

Review

Transparency Through Testing: Rethinking Certification and Safety in Personal Care Products

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Abstract

The personal care product market has expanded rapidly in recent years, along with growing consumer awareness of chemical exposures and increasing demand for “clean” products. Consumer perceptions of product safety and potential health impacts are commonly based on ingredient labels, intended use, and certifications, rather than the full chemical composition of finished products. In this study, we conducted a targeted review of certification and ingredient-evaluation programs in the United States and European markets. Eighteen programs were identified and characterized based on their evaluation approaches, data sources, and whether they incorporate analytical measurement of finished products. We also evaluated the current U.S. and EU regulatory frameworks. Across both certification and regulatory systems, evaluation was found to rely primarily on ingredient-based approaches and supporting documentation, with limited incorporation of analytical measurement. As a result, contaminants, impurities, and incidentals/non-intentionally added substances (which have previously been identified in many consumer products) may not be consistently identified or evaluated for safety. These findings highlight a fundamental gap between intended formulation and actual product composition. Incorporating analytical measurement, particularly non-targeted approaches, provides a complementary groundwork for identifying previously unrecognized chemical exposures and improving the accuracy of product safety certification programs and hazard assessments. Aligning evaluation with measured chemical composition may enhance transparency and better reflect real-world exposure, support more credible sustainability claims, enhance consumer trust, support growing market demand, support consumer safety, and contribute to more effective regulation in the personal care industry.

Keywords: personal care products; non-targeted analysis (NTA); non-intentionally added substances (NIAS); chemical safety; product certification; chemical transparency; endocrine-disrupting chemicals; conformity assessment



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1. Introduction

Public concern over harmful chemicals in everyday products has grown over recent decades, driven by advances in environmental health science and increasing evidence of widespread human exposure [1–3]. Government agencies (such as the United States Environmental Protection Agency (U.S. EPA)) have established regulations to protect air

and water quality; however, oversight of chemicals in many consumer products, including personal care products, remains limited [4]. At the same time, demand for “clean” products, often defined by simple ingredient lists, environmental sustainability, or lower toxicity, has increased substantially [5–11]. However, consumers rely on ingredient labels and third-party certifications as primary tools for evaluating product safety and reducing chemical exposures [12]. Because labels only reflect the intended formulation and disclosed ingredients rather than the measured chemical composition of finished products, consumers may be unable to make informed decisions about clean products.

Emerging evidence suggests that the distinction between product labels vs. true product composition is important. In prior biomonitoring studies, individuals who received personalized exposure data and education demonstrated improvements in environmental health literacy and reductions in some endocrine-disrupting chemicals (EDCs) [13,14]. However, certain exposures persisted despite reported behavior changes and product swaps, suggesting that sources of exposure may include contaminants and other non-intentionally added substances (together termed “NIAS”) or undisclosed substances not captured on product labels [15–18]. Consistent with this possibility, both targeted and non-targeted/suspect screening analyses (together termed “NTA”) of consumer products have identified unlisted chemicals, including fragrance components, functional chemicals, and likely NIAS, not reflected in ingredient disclosure [16,17,19]. Further, between 2011 and 2023, 334 skin care products were recalled, encompassing 77,135,700 units. Each recall can cost companies millions in logistics, liability, and brand damage, making product safety an increasingly material economic risk [20]. Targeted and non-targeted/suspect screening approaches differ in that non-targeted approaches aim to capture all detectable chemicals with or without a broad predetermined list, which shifts the awareness matrix from targeted “known knowns” to suspect screening “known unknowns” to non-targeted “unknown unknowns”, and reveals invisible but critical chemicals that targeted approach completely misses [21,22].

Together, these findings highlight a critical gap between manufacturer and consumer intent and actual exposure, indicating that current labeling and certification approaches may not adequately identify harmful substances or support meaningful exposure reduction.

This gap is not limited to consumer-facing tools. Regulatory frameworks governing personal care products similarly rely on ingredient-based restrictions and documentation, product manufacturer-reported safety standards, and have limited requirements for direct analytical measurement of finished products [23–25]. As a result, both regulatory and certification systems are primarily designed to evaluate what is intended to be in a product, as reported by the product manufacturers, rather than what is actually present in the final formulation.

To address this gap, we conducted a review of product certification and screening programs in the U.S. and EU personal care markets. We also reviewed state and federal laws and regulations regarding ingredient safety of personal care products. Specifically, we assessed the extent to which certification programs and regulations protect consumer health, identify harmful NIAS, promote transparency and accountability, and enable informed choices that reduce exposure to EDCs. Together, these certification and regulatory frameworks function as standards-like systems for chemical safety and conformity assessment in personal care products, yet the degree to which they incorporate independent verification of finished-product composition and contaminant testing has not been systematically evaluated.

2. Methods

Identification and Characterization of Certification and Evaluation Programs

Throughout this review, the term *program* is used broadly to refer to certification schemes, retailer standards, consumer ingredient-scoring applications, and related evaluation frameworks. To characterize certification and ingredient-evaluation programs relevant to personal care products, we conducted a structured, targeted review of certification programs and consumer-facing ingredient screening platforms operating in the United States and European markets. The objective was to describe major, widely used programs that function as representative standards or consumer-facing screening applications. European markets were included because many certification programs and ingredient-evaluation frameworks operate internationally or influence U.S. standards, and personal care products are frequently formulated, marketed, and distributed across both regions.

Programs were identified via multiple sources, including those identified during prior work related to personal care product evaluation, additional programs suggested by coauthors, and supplemental web searches (Google) conducted during manuscript preparation to identify comparable certification programs and ingredient screening evaluation frameworks. Publicly available methodology for each candidate program was then reviewed against predefined eligibility criteria.

Programs were eligible for inclusion if they met all of the following criteria: (1) applied to cosmetic or personal care products; (2) operated in the U.S. and/or European markets; (3) had publicly available standards, certification criteria, or methodology; and (4) were active as of May 2026.

Programs were excluded if the following were met: (1) they focused exclusively on non-cosmetic/personal care categories; (2) the methodology was not publicly disclosed; (3) they had a similar framework as other programs with greater market relevance; (4) they addressed only a single attribute (unless included as example of attribute-specific certifications); (5) they were discontinued or inactive.

For each program, we reviewed publicly available standards, certification criteria, and technical documentation to characterize key methodological features relevant to their role as de facto standards and conformity assessment tools. These features included (1) program type and governance structure, (2) primary data sources used for evaluation (e.g., ingredient disclosure, supplier documentation, or toxicological databases), (3) the primary emphasis of the certification or evaluation framework (e.g., human health hazard screening, environmental sustainability, or single-attribute claims), and (4) whether the program incorporates analytical measurement of finished products, including targeted testing or non-targeted chemical screening capable of identifying NIAS. Programs were then grouped into conceptual categories based on their evaluation framework, including structured certification systems, retailer or NGO ingredient-screening programs, consumer ingredient-scoring applications, and attribute-specific certifications. The 18 programs presented in Table 1 were selected as representative programs from this set. Programs meeting inclusion criteria with similar characteristics were further evaluated for market relevance using criteria such as name recognition, retailer adoption, manufacturer participation, and consumer use. The aim of this review was to identify the major evaluation frameworks currently in use. Sixteen programs were included in quantitative comparisons because they explicitly evaluate chemical hazards or ingredient safety and two programs focusing on single-attribute presence were characterized descriptively but excluded from quantitative analysis. See Figure 1 for the certification program identification methodology.

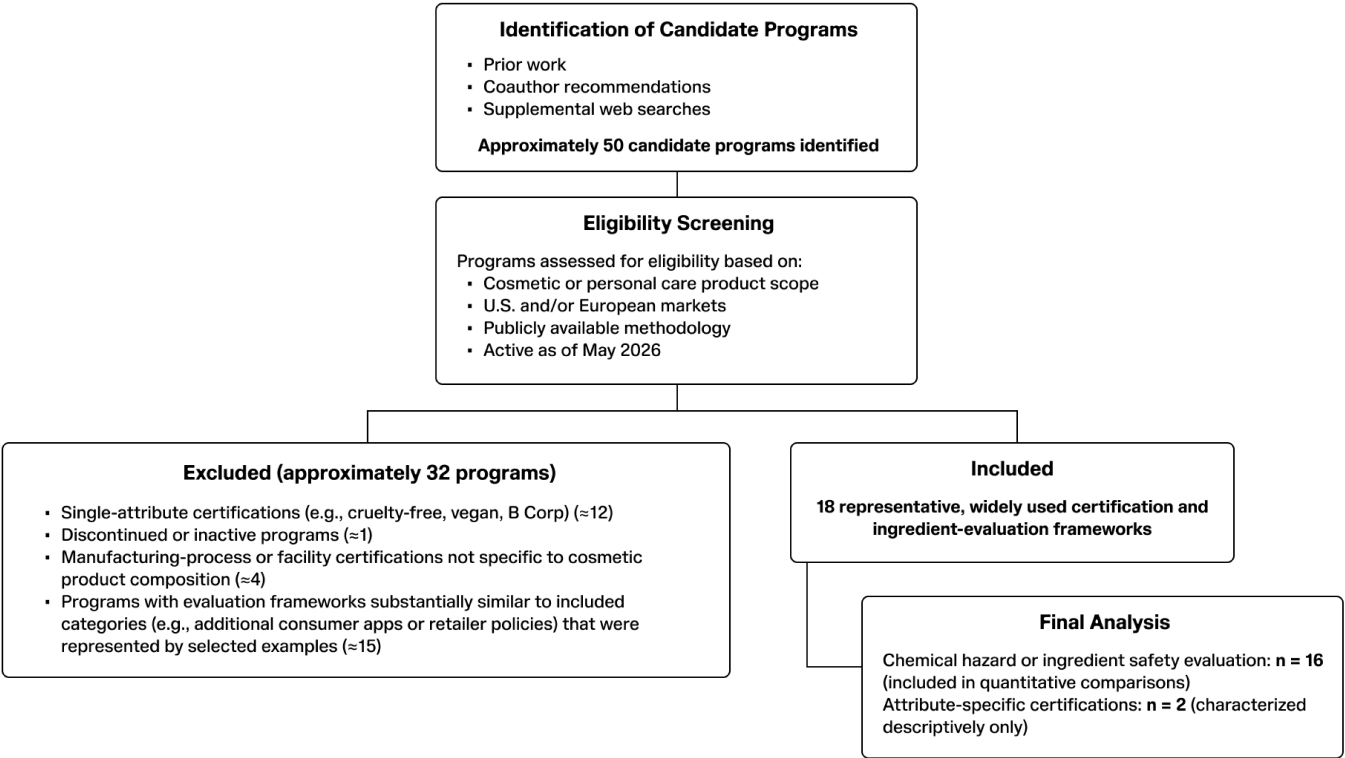


Figure 1. Flow diagram of program identification and selection. Approximately 50 candidate certification and ingredient-evaluation frameworks were identified through prior work, coauthor recommendations, and supplemental web searches. Programs were screened based on predefined eligibility criteria, resulting in the inclusion of 18 representative frameworks. Sixteen chemical hazard or ingredient-safety frameworks were included in the quantitative analyses, while two attribute-specific certification programs were included for descriptive comparison only. Figure created by the authors using Figma (Version 126.7.6, Figma Inc., San Francisco, CA, USA); the figure is original and has not been previously published or adapted from another source.

Regulatory frameworks, current as of May 2026, were initially identified using the Safer States Bill Tracker (Personal Care Products category). The Safer States Bill Tracker is a publicly available database maintained by the nonprofit organization Safer states, that tracks state legislation related to toxic chemicals and consumer product safety across the U.S [26]. We verified and consolidated the results of this search using primary legislative sources. Policies were included if they established requirements related to chemical restrictions, reporting, labeling, or product composition.

Table 1. Overview of certification and ingredient-evaluation programs applicable to personal care products in the United States and European markets.

Program	Organization Type	Primary Data Source	Primary Focus	Finished-Product Testing?	NTA Testing?	NIAS/Contaminants Evaluated?
Structured Hazard & Multi-Attribute Certifications						
Cradle to Cradle [27]	Nonprofit organization	FID; MD; SD	Multi-attribute sustainability and materials health	NRR; VOC emissions/content testing required for some product categories	No	Limited; environmental emissions and restricted substances evaluated
MADE SAFE [28]	Nonprofit organization	FID; MD; SD	Human health and ecosystem hazard screening	NRR; targeted testing may be requested	No	Limited; impurities and sub-ingredients reviewed through documentation

Table 1. Cont.

Program	Organization Type	Primary Data Source	Primary Focus	Finished-Product Testing?	NTA Testing?	NIAS/Contaminants Evaluated?
COSMOS [29]	International nonprofit consortium	FID; SD	Natural/organic standards and sustainability	NRR; targeted testing may be requested or required in specific contexts	No	Limited; contaminant limits may apply to specific ingredients
NATRUE [30]	International nonprofit association	FID; RMD	Natural/organic ingredient composition and sustainability	NRR	No	Limited; addressed through ingredient restrictions, impurity limits, and manufacturing controls
Nordic Swan Ecolabel [31]	Government-supported regional ecolabel (Nordic Council of Ministers)	FID; SD	Environmental sustainability and chemical hazard restrictions	NRR; performance testing may be required	No	Limited; addressed through ingredient restrictions, impurity limits, and environmental criteria
EU Ecolabel [32]	Government program (European Commission)	FID; SD	Environmental life-cycle sustainability	Targeted testing for performance or environmental criteria	No	Limited; addressed through ingredient restrictions and impurity criteria
EPA Safer Choice [33]	Government program (U.S. EPA)	FID; toxicological hazard criteria	Human health and environmental hazard screening of ingredients	NRR; performance testing may be required	No	Impurities addressed through ingredient criteria
EWG Verified [34]	Nonprofit advocacy organization	DIL evaluated against hazard databases	Ingredient hazard screening for consumer guidance	NRR	No	Generally not evaluated unless disclosed by the company
Retailer Ingredient-Screening Programs						
Clean at Sephora [35]	Retail corporation	DIL	Restricted substance list compliance	NRR	No	Not evaluated
Credo Clean Standard [36]	Retail corporation	DIL; brand-provided testing results	Restricted ingredient list screening and product safety testing guidance	Some targeted testing required (e.g., contaminants, preservative efficacy, irritation)	No	NIAS may be evaluated through targeted testing
Target Clean [37]	Retail corporation	DIL	Ingredient transparency and restricted substances	NRR	No	Not evaluated
Ulta Conscious Beauty [38]	Retail corporation	DIL; brand disclosures	Ingredient transparency, restricted substances, and sustainability attributes	NRR	No	Not evaluated
Consumer Ingredient Scoring Apps						
Yuka [39]	Private technology company	PIL	Algorithm-based hazard scoring	No	No	Not evaluated
INCI Beauty [40]	Private technology company	PI; external hazard databases	Algorithm-based ingredient scoring	No	No	Not evaluated
Clearya [41]	Private technology company	PIL	Ingredient hazard identification and consumer alerts	No	No	Limited; may incorporate external testing reports
Think Dirty [42]	Private technology company	PIL	Algorithm-based ingredient scoring	No	No	Not evaluated

Table 1. *Cont.*

Program	Organization Type	Primary Data Source	Primary Focus	Finished-Product Testing?	NTA Testing?	NIAS/Contaminants Evaluated?
Attribute-Specific Certifications						
USDA Organic [43], *	U.S. government agency	FID; supply chain verification	Organic agricultural standards	Not designed for contaminant profiling	No	Not designed to evaluate NIAS
NSF (sector-specific) [44], *	Nonprofit standards organization	FID; sector-specific standards	Compliance with defined standard	Varies by standard	No	Not generally designed for NIAS detection

NTA = non-targeted analysis NIAS = non-intentionally added substances, including process-related impurities, degradation products, and packaging migrants; VOC = volatile organic compounds; FID = full ingredient disclosure; MD = manufacturer documentation; SD = supplier documentation; RMD = raw material documentation; DIL = declared ingredient lists; PIL = public ingredient lists; NRR = not routinely required; * USDA Organic and NSF (sector-specific) are attribute-specific certifications and not included in our analysis of certifications designed to evaluate chemical hazards.

3. Results

From our review, we identified 18 certification or ingredient-screening programs currently operating in U.S. and European markets for personal care products, established by government agencies, nonprofit organizations, retailers, and private companies (Table 1). Of the 18 programs identified, 16 evaluated chemical safety and were included in the primary analysis. Attribute-specific certifications (e.g., USDA Organic, NSF) were retained for completeness but not included in quantitative comparisons, as they are not designed to evaluate chemical hazards or NIAS.

These programs were grouped into five categories based on their evaluation approach. These categories were intended to summarize dominant methodological approaches among the selected programs and may not capture all possible variations in the broader market. The categories included the following: (1) Structured Hazard and Multi-Attribute Certifications are third-party programs that evaluate products against predefined criteria spanning multiple domains (e.g., human health, environmental impact, and sustainability), with assessments based on ingredient disclosure and documentation review. (2) Structured Hazard-Based Certifications assess declared ingredients against established toxicological or regulatory hazard criteria. (3) Retailer/NGO ingredient-screening programs evaluate products against restricted substance lists or hazard databases using declared ingredient information. (4) Consumer Ingredient Scoring Apps assign product scores based on publicly available ingredient lists and hazard databases. (5) Attribute-Specific Certifications verify a single product attribute (e.g., organic or cruelty-free) and are not designed to assess chemical hazards or NIAS. Across these categories, programs differed not only in their hazard criteria but also in their underlying standardization model, ranging from formal third-party certification frameworks to lighter-weight conformity assessment approaches relying on manufacturer self-declaration and documentation review.

Non-targeted analysis (NTA) refers to analytical approaches (including non-targeted analysis and suspect screening) designed to detect and tentatively identify a broad range of chemicals without relying on a predefined target list [17]. These methods provide broad coverage of volatile and semi-volatile compounds and results are typically considered semi-quantitative rather than exact concentrations, although detected compounds are typically underestimates of the actual concentrations [16,17,19].

Figure 2 provides a visual summary of the evaluation frameworks identified across the certification programs reviewed. Overall, the programs rely on ingredient disclosure lists and supporting documentation provided by manufacturers or available through public disclosures. These frameworks often incorporate hazard screening and sustainability

criteria designed to reduce the use of known harmful substances. None of the programs reviewed (0/16) required routine analytical measurement of finished products, and NTA was not incorporated into any certification or evaluation framework. Programs classified as incorporating contaminant or impurity consideration (6/16) were limited to those explicitly addressing unintended substances as a defined category, rather than through ingredient-level criteria or targeted testing alone. As a result, these frameworks may not fully capture the chemical composition of finished products, leading to incomplete characterization of exposure and potentially limiting the ability of consumers to make informed decisions about chemical exposures, while leaving companies vulnerable to recalls and lawsuits. These findings were consistent across certification types, retailer standards, and consumer-facing ingredient scoring tools.

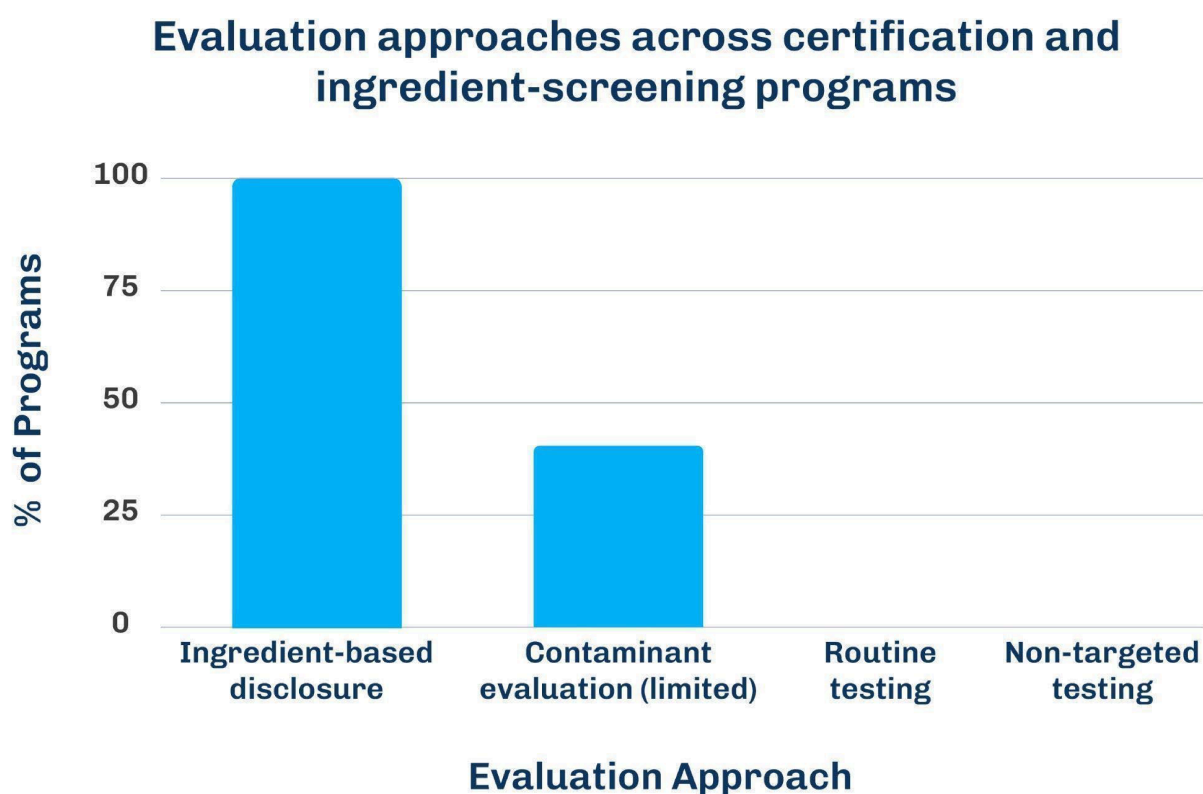


Figure 2. Evaluation approaches across certification and ingredient-screening programs. Programs are grouped into five conceptual categories based on their primary evaluation methodologies and publicly available documentation. Figure created by the authors using Figma (Version 126.7.6, Figma Inc., San Francisco, CA, USA); the figure is original and has not been previously published or adapted from another source.

Although all of these programs rely primarily on ingredient disclosure and documentation, their evaluation approaches differ in the depth and purpose of their evaluation. Structured hazard and multi-attribute certifications (e.g., Cradle to Cradle, MADE SAFE, COSMOS, NATRUE, Nordic Swan, EU Ecolabel) apply published criteria addressing multiple aspects of product evaluation, such as ingredient hazard, human health, environmental toxicity, raw material sourcing, manufacturing practices, biodegradability, packaging, and broader sustainability considerations [27–34]. The exact scope varies by program; however, these frameworks generally require ingredient disclosure and supporting manufacturer or supplier documentation to assess compliance with predefined standards. Retailer standards and ingredient-based certification programs generally focus more narrowly on declared ingredients and restricted substance lists, relying primarily on manufacturer disclosures

rather than routine analytical verification. Consumer ingredient-scoring applications take a different approach by interpreting publicly available ingredient lists and information from hazard databases to generate simplified product scores or ingredient ratings, rather than requiring independent documentation or testing. Attribute-specific certifications (e.g., organic or sector-specific standards) primarily verify individual product characteristics and are not designed to systematically evaluate chemical hazards or NIAS.

This lack of testing is reflected in regulatory approaches governing cosmetics and personal care products in the U.S. Table 2 summarizes the major regulatory categories, including U.S. federal regulations, European Union regulations, state restrictions on PFAS and other specified chemicals in cosmetics, state contaminant limits (e.g., 1,4-dioxane), broader PFAS restrictions in consumer products, and menstrual product disclosure laws (see Supplementary Table S1 for detailed state-by-state regulatory information and corresponding legislative references). Across these categories, compliance is demonstrated primarily through ingredient disclosure, manufacturer documentation, and reporting requirements, with relatively few frameworks requiring analytical verification of finished products. Federal and state frameworks include safety standards, ingredient disclosure requirements, and ingredient-based restrictions on specific chemicals or chemical classes. State-level policies vary in scope and implementation, including class-based restrictions (e.g., PFAS) and disclosure requirements. Only a limited number of frameworks establish concentration-based limits for contaminants (e.g., 1,4-dioxane), and routine analytical measurement of finished products is not required. In both the U.S. and European Union, regulatory approaches are centered on ingredient-based evaluation and documentation, with limited requirements for targeted testing of specific contaminants or regulated substances. While the EU has more comprehensive premarket oversight and broader ingredient restrictions, both systems focus primarily on intended formulation rather than the measured chemical composition of finished products.

Table 2. Overview of EU and U.S. federal and state-level regulatory approaches to chemical safety in personal care products, including ingredient-based restrictions and limited contaminant-based controls [25,45–64].

Regulatory Category	Representative Frameworks	Product Focus	Targeted Chemicals/Classes	Primary Regulatory Approach *	Verification Approach
U.S. (Federal)	Federal Food, Drug, and Cosmetic Act (FD&C Act); Modernization of Cosmetics Regulation Act (MoCRA); Fair Packaging and Labeling Act (FPLA); FDA Color Additive Regulations	Cosmetics; consumer products incl. cosmetics	General safety standard; ingredient disclosure; approved color additives	I (limited), D	Manufacturer safety substantiation and documentation; limited premarket review except specified product categories; no routine finished-product analytical verification
European Union	EU Cosmetics Regulation (EC No 1223/2009); REACH restrictions relevant to personal care products (e.g., D4/D5/D6 limits in wash-off and leave-on cosmetics); selected Omnibus Acts updating Annex II/III substance restrictions	Cosmetics and personal care products	Restricted/banned substances lists; concentration limits for specific substances (e.g., certain silicones, CMRs, allergens)	I (with selected IC-like substance limits)	Premarket safety assessment by a qualified safety assessor, Responsible Person oversight, and technical documentation before market placement; limited routine finished-product analytical verification

Table 2. Cont.

Regulatory Category	Representative Frameworks	Product Focus	Targeted Chemicals/Classes	Primary Regulatory Approach *	Verification Approach
States—PFAS and specified chemicals in cosmetics	California Toxic-Free Cosmetics Act (AB 2762); California PFAS in Cosmetics Ban (AB 2771); Maryland Cosmetic Products Safety Act (HB 643); Oregon Toxic-Free Cosmetics Act (HB 3043); New Jersey PFAS in Cosmetics Ban (A3550)	Cosmetics	PFAS; selected hazardous chemicals (e.g., formaldehyde releasers, phthalates, specified listed chemicals)	I	Compliance through ingredient declarations and manufacturer documentation
States—contaminant limits in cosmetics	New York Prohibition of Cosmetic and Personal Care Products Containing 1,4-Dioxane or Mercury (§37-0117); Vermont Chemicals in Cosmetic Products (§2494b)	Cosmetics & personal care products	1,4-Dioxane (contaminant); mercury (intentionally added, NY); selected co-regulated chemicals	IC	Compliance may require targeted analytical measurement for specified contaminants but not comprehensive chemical characterization
States—PFAS in consumer products incl. personal care	Colorado PFAS in Consumer Products Law (HB 22-1345); Maine PFAS in Products Law (LD 1503); Minnesota Amara's Law (HF 2310); Virginia PFAS in Food Packaging and Consumer Products (HB 1085); Washington Safer Products for Washington (RCW 70A.350)	Consumer products incl. personal care	Intentionally added PFAS; priority chemicals in specified categories	I	Manufacturer ingredient reporting and labeling
Menstrual product disclosure and bans	Nevada Menstrual Products Right to Know Act (SB 327); New York Menstrual Products Chemical Disclosure (GBL §399-II); Vermont Menstrual Products Chemical Disclosure and Ban (Act 85); Virginia Menstrual Products Ingredient Disclosure (HB 2128)	Menstrual products	All intentionally added ingredients; PFAS; phthalates; heavy metals; selected hazardous chemicals	D or ID	Manufacturer ingredient reporting and labeling

* Primary regulatory approach codes: I = ingredient-based restrictions/prohibitions on intentionally added substances; IC = ingredient-based restrictions plus explicit contaminant concentration limits; D = disclosure/labeling requirements without bans or testing; ID = combined ingredient bans and disclosure requirements. CMRs = carcinogenic, mutagenic, and reproductive toxicants. Detailed EU and U.S. Federal and state-by-state information and associated references are provided in Supplementary Table S1.

Overall, the certification and regulatory frameworks reviewed here share a common reliance on ingredient disclosure, supplier documentation, and predefined lists of restricted substances or hazard criteria to evaluate product safety, while explicit requirements for routine analytical measurement of finished products were uncommon (Table 3). Certification programs generally apply voluntary standards that brands choose to meet, functioning as market-driven signals and conformity assessment tools, whereas regulatory frameworks establish minimum legal requirements and enforcement mechanisms. In practice, certification schemes may go beyond regulatory baselines in some areas (e.g., broader restricted substance lists), but both systems focus primarily on declared, intentionally added ingredients and documentation, with limited use of direct analytical measurement of finished products or systematic evaluation of NIAS.

Table 3. Overall findings from chemical safety certification programs, retailer standards, consumer apps, and regulations.

Evaluation Approach	Relies on Ingredient Disclosure	Uses Analytical Measurement	Detects Contaminants/NIAS
Certifications	Yes	Limited	Limited
Retailer standards	Yes	Rare	Limited
Consumer apps	Yes	No	No
Regulations	Yes	Limited	Limited
Needed frameworks	Yes	Yes	Yes

4. Discussion

In this review, we identified the current consumer product chemical safety certifications and regulations, and the extent to which they promote consumer protection and manufacturer transparency. Across the certification and regulatory frameworks reviewed, chemical safety is evaluated primarily through manufacturer-reported ingredient information and documentation. Almost no current programs require analytical measurement, and none of them employ non-targeted analysis (NTA) to identify contaminants or confirm label claims. Certification programs, retailer standards, and ingredient-scoring platforms rely on ingredient disclosure and hazard-based screening of intentionally added substances, without routine analytical measurement of finished products. This may limit consumers’ ability to make informed decisions about chemical exposures, including avoiding endocrine-disrupting chemicals. The current frameworks also limit transparency and accountability of manufacturers, thus potentially undermining consumer trust, and may leave companies vulnerable to recalls and lawsuits if later testing reveals contamination.

Each of the frameworks reviewed has strengths but also important limitations. Structured hazard and multi-attribute certifications use published, predefined criteria that may span human health, chemical hazard, environmental impact, sourcing, manufacturing, packaging, and sustainability [27–34]. Although the specific requirements differ among programs, evaluations generally rely on ingredient disclosure and supporting documentation rather than routine analytical measurement of finished products. Hazard-based certifications and retailer standards provide clearer list-based controls on specific chemicals and can be implemented at scale through purchasing policies, but these also rely on self-declared compliance, and rarely evaluate NIAS. Consumer ingredient-scoring applications make hazard information more accessible and interpretable for the public, but simplify complex data into scores that may not reflect real-world exposure or contamination and lack independent verification. Attribute-specific certifications (such as organic or cruelty-free labels) can meaningfully address single attributes, but have limited insight into broader chemical hazard or contaminant profiles, which reenforces the need for complementary analytical approaches.

Current certification programs and regulatory frameworks nevertheless play a critical role in reducing the use of known hazardous substances and improving transparency in product formulation. These limitations do not diminish the value of current certification programs. Instead, they indicate that analytical measurement should complement existing ingredient-based approaches. As illustrated in Figure 3, analytical testing is a missing layer to the current ingredient-based certification approach, capable of identifying unlabeled NIAS. Analytical measurement is not intended to replace ingredient disclosure or hazard screening, but rather to complement these existing approaches by providing direct evidence of finished-product composition. Together, documentation-based evaluation and analytical

measurement provide a more comprehensive framework for conformity assessment than either approach alone.

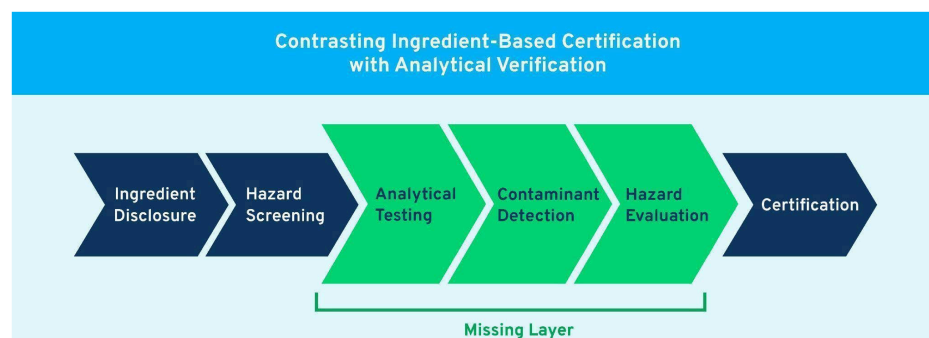


Figure 3. Conceptual comparison of ingredient-based certification and analytical testing approaches. The figure presents the authors’ conceptual framework illustrating how analytical measurement complements ingredient disclosure by enabling identification of NIAS and verification and hazard evaluation of finished-product composition. Figure created by the authors using Figma (Version 126.7.6, Figma Inc., San Francisco, CA, USA); the figure is original and has not been previously published or adapted from another source.

No previous reviews have assessed the current certification/regulatory landscape in regard to the need for analytical testing. However, prior analyses of certification and sustainability in the cosmetics industry has found that the lack of harmonization within the “green” market, including inconsistent labeling definitions, greenwashing practices, and variability in verification rigor and transparency, has contributed to consumer confusion regarding product safety [65]. Similar critiques have been raised in other consumer product sectors, particularly food contact materials. Regulatory and scientific frameworks for food contact materials explicitly recognize NIAS (e.g., impurities, degradation products, and reaction byproducts) as chemicals that may migrate into food and require evaluation under European Union food-contact material regulations [66,67]. Although food and food packaging regulations rely primarily on targeted analytical methods rather than routine NTA, they nevertheless incorporate direct analytical measurement of NIAS into product safety evaluation. In contrast, cosmetic and personal care product certification and ingredient-evaluation programs rely predominantly on ingredient disclosure and supporting documentation, with limited use of analytical testing of finished products. This review extends previous critiques of greenwashing, sustainability claims, and certification transparency by highlighting the need for analytical approaches, including NTA, to verify that finished products are consistent with their labels, certifications, and safety claims.

This lack of testing is also observed in regulatory approaches to chemical safety. As shown in Table 2, state-level regulatory frameworks have expanded in recent years, with multiple states implementing restrictions on specific chemicals or chemical classes, particularly PFAS. These frameworks vary in scope and implementation, including ingredient bans, labeling requirements, and reporting obligations. In some cases, regulatory frameworks combine both ingredient-based and contaminant-based approaches. With few exceptions (e.g., 1,4-dioxane limits in New York and Vermont), regulatory frameworks governing cosmetics and personal care products are primarily designed to restrict intentionally added substances or require disclosure, rather than to measure or control NIAS in finished products. However, despite these advances, regulatory approaches remain primarily ingredient-based and documentation-driven, focusing on manufacturer-reported intentionally added substances and intended formulation rather than the full chemical composition of finished products. Routine analytical measurement is not systematically required, limiting the ability to identify NIAS.

From a standards perspective, these findings indicate that most current regulatory frameworks define what manufacturers must disclose or restrict but provide comparatively few requirements for how finished-product composition should be analytically verified. This represents an opportunity for future conformity assessment standards to integrate analytical measurement alongside documentation-based evaluation.

Current regulatory and certification frameworks also shape how compliance is demonstrated in practice, relying on a distributed system of documentation, supplier verification, and limited analytical measurement across multiple actors in the supply chain. Verification refers to the process by which a certification or standards body confirms that a product or ingredient complies with its stated requirements. This may include review of ingredient disclosures, supplier documentation, safety data sheets, manufacturing records, certifications from upstream suppliers, or audit materials. In many certification systems, verification relies primarily on paper-based review and attestations rather than direct analytical testing of finished products or raw materials for adulterants or NIAS. This distribution of roles is summarized in Table 4. As a result, compliance is most often demonstrated through documentation and supply chain transparency rather than direct analytical measurement of finished products.

Table 4. Compliance and verification roles across the supply chain.

Actor	Compliance & Verification Approach
Manufacturer/Brand	Primary responsibility for compliance; relies on supplier documentation, formulation review, and selective analytical testing
Suppliers	Provide ingredient disclosures and certifications (absence of intentionally added restricted substances)
Retailers	May impose private standards and require documentation or testing as a condition of sale
NGOs	Conduct independent product testing and public reporting, may identify NIAS not captured through documentation
State regulators	Conduct limited market surveillance, request information, and enforce compliance through regulatory actions

Other regulated sectors provide important models for advancing chemical safety evaluation and standardization beyond ingredient-based approaches. In food safety and drinking water regulation, contaminants are routinely measured and controlled through concentration-based limits, reflecting the presence of unintended substances in finished products [68,69]. Pharmaceutical regulation goes further by requiring the identification and control of impurities and degradation products, [70] while food packaging frameworks explicitly recognize NIAS and their potential for exposure [68,69]. These sectors demonstrate how clear performance standards for contaminants, impurities, and NIAS can be embedded within formal conformity assessment processes, linking measurement requirements directly to enforcement and market access.

In contrast, cosmetic regulation remains largely focused on intentionally added ingredients and documentation-based compliance, with limited mechanisms to identify or evaluate contaminants, impurities, or unknown substances in finished products. While regulatory approaches vary internationally, both U.S. and European frameworks primarily rely on ingredient disclosure and documentation to evaluate product safety. The European Union has implemented more extensive premarket regulatory requirements through frameworks such as the EU Cosmetics Regulation and REACH, including ingredient restrictions, product notification requirements, and formal safety assessments conducted by qualified assessors. EU regulations also designate a legally accountable “Responsible Person” for cosmetic products placed on the market. These measures provide a more structured system

of oversight and accountability than currently exists in the United States [71]. However, these systems still remain primarily focused on known substances and documentation rather than direct analytical characterization of finished products. As summarized in Table 2, both U.S. and EU frameworks are predominantly ingredient-based, with only limited use of explicit contaminant concentration limits and no general requirement for routine analytical measurement of finished products. As a result, undisclosed ingredients and incidentals/non-intentionally added substances may still be present in consumer products despite regulatory compliance. This is not just speculation; prior analyses of fragrance products have identified multiple undisclosed chemical constituents not reflected on product labels [72], and recent NTA testing of a wide array of consumer products found most of them contained harmful undisclosed ingredients and NIAS [16,17].

Prior analytical investigations using NTA demonstrate the widespread presence of unlabeled chemicals and NIAS in consumer products. In one study evaluating 31 personal care products selected from a larger set of 546 products, unlabeled chemicals of concern were identified in 30 products tested (97%), with 22 chemicals of concern not disclosed on product labels. Overall, only 23% of detected chemicals of concern were listed on ingredient labels, and some products with no listed chemicals of concern were found, through targeted and suspect screening laboratory analysis, to contain between 2 and 7 such compounds [16]. A more recent non-targeted analysis of 113 personal care and cleaning products found that 57.5% of products failed hazard-based contamination criteria due to unlabeled contaminants [19]. Importantly, many of the detected contaminants included endocrine-disrupting chemicals, reproductive and developmental toxicants, carcinogens, sensitizers, and other compounds with known or suspected toxicological hazards [19]. Several contaminants, including siloxanes, fragrance-related compounds, benzyl chloride, and butylated hydroxytoluene, were detected repeatedly across product categories and, in some cases, at estimated concentrations reaching hundreds to thousands of parts per million, suggesting that these are not isolated trace findings [19]. The same study also found that 26% of products contained chemicals that directly contradicted marketing or label claims. Examples included products labeled as “100% natural” that contained synthetic chemicals, products marketed as “phthalate-free” or “paraben-free” that contained those chemical classes, and products labeled as “hypoallergenic” that contained known allergens or sensitizers [19]. Such labeling discrepancies may mislead consumers and pose particular risks for individuals with allergies or sensitivities who rely on ingredient labels to avoid harmful substances. Together, these findings suggest that undisclosed contaminants and NIAS are common across product categories and are not limited to isolated cases; across both studies, most evaluated products contained at least one unlabeled contaminant or chemical of concern [16,19]. Because personal care and household products are often used daily and in combination, undisclosed contaminants may contribute to cumulative and repeated human exposure over time, potentially increasing risks of endocrine disruption, reproductive toxicity, adverse developmental outcomes, allergic sensitization, and other chronic health effects, particularly among populations with frequent or high product use.

Many detected contaminants were also associated with significant toxicological concerns and, in some cases, occurred at concentrations well above trace levels. These included cyclohexasiloxane (D6), detected unlabeled in 22 products at concentrations up to 2200 ppm; cyclopentasiloxane (D5), detected in 16 products at concentrations up to 202 ppm; dimethyl oxazolidine, detected at concentrations up to 220 ppm; benzyl chloride, detected in 19 products at concentrations up to 52.8 ppm; and toluene, detected in 6 products at concentrations up to 48.1 ppm [19]. Prior work similarly identified carcinogens including benzyl chloride and 1,4-dioxane in multiple personal care products, with benzyl chloride detected at concentrations up to 39 µg/g in a leave-on lotion [16].

Both studies also identified unlabeled phthalates, although concentrations varied substantially across products [16,19]. Notably, unlabeled 1,4-dioxane was detected at up to 31 ppm, [16] exceeding current New York limits for certain personal care products, which were specifically established to address incidental contamination arising from manufacturing processes [60]. These findings demonstrate that unlabeled contaminants may occur not only as trace impurities, but in some cases at significant concentrations with potential regulatory and toxicological relevance. As a result, standardized analytical verification could improve the information available to manufacturers, regulators, certification programs, and ultimately consumers.

Quality assurance and supplier oversight likely vary substantially across manufacturers. Company size may contribute to contamination levels as larger companies generally have greater resources for quality assurance/quality control (QA/QC) infrastructure, supplier auditing, and analytical testing than smaller brands. However, these efforts are often incomplete. In fact, our previous research evaluating products from 102 companies of varying sizes found similar levels of contamination across both large and small companies, with contaminants such as 1,4-dioxane appearing more frequently in products from larger companies [17,19].

Taken together, these findings suggest an important gap in current approaches and supports the need for frameworks that directly characterize the chemical composition of finished products.

4.1. Advancing Product Safety Through Analytical Measurement

Few of the current certification or regulatory programs require analytical testing, whether targeted (i.e., testing for predetermined compounds) or non-targeted (NTA). NTA is a powerful tool for identifying chemical contaminants in products, without restriction to a predefined list of target compounds. Unlike traditional targeted methods, which are limited to known and expected chemicals, NTA captures all detectable signals generated by high-resolution analytical platforms, allowing for the identification of both known substances and previously unrecognized or undisclosed NIAS. NTA is commonly performed using high-resolution chromatographic and mass spectrometric techniques, such as gas chromatography (GC) and liquid chromatography (LC), which allow for broad chemical coverage and sensitive detection. This approach is often used alongside suspect screening, which targets compounds from existing chemical lists or libraries; together, these methods provide a comprehensive strategy for identifying chemicals of concern in complex samples [17]. Broader adoption of NTA has the potential to substantially improve transparency, strengthen exposure assessment, and inform regulatory and manufacturing decisions by revealing the true chemical composition of consumer products. NTA also supports more defensible safety claims, positioning products as genuinely safer and helping brands meet the growing demand among consumers for cleaner, more trustworthy options [5–11].

Thus, a chemical safety approach that incorporates analytical measurement (specifically NTA) of finished products is needed to more effectively ensure product safety, strengthen conformity assessment, and support the validity of “clean product” claims. This approach is informed by prior analytical investigations of personal care products using non-targeted methods, which have demonstrated that finished products may contain both intended ingredients and non-intentionally added substances not captured through ingredient disclosure [16,17,19]. Such approaches, which aim to broadly characterize product composition without limiting analysis to predefined compounds, are particularly useful for identifying NIAS. Targeted testing can be very costly as each chemical target requires its own testing, and is limited to a predetermined set of known chemical targets. NTA methods provide an efficient and

cost-effective way to identify any chemicals of potential concern, and can serve as a screening step prior to targeted analysis to confirm identity and quantify selected compounds of interest.

From a standardization perspective, integrating NTA into certification and regulatory frameworks would not require inventing an entirely new paradigm, but rather aligning analytical testing with existing conformity assessment and laboratory quality systems. Many current safety evaluations already operate within structured standards, such as internationally recognized test guidelines and lab accreditation frameworks, which specify how methods are validated, how data quality is assured, and how results are documented for regulatory use. Extending these principles to NTA would mean defining minimum performance benchmarks, validation requirements, and reporting conventions for high-resolution screening of cosmetics and personal care products, so that results are interpretable and comparable across laboratories. In practice, NTA could be incorporated into conformity assessment systems as one piece of evidence rather than a stand-alone decision tool. For example, non-targeted screening could be used for batch or periodic surveillance testing, or for targeted investigations when documentation-based review raises concerns. It could also be used to verify compliance with contaminant limits. Follow-up targeted methods could then be used to confirm identity and quantify specific compounds of interest. This approach is conceptually aligned with current risk-based regulatory paradigms. NTA broadens the ability to identify potential NIAS, while existing toxicological assessment and exposure-based decision criteria continue to govern how risk is evaluated.

Beyond analytical performance, there are practical challenges associated with integrating NTA into regulatory and certification frameworks. Regulatory programs and certification standards are typically built around predefined substance lists, established toxicological thresholds, and validated targeted analytical methods. NTA generates broad chemical profiles that may identify many compounds without clear regulatory status. This raises questions about how to interpret and act on tentative identifications, how to define action levels for newly identified contaminants, and how to balance the risk of false positives or negatives against the benefits of broader chemical coverage. These challenges demonstrate the need for more standardized NTA workflows and reporting practices. Harmonization of data processing, compound identification confidence criteria, and quality assurance/quality control procedures will need to be developed to ensure that results are comparable across laboratories and over time. Similarly, common reporting formats that clearly distinguish tentatively identified contaminants from confirmed analytes would make it easier for regulators and certification programs to interpret NTA data consistently and integrate them into conformity assessment decisions. Existing NIAS frameworks used in food packaging and other regulated sectors can be a starting point in developing specific guidance for cosmetic and personal care products. Future standardization work could be supported by established standards bodies, such as the International Organization for Standardization (ISO) and the Organisation for Economic Co-operation and Development (OECD), drawing on their existing structures for method validation, interlaboratory comparison, and regulatory acceptance. Although a full discussion of standardization pathways is beyond the scope of this review, highlighting these needs is intended to frame NTA as an approach that can be developed within existing standards and conformity assessment structures rather than as a parallel system.

This framework is grounded in the principle that the final composition of a product may include both intentionally added ingredients and NIAS arising from raw material impurities, manufacturing processes, degradation, or leaching from packaging [73]. By incorporating analytical measurement as a core component of evaluation of finished products, this approach enables the identification of NIAS that may not be reflected in formulation records or ingredient disclosure [74].

4.2. Implications for Consumers and Market Claims

The lack of consumer product certification and regulation testing requirements has important implications for consumer decision-making and the interpretation of product claims. Public concern regarding chemical exposures in everyday products has increased alongside demand for “clean” alternatives, yet consumers’ ability to make informed choices remains constrained by reliance on ingredient-based information and gaps in regulatory oversight [5–11]. Also, products with undisclosed contaminants but certifications earned in today’s market can currently be positioned as safer than cleaner products that hold the same certifications or none at all. In the absence of direct analytical measurement, consumers must depend on ingredient labels and certification programs that reflect intended formulation rather than actual product composition.

This creates conditions in which marketing claims such as “clean,” “natural,” or “free-from” may not reflect the presence of substitutes and NIAS. For example, “bisphenol a (BPA)-free” claims do not necessarily indicate the absence of endocrine activity, as structurally similar substitutes such as bisphenol s (BPS) or bisphenol f (BPF) may be used and have been associated with similar biological effects [75]. As a result, even informed consumers may be unable to accurately assess product safety based on available information, contributing to confusion and potential misinterpretation of risk. This dynamic contributes to the persistence of greenwashing practices, where products marketed as safer alternatives may still contain unrecognized or undisclosed chemicals.

Consumer pressure and literacy are critical components of the certification landscape. Manufacturers may be reluctant to adopt certifications that require testing, as identifying and eliminating sources of contamination can be time- and cost-intensive. Ongoing requirements, such as annual or batch testing, add further financial burden. However, consumer education and strong demand for transparency can compel companies to comply in order to remain competitive. If market forces alone are insufficient to drive progress toward chemical safety, regulatory action mandating testing requirements will be necessary to protect public health (Figure 4).

Figure 4 emphasizes that adoption of analytical measurement is unlikely to result from a single driver. Instead, meaningful implementation will require coordination of consumer demand, voluntary certification, regulatory policy, analytical standardization, and manufacturer engagement, creating a continuous cycle of product improvement and increased transparency.

4.3. Forward Pathways

Integration of NTA into certification programs, regulations, and regulatory compliance programs could begin with voluntary programs and market-driven certifications, focusing initially on higher-risk product categories. These categories include products used by vulnerable populations such as babies and pregnant women, and products with higher exposure potential, such as leave-on products (e.g., sunscreens and fragrances) and sensitive-area products (e.g., feminine washes and menstrual products). As sector-specific validation and standardization data increase, regulators could begin to reference agreed analytical approaches in guidance documents, inspection protocols, or enforcement policies.

However, testing alone is not sufficient to protect consumers. Hazard assessments of identified chemicals as well as human risk assessments (including factors such as exposure routes/potentials and chemical concentrations) are needed for manufacturers and brands to effectively create safe products and adhere to certifications and regulations. NTA data could strengthen existing hazard assessment and human health risk assessment frameworks by identifying previously unrecognized contaminants and providing a more complete characterization of chemical exposures. Translating these scientific findings into accessible information

for manufacturers, regulators, healthcare professionals, and consumers will be essential for building environmental health literacy and supporting informed decision-making.

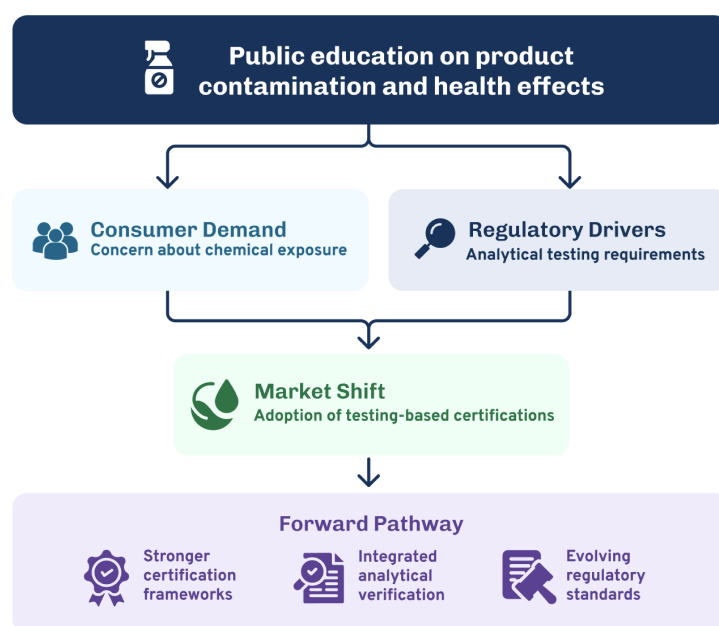


Figure 4. Drivers for adoption of analytical testing for consumer safety in the personal product industry. Conceptual framework illustrating drivers that may facilitate broader adoption of analytical measurement in personal care product evaluation, including consumer demand, voluntary certification, regulatory action, and industry implementation. Figure created by the authors using Figma (Version 126.7.6, Figma Inc., San Francisco, CA, USA); the figure is original and has not been previously published or adapted from another source.

Ultimately, analytical testing should feed back into certification programs, regulatory standards, consumer purchasing decisions, and product reformulation, creating a continuous cycle of product improvement. While voluntary certification programs may serve as an important starting point, market incentives and consumer pressure alone may not be sufficient to achieve widespread adoption. Broader implementation will likely require coordinated policy development, regulatory action, and multidisciplinary collaboration among analytical chemists, toxicologists, exposure scientists, risk assessors, standards organizations, regulators, manufacturers, and consumer advocates.

4.4. Implications for Supply Chains

These findings also have implications for product integrity within complex supply chains. Modern cosmetic and personal care supply chains are highly globalized, with raw materials, intermediates, catalysts, and processing aids often shipped across multiple countries and facilities for further processing. As a result, downstream manufacturers and distributors may have limited visibility into upstream chemical manufacturing practices, sanitation procedures, or potential sources of contamination. Ingredients may be altered or substituted without disclosure, introducing substances that are not reflected in formulation records or product labels.

Contamination and adulteration may occur at multiple stages, including raw material sourcing, ingredient processing, and manufacturing, and may not be fully visible to downstream manufacturers. Suppliers may shift to alternative raw material sources to maintain product continuity, sometimes without clearly informing their brand clients. This kind of substitution is particularly common during shortages or major global disruptions, as seen recently during the COVID-19 pandemic [76].

As a result, reliance on supplier documentation alone may be insufficient to ensure product composition. Potential contamination may also arise from shared manufacturing equipment, sanitation agents, processing aids, or cross-contamination during production. These factors may not be captured through ingredient documentation or paper-based verification systems alone. The complexity of these supply chains demonstrates the need for analytical measurement at multiple stages of product development, including both raw materials and finished products, to more effectively identify contamination and verify product integrity.

4.5. Limitations

This work is a structured targeted, purposive review rather than a systematic review. Programs and frameworks were identified primarily through web searches and author expertise; final selection was based on market visibility and relevance, including criteria such as name recognition, retailer adoption, manufacturer participation, and consumer use. Consequently, some programs may have been overlooked; however, any omitted programs were likely to have limited market presence or adoption. Certification programs with a primary focus outside of the United States and European markets or with documentation in languages other than English were excluded. Numerous attribute-specific certifications (e.g., cruelty-free, vegan, B Corp.) were identified, but only a limited number of representative programs were retained and these were not included in the comparative analysis. The regulatory review focused on selected U.S. federal and state frameworks identified via the Safer States Bill Tracker and primary legislative sources, with European regulatory systems addressed qualitatively in the Discussion section. We did not attempt to systematically map international cosmetic regulations.

Although we focus on NTA as a complementary approach for product safety evaluation, these methods have important limitations. NTA is semi-quantitative and primarily suited for identification rather than precise quantification, so follow-up targeted testing may be required to confirm exact concentrations. Compound identification relies on algorithm- and library-assisted interpretation, and expert review is often needed to confirm results. While NTA provides broad coverage for chemical identification, it does not capture all chemical classes. In addition, broadly applicable and sector-specific guidance for NTA workflows and reporting is still emerging, and the absence of widely accepted standards for data processing, identification confidence, and result interpretation may further limit near-term regulatory adoption. Finally, although NTA is cost-effective relative to targeted chemical testing, smaller companies and regulatory bodies with limited resources may still find the cost and technical complexity to be a barrier to adoption.

5. Conclusions

Current certification and regulatory frameworks for personal care products rely primarily on manufacturer ingredient disclosure and intended formulation, with limited consideration of the full chemical composition of finished products. While the current hazard assessment approaches are needed for protecting consumer health, incorporating non-targeted analytical methods offers a complementary approach to identify substances that may not be captured through existing systems. Previous analytical studies have demonstrated that finished personal care products frequently contain undisclosed substances (i.e., adulterants and NIAS), including chemicals with recognized health concerns. Based on the evidence reviewed, we believe that current and future certification and regulatory frameworks should incorporate analytical measurement as a complementary component of existing ingredient-based evaluation approaches. Aligning product evaluation and related standards with measured chemical composition has the potential to improve the accuracy of safety assessments, strengthen the

validity of product claims, better reflect real-world chemical exposures, and support more transparent product safety evaluation and greater consumer confidence.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/standards6030032/s1>, Table S1: Individual E.U. and U.S. federal and state-level regulatory approaches to chemical safety in personal care products, including ingredient-based restrictions and limited contaminant-based controls, by government entity.

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Conflicts of Interest: Johanna R. Rochester, Kim Schultz, Michael Kupec Lathrop, Jenna Hua, and Jarod Grossman are affiliated with Million Marker and Million Marker Research Institute, the nonprofit arm of Million Marker. Million Marker and its affiliated entities provide environmental exposure testing and related services. Because this review discusses approaches for evaluating the chemical composition and safety of consumer products, these affiliations may be perceived as potential competing interests. Jarod Grossman is also affiliated with Albert Invent Corp., a company that provides software and artificial-intelligence tools for chemical and materials research, formulation development, laboratory data management, and regulatory workflows. Because this review discusses analytical testing, chemical safety evaluation, and related industry practices, this affiliation may be perceived as a potential competing interest. Albert Invent Corp. did not fund the study and had no role in the study design, analysis, interpretation, preparation of the manuscript, or decision to publish. Gay C. Timmons is affiliated with Oh Oh Organic Inc. Martin J. Mulvihill is affiliated with Safer Made LLC, a venture capital firm that invests in companies focused on safer chemicals and sustainable products. These affiliations represent potential competing interests. The authors declare that these affiliations did not influence the design, analysis, interpretation, writing, or reporting of this review. The present work is a review of publicly available certification and regulatory frameworks and does not evaluate or validate Million Marker Research or programs nor does it evaluate, promote, or endorse Million Marker products or services.

Glossary

Analytical measurement/testing	Laboratory determination of the chemical composition of a finished product using analytical chemistry methods, including targeted and non-targeted approaches.
Attribute-specific certification	Certification that verifies a single product attribute (e.g., organic, cruelty-free) rather than overall chemical safety.
Conformity assessment	Activities used to demonstrate that a product meets specified standards or regulatory requirements, including documentation review, testing, inspection, or certification.

Contaminant	An unintended chemical present in a finished product as a result of raw material impurities, manufacturing processes, cross-contamination, packaging, storage, or environmental exposure. Contaminants may include non-intentionally added substances (NIAS) and can be present even when they are not listed on product labels or formulation records.
Documentation-based evaluation	Assessment of product safety based primarily on ingredient disclosure, supplier documentation, formulation records, and related documentation rather than direct laboratory analysis.
Finished product	The final marketed product available to consumers after formulation and packaging.
Hazard screening	Evaluation of ingredients or chemicals against established toxicological, regulatory, or hazard criteria to identify substances of concern.
Ingredient disclosure	Manufacturer-provided list of intentionally added ingredients appearing on product labels or supporting documentation.
Intended formulation	The composition of a product as designed and reported by the manufacturer.
Measured chemical composition	The chemical composition of a finished product as determined through analytical measurement.
Non-intentionally added substances (NIAS)	Chemicals not intentionally added during formulation, including impurities, degradation products, reaction byproducts, contaminants, and packaging migrants.
Non-targeted analysis (NTA)	Analytical approaches that detect and tentatively identify a broad range of chemicals without relying on a predefined target list, including suspect screening methods.
Program	A structured framework used to assess, certify, rate, or regulate products. Throughout this review, <i>program</i> is used as a general term encompassing certification schemes, retailer standards, consumer ingredient-scoring applications, and regulatory frameworks.
Supplier documentation	Information provided by ingredient suppliers, such as safety data, ingredient composition, certifications, and manufacturing documentation, used to support product evaluation.
Suspect screening analysis	An analytical approach that searches for chemicals from predefined suspect lists using high-resolution analytical methods without requiring analytical standards for every compound.
Targeted analysis	Analytical methods designed to identify and quantify a predefined list of chemicals with high specificity and sensitivity.

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