.150)	-0.154 (0.137)	-0.086 (0.086)
Trust EU (BPA)	0.206*** (0.013)	0.192*** (0.012)	0.231*** (0.020)
Chemophobia score	0.053* (0.030)	0.056** (0.029)	0.211*** (0.043)
Constant	1.519*** (0.322)	3.268*** (0.314)	2.699*** (0.565)
Observations	8,024	7,968	2,791
R2	0.167	0.157	0.178
Adjusted R2	0.163	0.152	0.165
Residual Std. Error	2.332 (df = 7980)	2.194 (df = 7924)	2.111 (df = 2747)
F Statistic	37.262*** (df = 43; 7980)	34.194*** (df = 43; 7924)	13.843*** (df = 43; 2747)

Note: * p<0.1; ** p<0.05; *** p<0.01
Note: Models (1) (2), and (3) control for the geographical fixed effects (not displayed)
Note: Note: White's Robust standard errors

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1)

Regression results for the three models are displayed in Table 25. The sample size is lower than the original N (8600 respondents) for models CONCERN and HR_own due to the choice of treating 'Don't know' responses as missing, and – as previously discussed – even lower for the HR_child model, which only includes about 35% of respondents with a child aged 14 or less.

6.6. Discussion

In all three models, the coefficients for *value* and *qual* were statistically significant, in relation to the baseline level (*nomsg)*.

Furthermore, we compared the values of the *'value'* and *'qual'* message formats, by testing the equality of the respective coefficients. For all three models (1) (2) and (3), linear hypothesis F testing confirmed that the coefficients associated with the two different types of message, *value* and *qual*, are not significantly different.

An additional Wald test for joint equality of these coefficients to 0, rejected the Null for the concern model (1) as well as for HR_own (2), while the evidence was weaker for model (3) on HR_child: the p-value of the Wald test for joint equality of the coefficients value and qual to 0 was 0.0438. Within the HR_child model, risk perceptions are higher, and the message format seems less influential. Additionally, having children leads concern measures to rise even for what does not concern children. T-tests on Concern and HR_own variables confirms that means are significantly higher for the parents subgroup. Thus, the parenthood subsample shows in general higher levels in the target variables with respect to these respondents without children/with 14+ years-old children in this sample.

Being males shows significant and negative coefficient in all of three models in Table 25, proving females to be the most concerned, which confirms results of existing literature (Nardi, et al., 2020). Children's ages' dummies do not emerge as relevant variables, their associated coefficients are not significant except for *Children age → 10-14* in model CONCERN (1) where some evidence of a higher concern is detected. Also, having responded correctly to the question assessing knowledge about infant products containing BPA does not significantly inflate target variables. The *Age* of respondents shows instead strong significance in predicting BPA concern (1) and HR_own (2), even if with a rather limited impact. Higher levels of *education* (in terms of age at which education was completed), from 15 y/o or younger to 20 y/o or older show growing and significant coefficients as for Concern (1) and HR_own (2). The path related to education completion age gets more uncertain when it comes to HR_child (3). The most relevant variable is, as expected, associated to *BPA Avoidance* behaviour. Given a base level of "Don't check", not avoiding BPA has across the three dependents of (1) (2) and (3) negative, high and significant coefficients, while the exact opposite occurs for Avoiding BPA. Proxied BPA consumption does not result to be relevant. Trusting EU when it comes to BPA*,* drives positively all of the three dependents measures Concern, HR_own and HR_child as well. Lastly, as expected, chemophobia is a positive predictor of BPA concern (1), HR_own (2) and HR_Child (3). The estimated effect of chemophobia is much larger (about 4 times larger) for the HR_Child model relative to the first two models: when the chemophobia score of the respondent increases by 1 point, the extent to which the respondent thinks that BPA poses a risk on children's health grows by 0.21 in the 0-10 scale .

6.7. Concluding remarks

Public information about food safety events may have short to long-term effect on consumers: from changes in food demand, causing changes prices, to media discussion arising (Lee, et al., 2023). BPA was eventually banned from food contact materials, but the present study helps capturing the impact of different communication strategies and message format, and EFSA will consider these results in targeting their communication strategies. Based on the collected data and our estimates, we find no differences on the ultimate outcomes (BPA-related concern and perceived own and children health risks) when the new BPA tolerable daily intake is communicated in alternative ways.

The usage of a verbal qualifier as "significantly lower" or the presentation of the new value and the calculated reduction "20 thousand times lower" are equivalent in terms of their effect on the target variables. Instead, a significant difference emerges occurring when a message, whatever type, is received: both concern and perception of one's health risk significantly increase relative to the "no message" baseline. This finding is consistent these from Luo et al. (2022), which highlights that when detailed information is given to consumers about a food concern, their willingness to pay for safety attributes increases (Luo, et al., 2022). On the other hands, it does not contribute evidences to the recent research debate about risk communication with words vs numbers.

The parenthood condition, according to the findings of this study, does not automatically boost negative beliefs about BPA, but when questions on the theme are asked with specific reference on children, levels of BPA concerns and risk perceptions inflate. This signals that parents are a population subgroup who bares special beliefs and sensitivity to food risk matters, demanding care about these aspects when communication about food-contact-materials risks is directed to them.

Avoidance patterns are also strongly associated with measures of concern and of BPA health risk perceptions, as well as trusting EU institutions to evaluate risks for European population' food safety.

7. Conclusions

This chapter closes the thesis by drawing together the main threads running through the two empirical studies and the broader argument. Rather than enumerating findings, it offers a reading of how the evidence speaks to communication about chemical risks in food-contact materials, with BPA as a focal case, while situating patterns in the light of prior research. The aim is to connect what we have learned about knowledge, attitudes and risk perception with a pragmatic agenda for public communication, without forcing the complexity of the results into a rigid schema.

A first, persistent motif is the modest and uneven state of objective knowledge. Basic elements of dose–response reasoning are not widely internalized and familiarity with concrete exposure routes remains patchy. This is less a story of entrenched misinformation than of variable literacy. Attitudes map onto this terrain in sensible ways: when people absorb dose–response, views tend to become more proportionate; when exposure becomes concrete, precaution rises. These movements coexist rather than contradict each other and they echo the literature that has long documented how risk salience, personal relevance and experience shape expressed concern (e.g. (Slovic, et al., 1997)). They also align with strands of work showing that knowledge can redirect choices in health and food domains (Aikman, et al., 2006), a point we see again when we consider downstream behavioral guidance and label use.

Sociodemographic regularities are not the main object of the thesis, yet they recur and deserve mention because they travel well with previous evidence. Women are typically more attentive to safety and health aspects than men, and younger respondents are, on average, less concerned than older ones, a pattern consistent with earlier findings on food-related interests and risk sensitivity (Roininen, et al., 1999). More generally, men appear less likely to perceive certain hazards that women register as meaningful, a difference noted in the broader risk-perception literature (Dosman, et al., 2001; Slovic, et al., 1997). The communication corollary is straightforward: one size is unlikely to fit all. Messages should anticipate how life stage and gender may shape reception and should be tailored accordingly, not to stereotype audiences but to meet them where they are. This goes along with recent research outcomes, suggesting almost participative and adaptive models, towards tailoring of communications when it comes to food risk (Onyeaka, 2025).

Trust emerges as a quiet protagonist, validating existing literature. Where trust in European institutions is higher, both knowledge and attitudes shift in ways that favour understanding and acceptance. Trust does not merely make messages easier to receive; it filters how uncertainty is interpreted and how apparently conflicting cues are reconciled. The policy lesson worth restating: standards only protect if they are recognized as credible by the people they are meant to protect (Dosman, et al., 2001). In practice, this argues for coherence across public instances, visible and timely updates about enforcement and a communicative posture that treats uncertainty as something to be managed openly.

The communication experiment reinforces a pragmatic point: message presence matters more than endless fine-tuning of format. Exposure to an official message about the revised TDI elevates concern relative to silence, whether the message is expressed verbally or numerically. Given finite resources, investing in reach, timing and repetition, ensuring that the right audiences encounter authoritative information when it is most relevant, seems more consequential than iterating ad infinitum over wording. This is not to downplay format, but to situate it: second-order relative to exposure and source credibility.

Perceptions of risk become more acute when children's health is at stake. This is not a "bias" to be corrected but a protective motive to be respected. Child-focused communication is likely to activate precaution, particularly among parents and caregivers, and it should therefore be paired with simple, doable steps (substitution options, label cues and concrete points of contact) so that concern becomes capability rather than worry.

The link from knowledge to action is visible beyond the BPA case. The expectation that stronger objective knowledge empowers healthier or safer choices is supported by evidence on nutrition policy: for example, improved label understanding has been shown to shift purchasing behaviour in the wake of labelling reforms (Liu, et al., 2014). When people know what to look for and believe that the guidance is credible, they are more likely to choose in line with it.

If these strands are taken together (i.e. patchy literacy, dual pathways from learning to attitudes, the gatekeeping role of trust, and the primacy of exposure), then the communication agenda becomes less about crafting the "ideal" message and more about building a reliable presence. Early in a communication sequence, dose–response should be made visually salient to anchor proportionality. Explanations of exposure routes should be immediately accompanied by low-effort mitigations for consumers and operators, so that learning does not culminate in helplessness. Trust requires consistency across institutions and continuity over time: aligned narratives, transparent handling of uncertainty, and timely feedback about monitoring and compliance. Targeting should be pragmatic, with tailored assets for parents and older adults and channels that respect constraints on time and attention.

None of this sits apart from the wider sustainability agenda. As packaging systems evolve toward circularity and lower footprints, new materials and processes will come into view. The BPA lessons travel: dose-aware explanations, practical guidance on safe use and substitutions, and regular public reporting can maintain confidence without slowing technological change. In that sense, good communication is not a brake on the Green transition; it is the infrastructure that allows it to proceed with public confidence.

In conclusion, the thesis suggests a simple operational maxim: communicate early, clearly and credibly, anchoring proportionality through dose–response, acknowledging uncertainty and pairing concrete exposure facts with practical steps. When institutions do this consistently and with attention to the audiences for whom the stakes are higher, people respond in ways that are more balanced and capable. Communication, in this light, is not an afterthought to regulation; it is part of the protective function of the food-safety system itself.

7.1. Implication of research findings for further data collection and public risk communication strategies

This thesis used data collected from a survey promoted by EFSA to explore public perceptions of BPA, and produce quantitative evidence which may guide future risk communication strategies. Furthermore, based on our analysis of the survey data, it is possible to recommend extensions and adjustments in the data collection process. Although our findings are specific to the BPA-case studies, some results may be also informative for studies and communication activities on broader topics related to consumer concerns on food contact materials.

<u>*Survey design and Data collection*</u>

- <u>Questionnaire design</u>

  A first element to be considered is the consistency between the objective of questionnaire items and the information that was actually obtained from respondents. Based on our analysis, in future similar surveys some of the items might be designed in more effective ways. For example information on the respondent’s education level (variable Education, described in Table 1, see Appendix#1/Q9), allowed for a “don’t know” option which reduced the number of available observation and is probably undesirable. Since it is reasonable to expect that respondents are aware of the age when they stopped their full-time education, it is possible that allowing for “don’t knows” generate selection biases, and most likely reflect a low level of collaboration to the survey. It may be worth exploring alternative formulations for this questions, for example referring to the completed education level rather than age without allowing for don’t knows could prevent loss of relevant information.

Given the focus on assessing BPA knowledge and dose-response understanding, it may be worth to expand the scope of future survey to account for some broader determinant. For example, one might ask respondents whether they have ever attended a chemistry course at school, or food education, since educational approaches improves comprehension on chemical risks (Yeak, et al., 2025).
Furthermore, an interesting extension could be to account for the so-called *availability bias*, or more generally explore to what extent an experience of food intoxication and its timing (how recent) may have generated an information search on the topic, or a major shift in concerns. More generally, given some interesting insights on the relevance of BPA concerns which have emerged in this thesis, a future research step should address a more thorough investigation of the determinants.

Under a more technical standpoint, future surveys might take more specific actions towards limiting “guessing behaviours”, especially in relation to the assessment of knowledge. Although the current survey does inform the respondents about the possibility of stating lack of knowledge (“If you don't know, you can just indicate so”) in the final part of the knowledge assessment section, it is not entirely clear how this recommendation is processed by respondents. The statement could be more explicit and direct, for example “Please clearly indicate when you don’t know the answers, as this is relevant to the research objective”. One might also take actions to avoid guessing as a social desirability issue, for example stating that “Some of these questions are not about common knowledge, and it’s important for us to asses precisely the proportion of respondents who don’t know the answer”.

- Bias from self-selection

  A further concern on the survey design is the potential selection bias generated by the fact that respondents are selected by the contractor upon their availability to participate in marketing research activities, i.e. contractors use their proprietary panels. Although it is challenging to eliminate such bias, and any probabilistic sampling from other frames would require a much higher budget, it should be possible to adopt actions to assess and mitigate this issue, for example by having some check variables which could be compared with known population distributions, or by running a smaller validation survey based on probabilistic sampling.

Analytical methods

- Variables form treatment

  In the statistical analysis phase, for variables which are available in numeric, detailed form (age, for instance) it is recommended to maintain the same level of detail in future surveys, avoiding classification (e.g. 15-24 years old) or categorization (e.g. Youth, Elderly), which could be adopted ex-post for descriptive purposes. A similar rationale should be applied to categorical items: dropping some levels or excessive aggregation leads to loss of variability in the analysis phase.

- Proxies for consumption frequencies

  Measuring consumption based on proxies for consumption frequencies, in this case estimating the level of BPA intake based on self-reported weekly frequencies of potential intake occasions, is a very challenging strategy. In this work, proxied intakes were based on the collected information (Appendix#1/Q11) based on a relatively subjective indicators. More specifically, it was chosen to impose restrictive limits for classifying “Low” and “High” intakes, while most observations were aggregated into the “Medium” category. Again, it might be desirable to maintain a higher variability, and possibly, even to consider some more continuous measure.

Insights for risk communication strategies

- Demand for communication

  The main results and insights from the present study show that risk communication has an effect when implemented. It remains a big topic to explore the implication of communicating low-risk levels (Maxim, et al., 2021), as this decision has potentially consequences on consumer behaviour and the overall trust building for the Authority. Evidence from the second study clearly shows how respondents who did not receive any communication about changes in the BPA TDI had lower levels of concern. This is a known implication for food risk communication, but future research might address how proper communication might insist more on leveraging knowledge and awareness than merely raising food safety concerns.

- Customization of messages

  As shown by previous literature, segmentation of the target audience has a key role in planning communication. Different population subgroups may receive and elaborate the same communication differently in terms of risk perception and concerns. In our case, we do find that parents show a higher concern and perceive higher levels of risk compared to other sub-groups, independently from the message they receive. A targeted communications for parents (or for other subgroups emerging as having a specific response to communication) is needed, and in terms of message content and framing, and explicitly accounting for a higher sensitivity to health matters and hazards that are potentially relevant for their children.

These recommendations are inevitably limited to the analysis carried out for this thesis on the EFSA BPA Flash-poll 2022, which is only one of multiple and evolving sources of information and analysis used by EFSA to develop their communication strategy, and include stakeholder consultations, ad-hoc surveys, and analysis of secondary data. Thus, while it could be useful consider limitations and potential extension of the research covered in this thesis, any conclusion should not be generalized to overall EFSA practices.

Final remarks

The relevance of quantitative research to support public institutional communication in food safety

Beyond the BPA2_Comm findings demonstrating that disclosure of the newly established BPA TDI elevates concern and perceived health risks, the evidence corroborates the thesis that public communication in food safety is essential, can drive behavioural change, and merits systematic investigation. The rationale is, at its core, quantitative: meeting the targets of the 2030 Agenda requires a rapid transition to sustainability in the global agrifood sector (see Chapter 2.2). Every individual is both a stakeholder in, and an agent of, this change. Even under the generous (likely overestimated) assumption that all knowledge workers worldwide are engaged in the sustainability transition, their number is limited. Using full-time-equivalent (FTE) researchers as the most clearly defined subset of knowledge workers, available estimates put the global researcher population at about 8.8 million in 2018 (UNESCO Institute for Statistics (UIS), 2018), (Organisation for Economic Co-operation and Development (OECD), 2025). In industrialized countries, researchers account for roughly 0.9–1.5% of the workforce, rising to around 2% in R&D-intensive economies such as the Nordic countries and South Korea (National Science Foundation (NSF), 2018). However, these figures do not completely encompass the broader spectrum of knowledge workers — such as university professors, higher education professionals, applied scientists, or specialists in information-intensive sectors — making it difficult to establish a definitive global percentage. From a scientific perspective, it is therefore plausible to state that researchers account for less than 2% of the global labor force, while extending the category to knowledge workers in a broader sense would imply significantly higher values, which have not yet been systematically quantified. “We” are clearly not sufficient to obtain the effectiveness of the transition within the necessary deadlines. “We” need the other 98% of the world to obtain the goal, “we” need them to understand it and to commit to it. And this is precisely why “we” need to continue to investigate how public communication should be done properly to redirect unsustainable habits, whatever type, to comply with ESG needs.

Knowledge of today’s global challenges and viable pathways to a sustainable future cannot remain confined to science; it must be shared with—and understood by—the public at large. Communication—and, in particular, education—is the bridge to the “other 98%” beyond the research community and a key instrument of global governance.

APPENDIX

APPENDIX #1

Flash Poll #3: BPA

DECEMBER 2022

Contract: FRAMEWORK CONTRACT OC/EFSA/COM/2021/01 LOT3 CT 1

Prepared by: EFSA

Date: 07/12/2022 (Day 5)

QUESTIONNAIRE - FINAL

NOTES: 1. No question has been included on the respondent's **country** as this would be part of the screener. 2. No question has been included asking to **consent** (e.g. Would you like to proceed and are you at least 15 years of age? Yes/No") as it is assumed this was covered as part of the screener/inclusion on the consumer panel. 3. The seven **socio-demographic questions** have been split such that questions on age, gender, and parenthood are asked upfront (**Q1 to Q3**), and the other four questions are included at the end (**Q9 – Q12**). 4. **Screening question**: • Q0 should be used in view of recruiting the desired quotas for this project, namely: "QUOTA I" = **40% of each country sample who is NOT AWARE of BPA**, i.e. provided answer 1 to Q0 (i.e. "Never heard of it"); and "QUOTA II" = **60% of each country sample who is AWARE of BPA**, i.e. provided answer 2, 3, OR 4 to Q0 (i.e. "Heard of it, but do not know much about it"; "Heard of it, and feel I am reasonably well informed"; "Heard of it, and feel I am very well informed"); • Feasibility of these preferred quotas to be confirmed at the end of day 1 of data collection, and adjustments to be discussed by TP and EFSA if applicable. • As for any of the other questions, response to Q0 for each of the participants comprised in the sample should be saved in the data file. 5. **Quota sampling**: A sample from the general population should be invited, and the target sample for each country should be approx. 40% for "QUOTA I" & 60% for "QUOTA II". Also, if feasible, for each of the two quotas (I, II), the sample should ideally be	

close to the nationally representative for age and gender (+/- 5 percentage points relative to the reference values). 6. **All questions are mandatory**.	
Questions	**Instructions**
WORD COUNT: **910 words** **Towards obtaining the closest approximation, we excluded from the word count:** • **Text highlighted in green since it refers to a) text that can be re-used** from the 2nd flash poll; or b) repeated text in the case of Q8. • **Programming instructions** (column to the right); • **Question/items numbers as translation doesn't apply to these** (e.g. we counted "How old are you?" instead of "1. How old are you?" > slightly over to 100 "words") • Q8 is missing three values as indicated above. We don't expect the text of Q8 to change once we receive the numbers, but just in case we have reserved/added an extra 44 words to the count. • **Grey text in the right column since this refers to annotations** (e.g. [ROWS]).	
Dear participant, **This survey is being conducted by the "Teleperformance" company, on behalf of the European Food Safety Authority (EFSA). EFSA is an agency of the European Union that provides scientific advice and communicates on food-related risks to help protect consumers, animals and the environment.** **The aim of this survey is to gather citizens' preferences and attitudes on food-related topics to support EFSA's communication activities in the future.** **Answering should take up to 10 minutes, and anonymity of the information will be assured so that no identification can be made.** **Thank you in advance for your participation.**	*[INTRO 1]* [NOTE: SAME TEXT AS IN FLASH POLL 2 (PLEASE RE-USE TRANSLATION FROM THERE)]
In this survey we are simply interested in your opinion, and not in right or wrong answers. Therefore, we ask you to answer the following questions as spontaneously as possible. Thanks in advance for your time! **Click to proceed.**	*[INTRO 2]*
Q0 [SCREENING QUESTION]. **Have you heard of bisphenol A (BPA) before?** **1. Never heard of it** **2. Heard of it, but do not know much about it**	*[SINGLE ANSWER]* *[QUOTA BASED SAMPLE, SUCH THAT: "QUOTA I": WITHIN EACH COUNTRY, APPROX. 40% WHOSE ANSWER = 1. "NEVER HEARD OF IT";*

3. Heard of it, and feel I am reasonably well informed **4. Heard of it, and feel I am very well informed**	*"QUOTA II": <u>WITHIN EACH COUNTRY</u>, APPROX. 60% WHOSE ANSWER = 2. "HEARD OF IT, BUT DO NOT KNOW MUCH ABOUT IT"; OR = 3. "HEARD OF IT, AND FEEL I AM REASONABLY WELL INFORMED"; OR = 4. "HEARD OF IT, AND FEEL I AM VERY WELL INFORMED"]* *<u>NOTE: (IF FEASIBLE)</u>, FOR EACH OF THE TWO QUOTAS (I AND II), THE SAMPLE SHOULD IDEALLY BE CLOSE TO THE NATIONALLY REPRESENTATIVE FOR AGE AND GENDER (+/- 5 PERCENTAGE POINTS RELATIVE TO THE REFERENCE VALUES).* ***IMPORTANT**: AS FOR ANY OF THE OTHER QUESTIONS, RESPONSE TO THIS QUESTION FOR EACH OF THE PARTICIPANTS COMPRISED IN THE SAMPLE SHOULD BE SAVED IN THE DATA FILE.*
Thank you, unfortunately your profile is not in line with what we were looking for.	*[SCREEN OUT MESSAGE, TO DISPLAY ONCE QUOTAS ARE FILLED]* *[<u>FOR EACH COUNTRY</u>, SKIP IF "QUOTA I" IS NOT COMPLETE, I.E.: SKIP IF ANSWER TO Q0 = 1. "NEVER HEARD OF IT" <u>&</u> % OF RESPONDENTS WHO ANSWERED Q0 = 1 IS LOWER THAN 40% OF COUNTRY SAMPLE]* *[<u>FOR EACH COUNTRY</u>, SKIP IF "QUOTA II" IS NOT COMPLETE, I.E.: SKIP IF ANSWER TO Q0 = 2, 3 OR 4 <u>&</u> % OF RESPONDENTS WHO ANSWERED Q0 = 2, 3 OR 4 IS LOWER THAN 60% OF COUNTRY SAMPLE]* *[ELSE, DISPLAY TEXT & SCREEN OUT]*
1. How old are you?	*[SINGLE ANSWER. NUMERIC RESPONSE ONLY]* *[IF ANSWER = 0 – 14 SCREEN OUT]* [NOTE: SAME QUESTION AS IN FLASH POLL 2 (PLEASE RE-USE <u>TRANSLATION</u> FROM THERE)]
2. What is your gender? **a. Male** **b. Female** **c. Non-binary** **d. Prefer not to answer**	*[SINGLE ANSWER]* [NOTE: SAME QUESTION AS IN FLASH POLL 2 (PLEASE RE-USE <u>TRANSLATION</u> FROM THERE)]
3. Which of the following apply to you? **1. Have no child/children aged 0-14 years-old** **2. Have a child/children aged 0-3 years-old** **3. Have a child/children older than 3 but younger than 10 years-old** **4. Have a child/children aged 10-14 years-old**	*[MULTIPLE ANSWER. SELECT ALL THAT APPLY; EXCEPT IF ANSWER = 1 (IN THAT CASE, MULTIPLE SELECTION SHOULD NOT BE POSSIBLE)]*
4. When you think of bisphenol A ('BPA' for short), what is the first association (word, image, or thought) that comes to your mind?	*[OPEN QUESTION – OPEN BOX. MIN 3 CARACTERS ENTERED BEFORE RESPONDENT CAN PROCEED. RECORD ANSWERS VERBATIM]*

<table>
<tr><td></td><td>[SKIP IF ANSWER TO Q0 (SCREENING QUESTION) = 1. NEVER HEARD OF IT]</td></tr>
<tr><td>

5. Please rate your perception of bisphenol A (BPA) on a scale from “extremely negative” (0) to “extremely positive” (10), with 5 being neutral.

[ANSWER SCALE]

<table>
<tr><td>0 - Extremely negative</td><td>❍</td></tr>
<tr><td>1</td><td>❍</td></tr>
<tr><td>2</td><td>❍</td></tr>
<tr><td>3</td><td>❍</td></tr>
<tr><td>4</td><td>❍</td></tr>
<tr><td>5 - Neutral</td><td>❍</td></tr>
<tr><td>6</td><td>❍</td></tr>
<tr><td>7</td><td>❍</td></tr>
<tr><td>8</td><td>❍</td></tr>
<tr><td>9</td><td>❍</td></tr>
<tr><td>10 - Extremely positive</td><td>❍</td></tr>
</table>

</td><td>

[SINGLE ANSWER]

[SKIP IF ANSWER TO Q0 (SCREENING QUESTION) = 1. NEVER HEARD OF IT]

</td></tr>
<tr><td>

6. Bisphenol A, ‘BPA’ for short, is a chemical used to make certain types of plastics and can be found in numerous consumer products. For example, it is one of the substances used in some food packaging.

Please indicate whether you think the following product can contain BPA or not. If you don't know, you can just indicate so.

[ROWS]

6.1. Bottles and food storage containers for infants, or young children up to 3 years old.
6.2. Beverage and food cans.
6.3. Polycarbonate plastic bottles, such as some reusables bottles used for water/sports.
6.4. Thermal paper (e.g. used for receipts in cash registers).

[COLUMNS]

1. Yes
2. No
3. Don’t know

</td><td>

[PROGRESSIVE GRID. SINGLE ANSWER PER ROW. RANDOMISE ROWS/STATEMENTS]

[KEEP THE INTRO TEXT ON THE SCREEN AND INCLUDE THE QUESTIONS 6.1 – 6.5 BELOW THE TEXT, ONE AT A TIME]

[
STATEMENT 1 CORRECT IF ANSWER = 2 (“No”).
STATEMENT 2 CORRECT IF ANSWER = 1 (“Yes”).
STATEMENT 3 CORRECT IF ANSWER = 1 (“Yes”).
STATEMENT 4 CORRECT IF ANSWER =2 (“No”).

</td></tr>
<tr><td>Thank you. Click to proceed to the next question.</td><td>

NA

[NOTE: SAME AS IN FLASH POLL 2 (PLEASE RE-USE TRANSLATION FROM THERE)]

</td></tr>
</table>

<table>
<tr><td>

7. For each of the following statements, please indicate whether you believe them to be true or false. If you don't know, you can just indicate so.

[ROWS]

1. **[DOSE RESPONSE] Being exposed to a synthetical chemical substance always has a serious impact on health, no matter what the level of exposure is.**
2. **[DOSE RESPONSE] Having a small amount of BPA in a consumer product, does not mean that it has a serious impact on health in the amount present.**
3. **Using plastic bottles or food storage containers which contain the label "BPA free" is safer for humans than similar products that do not contain this label.**
4. **BPA cannot transfer from the plastic lining of canned foods into the food stored inside.**
5. **Food is the major source of exposure to BPA in humans.**
6. **If a plastic container contains BPA, heating food in the microwave inside that container can increase the transfer of BPA into the food.**

[COLUMNS]

1. **True**
2. **False**
3. **Don't know**

</td><td>

[PROGRESSIVE GRID. SINGLE ANSWER PER ROW. RANDOMISE ROWS/STATEMENTS]

[STATEMENT 1 CORRECT IF ANSWER = 2 ("False").
STATEMENT 2 CORRECT IF ANSWER = 1 ("True").
STATEMENT 3 CORRECT IF ANSWER = 2 ("False").
STATEMENT 4 CORRECT IF ANSWER = 2 ("False").
STATEMENT 5 CORRECT IF ANSWER = 1 ("True").
STATEMENT 6 CORRECT IF ANSWER = 1 ("True").

</td></tr>
<tr><td>

Thank you. Click to proceed to the next question.

</td><td>

NA

[NOTE: SAME AS IN FLASH POLL 2 (PLEASE RE-USE TRANSLATION FROM THERE)]

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8.

[Group A/NO INTRO]

[Group B/INTRO1]

Please read the following text carefully.

Scientists working with the organisation responsible for food safety in the EU have assessed possible health risks associated with daily ingestion of bisphenol A (BPA). They proposed that the amount of BPA that an individual can ingest daily over a lifetime without health risk is 0.2 nanograms (= 0.0002 micrograms) per kilogram of bodyweight per day.

This new value of 0.2 nanograms is significantly lower than the temporary value established in 2015, as scientists established based on new evidence that the old value posed a health concern. The 2015 value was 4 micrograms per kilogram of body weight per day.

Click to proceed.

[Group C/INTRO2]

</td><td>

[RANDOMLY SPLIT RESPONDENTS INTO THREE GROUPS. STRATIFY GROUPS BY COUNTRY AND QUOTA (I.E, IN EACH COUNTRY, FOR "QUOTA I" WE SHOULD HAVE APPROX. 1/3 OF RESPONDENTS ALLOCATED TO GROUP A, 1/3 TO GROUP B, AND 1/3 TO C; IDEM FOR "QUOTA II").

IF POSSIBLE, STRATIFY ALSO BY GENDER, AGE GROUP (I.E. AGE RECODED AS 15-24; 15-36; 40-54, 55+)]

</td></tr>
</table>

Please read the following text carefully. **Scientists working with the organisation responsible for food safety in the EU have assessed possible health risks associated with daily ingestion of bisphenol A (BPA). They proposed that the amount of BPA that an individual can ingest daily over a lifetime without health risk is 0.2 nanograms (= 0.0002 micrograms) per kilogram of bodyweight per day.** **This new value of 0.2 nanograms is 20,000 times lower than the temporary value established in 2015, as scientists established based on new evidence that the old value posed a health concern. The 2015 value was 4 micrograms per kilogram of body weight per day.** **Click to proceed.**	
[THE QUESTIONS BELOW SHOULD BE PRESENTED TO ALL THREE GROUPS: A, B, AND C] [ROWS] **8.1. On a scale from 0 to 10, to what extent are you concerned or not about the fact that BPA is used in food packaging?** **8.2. On a scale from 0 to 10, do you think that BPA poses a risk or not to your health?** **8.3. On a scale from 0 to 10, do you think that BPA poses a risk or not to your child/children health?** **8.4. On a scale from 0 to 10, to what extent do you trust the regulators in the EU in relation to evaluating risks of BPA in food packaging?** [COLUMNS] **0 - Not at all** ❍ **1** ❍ **2** ❍ **3** ❍ **4** ❍ **5 - Neutral** ❍ **6** ❍ **7** ❍ **8** ❍ **9** ❍ **10 - To a great extent** ❍ **Don't know** ❍	*[PROGRESSIVE GRID. SINGLE ANSWER PER ROW]* *[FOR GROUPS B & C, KEEP THE INTRO TEXT FROM THE CELL ABOVE ON THE SCREEN AND INCLUDE THE QUESTIONS 8.1 – 8.4 BELOW THE TEXT, ONE AT A TIME]* *[SKIP Q8.3 IF Q3 = 1. "a. Have no child/children"]*
Thank you. Click to proceed to the next question.	NA [NOTE: SAME AS IN FLASH POLL 2 (PLEASE RE-USE TRANSLATION FROM THERE)]

9. How old were you when you stopped full-time education? **a. No full-time education** **b. 15 years-old or younger** **c. 16 to 19 years-old** **d. 20 years-old or older** **e. Still studying** **f. Don't know**	*[SINGLE ANSWER]* [NOTE: SAME QUESTION AS IN FLASH POLL 2 (PLEASE RE-USE TRANSLATION FROM THERE)]
10. Please indicate to what extent you agree or disagree with each of the following statements. [ROWS] **1. I trust the regulators to make sure every necessary step is taken to protect consumers' health.** **2. I believe that chemical substances are the main reason why people suffer from cancer.** **3. I do everything I can to avoid contact with chemical substances in my daily life.** **4. I would like to live in a world where chemical substances don't exist.** **5. Chemical substances scare me.** **6. I believe that chemical substances are the reason for most environmental problems.** [COLUMNS] **1. Strongly agree** **2. Agree** **3. Somewhat agree** **4. Somewhat disagree** **5. Disagree** **6. Strongly disagree**	*[SINGLE ANSWER PER ROW. RANDOMISE ROWS/STATEMENTS]*
11. Typically, how often do you do each of the following: [ROWS] **1. Consume packaged or canned food.** **2. Consume drinks in plastic bottles or in cans.** **3. Heat food in a microwave oven by using plastic containers.** [COLUMNS] **a. Never** **b. 3 times per week or less** **c. 4 to 6 times per week** **d. 7 times per week or more**	*[SINGLE ANSWER PER ROW. RANDOMISE ROWS/STATEMENTS]*
12. Do you avoid certain food or drink products if they contain bisphenol A (BPA) in their packaging? **a. Yes** **b. No** **c. I don't check if BPA is present or not.**	*[SINGLE ANSWER]*

APPENDIX #2

Correlation among knowledge Domains

	Knowledge BPA Specific	Lack of Knowledge BPA Specific	Knolwedge BPA Products	Knowledge Dose response
Knowledge BPA Specific	1			
Lack of Knowledge BPA Specific	-0.772***	1		
Knowledge BPA Products	0.335***	-0.455***	1	
Knowledge Dose-response	0.142***	-0.304***	0.208***	1

*Note: the table reports Pearson's correlations, p-values: *<0.1, **<0.05, ***<0.0*
Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1/Q6,7)

APPENDIX #3

Ordered Logit Model	**Knowl_BPA AWARE (1)**	**Knowl_BPA NON-AWARE (2)**	**Lack_knowl_BPA AWARE (3)**	**Lack_knowl_BPA NON AWARE (4)**
Knowl_DR1	0.207*** (0.065)	0.813*** (0.059)	-0.720*** (0.069)	-1.309*** (0.062)
Knowl_DR2	0.263*** (0.100)	0.546*** (0.101)	-0.806*** (0.108)	-1.378*** (0.103)
Age→ 25-39 yo	-0.082 (0.119)	-0.192* (0.115)	0.150 (0.131)	0.346*** (0.120)
Age→ 40-54 yo	-0.120 (0.124)	-0.303*** (0.115)	0.215 (0.135)	0.481*** (0.118)
Age→ 55+ yo	0.080 (0.127)	-0.331*** (0.114)	0.267* (0.139)	0.461*** (0.118)
Gender→ Male	-0.016 (0.061)	-0.121*** (0.053)	-0.074 (0.064)	0.105** (0.053)
Gender → Non binary/NA	-0.042 (0.641)	-0.423 (0.551)	0.771 (0.713)	0.408 (0.533)
Education →15 years-old or younger	0.174 (0.361)	-0.541*** (0.251)	-0.497 (0.387)	0.588** (0.251)
Education →16 to 19 years-old	0.645** (0.317)	-0.311 (0.202)	-0.487 (0.533)	0.328 (0.215)
Education → 20 years-old or older	0.673** (0.316)	-0.076 (0.202)	-0.566** (0.332)	0.156 (0.213)
Education → Still studying	0.234 (0.339)	-0.248 (0.233)	-0.198 (0.357)	0.430* (0.245)
Education → Don't know	0.191 (0.471)	-1.155*** (0.304)	0.495 (0.483)	1.457*** (0.312)
Trust_EU →No	0.207*** (0.070)	0.253*** (0.062)	-0.046 (0.072)	-0.130** (0.061)
chemoph_score	0.048 (0.032)	-0.005 (0.028)	-0.009 (0.034)	0.014 (0.028)
Consumption_level → Medium	0.097 (0.064)	0.086 (0.056)	-0.234*** (0.067)	-0.086 (0.056)
Consumption_level → High	-0.321** (0.146)	-0.249** (0.150)	-0.132 (0.162)	-0.156 (0.156)
Avoidance → Yes	0.599*** (0.096)	0.688*** (0.108)	-0.377*** (0.106)	-0.752*** (0.115)
Avoidance → Don't check	-0.063 (0.093)	-0.144* (0.087)	0.689*** (0.100)	0.464*** (0.091)
Observations	3,748	4,852	3,748	4,852
Note: *p<0.1; **p<0.05; ***p<0.01 Note: Models (1)(2)(3) and (4) control for geographical fixed effects (not displayed) Note: Nagelkerke Pseudo R2 (1) 0.062 (2)0.107 (3)0.134 (4)0.204				

Source: EFSA Flash-poll on BPA, December 2022 (see Appendix#1)

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The world will not be destroyed by those who do evil,

but by those who watch them and do nothing.

Albert Einstein