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A Review on the Effects of Daily Use Chemicals on Human Health

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ABSTRACT

Background: Widespread exposure to chemicals in daily-use consumer products, such as personal care items, cleaning agents, and food packaging, poses significant and under-recognized risks to human health. Despite mounting evidence of adverse effects, particularly endocrine disruption and chronic diseases, many substances remain inadequately studied, with regulatory gaps persisting globally.

Objective: This review aims to synthesize current toxicological and epidemiological evidence on the health impacts of commonly encountered daily-use chemicals, with a focus on exposure pathways, mechanisms of toxicity, and health outcomes among sensitive subpopulations.

Methods: A narrative review approach was used, sourcing peer-reviewed literature on chemicals of concern, including phthalates, parabens, bisphenol A, and triclosan, among others. Studies involving diverse populations were included, emphasizing findings from large observational cohorts, clinical investigations, and biomonitoring surveys. Inclusion criteria prioritized articles with robust methodological design and relevance to human exposure and health outcomes. No primary data collection or ethical approval was required for this review. Literature was analyzed for clinical significance, exposure-response relationships, and policy implications.

Results: Findings consistently demonstrate that chronic, low-dose exposure to daily-use chemicals is associated with increased risks of respiratory illness, endocrine disorders, neurodevelopmental delays, and reproductive toxicity, with children, pregnant women, and occupationally exposed individuals being most vulnerable.

Conclusion: Urgent regulatory reform, interdisciplinary research, and public education are required to reduce chemical-related disease burden, promote safer alternatives, and ensure real-world health protection.

INTRODUCTION

The integration of chemicals into modern daily life has become so pervasive that exposure is now virtually unavoidable. Synthetic compounds are found in cleaning agents, personal care products, food packaging, and a wide range of consumer goods, often with the intent to improve hygiene, durability, and convenience. However, many of these chemicals—including parabens, phthalates, synthetic fragrances, and volatile organic compounds (VOCs)—have not been thoroughly evaluated for their long-term health impacts. For instance, substances like parabens and phthalates are frequently present in cosmetics and toiletries, while household cleaners may contain ammonia, chlorine bleach, and other potentially harmful VOCs.

Plastics, now ubiquitous in packaging and storage, introduce further concerns, with chemicals such as bisphenol A (BPA) and microplastics leaching into food and beverages. Human exposure occurs through inhalation, skin absorption, or ingestion, leading to the accumulation of these compounds in tissues over time. Evidence from toxicological and epidemiological studies indicates that even chronic, low-dose exposures can result in bioaccumulation and potentially hazardous biological effects (1). These trends have raised significant public health concerns, as multiple studies report the presence of such chemicals in human biological samples—including urine, blood, and breast milk—demonstrating widespread exposure across all demographic groups (2). Of particular concern are chemicals identified as endocrine-disrupting compounds (EDCs), which can mimic or block natural hormones and disrupt physiological regulation. Phthalates, for example, are widely used to impart flexibility to plastics but can interfere with testosterone synthesis, affecting male reproductive health.

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Parabens, employed as preservatives in a variety of products, have demonstrated weak estrogenic activity and have been implicated in hormone-sensitive cancers, such as breast cancer. Moreover, chronic exposure to household cleaning agents containing VOCs has been associated with respiratory ailments, including asthma and chronic obstructive pulmonary disease (COPD), especially in individuals who spend more time indoors, such as women and children. Such findings highlight the urgent need for robust toxicological studies to clarify dose–response relationships, windows of critical exposure, and cumulative or synergistic effects of chemical mixtures (3). Epidemiological investigations have further elucidated links between chemical exposures and chronic health conditions, including metabolic disorders, infertility, neurodevelopmental delays, and malignancies. Increasingly, scientific consensus acknowledges that the "cocktail effect"—wherein low-level exposure to a combination of chemicals—may amplify risks in ways not anticipated by traditional safety assessments. For example, a comprehensive review by Gore et al. for the Endocrine Society documented substantial evidence associating EDCs with diverse health disturbances, underscoring the necessity of improved regulatory testing and a more precautionary approach in public health policy (4).

This review synthesizes current scientific understanding regarding the sources, routes, and health effects of chemicals commonly encountered in daily life, aiming to provide a critical appraisal of the available toxicological and epidemiological data. The discussion emphasizes vulnerable populations—such as infants, children, pregnant women, and individuals with pre-existing health conditions—who are likely to be disproportionately affected by chronic, low-level exposures. The review further identifies gaps in the literature, particularly regarding aggregate exposures, chemical combinations, and long-term impacts. In doing so, it seeks to inform researchers, policymakers, and the broader public about the importance of regulatory controls and the ongoing need for interdisciplinary analysis—spanning toxicology, public health, environmental science, and policy. Global discrepancies in regulatory enforcement, such as the contrast between precautionary frameworks in the European Union and the more permissive approach in the United States, highlight unresolved challenges in consumer safety and health equity. Notably, environmental pollution from hazardous chemicals remains a leading contributor to disease burden and premature mortality, particularly in low- and middle-income countries with weaker regulatory oversight (5).

Thus, this review serves not only as a scientific summary but also as a call to action for more comprehensive, science-driven strategies in chemical safety management. An integrated approach combining regulatory reform, public education, and innovation in green chemistry is urgently needed to reduce health risks associated with daily-use chemicals and to promote sustainability in both human and environmental health.

COMMON DAILY USE CHEMICALS

Household disinfectants, including bleach, ammonia, and a wide range of detergents, are integral to modern hygiene routines yet present significant health risks due to their reactive chemical profiles. These substances commonly release volatile organic compounds (VOCs) and other byproducts, leading to skin, eye, and respiratory irritation. For example, sodium hypochlorite—commonly known as bleach—liberates toxic chlorine gas when mixed with ammonia or acidic cleaners, causing acute symptoms such as coughing and difficulty breathing and contributing to long-term conditions like chronic bronchitis and asthma. Notably, a large-scale longitudinal survey within the European Community Respiratory Health Survey demonstrated that frequent use of household cleaning sprays was associated with a decline in lung function comparable to that observed in habitual cigarette smokers, a finding particularly pronounced in women and professional cleaners (6). Such evidence underscores the potential dangers of chronic inhalation exposure and highlights the importance of substituting less toxic alternatives, such as vinegar or baking soda, as well as ensuring adequate ventilation and protective equipment during cleaning tasks.

Personal care products—including shampoos, lotions, cosmetics, and deodorants—often contain chemicals such as parabens, phthalates, and triclosan, which have raised considerable concern due to their ability to disrupt the human endocrine system. These compounds are absorbed through the skin or mucous membranes and are capable of mimicking or interfering with natural hormonal processes, particularly those governed by estrogen and testosterone. Parabens, for instance, are widely used as preservatives but exhibit weak estrogenic activity and have been linked to abnormal breast tissue development and tumor formation. Phthalates, responsible for maintaining the plasticity and fragrance stability of products, have demonstrated associations with reproductive and developmental abnormalities, especially in males. Triclosan, formerly prevalent in antibacterial soaps and dental products, has drawn scrutiny due to its impact on thyroid function and its role in fostering antibacterial resistance. Research by Dodson and colleagues revealed widespread contamination of consumer products with endocrine-

disrupting chemicals, frequently without clear labeling, highlighting the challenge for consumers attempting to avoid these compounds (7). The omnipresence of EDCs in personal care items—even those marketed as "natural" or "green"—is further corroborated by biomonitoring studies, which consistently detect such chemicals in breast milk, urine, and blood samples (2). The growing evidence for endocrine disruption supports the urgent need for reformulation and transparent labeling within the personal care industry to safeguard public health.

Dietary exposure through plastic and pesticide residues also constitutes a significant route of daily chemical intake. Bisphenol A (BPA), widely used in polycarbonate plastics and epoxy resins for food containers and can linings, acts as an established endocrine disruptor, capable of mimicking estrogenic activity. BPA exposure has been associated with metabolic syndrome, reproductive and cardiovascular disorders, and neurodevelopmental issues. Meanwhile, the presence of microplastics in drinking water, seafood, and even table salt has increased as larger plastic items degrade, heightening concerns over cumulative exposure from ingestion. Pesticides such as DEET and permethrin, used in insect repellents and pest control, are neurotoxic compounds known to accumulate in human tissues over time. Children and pregnant women are particularly at risk, as their developing physiological systems are more susceptible to low-level, chronic exposure. A comprehensive review on BPA highlighted the disruption of multiple biological systems during critical developmental periods, with both animal and human studies linking exposure to altered neurodevelopment, behavioral changes, obesity, and diabetes risk (8). Although regulatory restrictions have increased in some jurisdictions, BPA continues to be widely used globally, and replacement chemicals like BPS and BPF may not provide safer alternatives. Furthermore, the daily intake of small quantities of diverse chemicals—the so-called "cocktail effect"—poses cumulative health risks that may elude conventional safety assessments, emphasizing the necessity of comprehensive risk evaluation for combined exposures rather than individual compounds alone (4).

In summary, the prevalence of hazardous chemicals in cleaning agents, personal care products, and materials associated with food and water highlights the complex and persistent nature of chemical exposure in everyday life. This reality underscores the need for both regulatory reform and public awareness to reduce health risks and protect vulnerable populations from the often-invisible dangers posed by routine use of synthetic chemicals.

ROUTES OF HUMAN EXPOSURE

Human exposure to toxic chemicals found in daily-use products primarily occurs through three main routes: inhalation, dermal (skin) absorption, and ingestion. Among these, inhalation represents one of the most direct and pervasive means of exposure, especially in indoor environments where ventilation is often inadequate. Volatile organic compounds (VOCs) released from air fresheners, disinfectants, and aerosol sprays can rapidly evaporate and persist in indoor air, resulting in continuous low-level exposure. Regular use of cleaning sprays, perfumes, and insecticides introduces chemicals such as formaldehyde, benzene, and toluene into household air. The health implications of such exposures are significant, as repeated inhalation is strongly associated with respiratory symptoms, reduced lung function, and even increased cancer risk. Notably, landmark longitudinal studies have shown that chronic inhalation of cleaning products produces declines in lung function comparable to the effect of smoking a pack of cigarettes per day, with especially marked impacts among women and individuals with pre-existing respiratory diseases (6). Children and the elderly, who typically spend more time indoors and have heightened physiological sensitivity, are particularly vulnerable to these effects. Additionally, frequent exposure to synthetic fragrances in air fresheners and deodorants can lead to hormone disruption and allergic responses, highlighting the importance of adequate indoor air quality and consumer awareness regarding the use of fragranced products (4).

Dermal absorption is another important and often underestimated route of exposure, particularly with respect to chemicals found in personal care products, soaps, detergents, and cosmetics. The skin, while serving as a natural barrier, is permeable to many small and lipophilic molecules, especially with repeated or prolonged application. Parabens, triclosan, and phthalates can penetrate the skin and enter the systemic circulation, accumulating in tissues over time. Biomonitoring studies have detected measurable levels of these chemicals in urine and blood, with concentrations significantly higher in individuals who frequently use cosmetics and personal care items (2). Clinical research has demonstrated that routine topical application of such products results in increased systemic levels, emphasizing the potential for bioaccumulation through skin exposure (9). Infants and young children are particularly susceptible due to their thinner skin and higher skin surface area relative to body weight, leading to greater absorption of toxicants. Occupational exposures in professions such as cosmetology and cleaning further compound these risks, underscoring the need for both consumer education and improved workplace safety standards. A significant barrier

to informed decision-making is the lack of comprehensive ingredient labeling, as many potentially hazardous chemicals are concealed under terms like “fragrance,” limiting consumer capacity to avoid harmful exposures (7).

Ingestion constitutes a third, critical route of chemical exposure in daily life, arising primarily through contaminated food, drinking water, and food packaging materials.

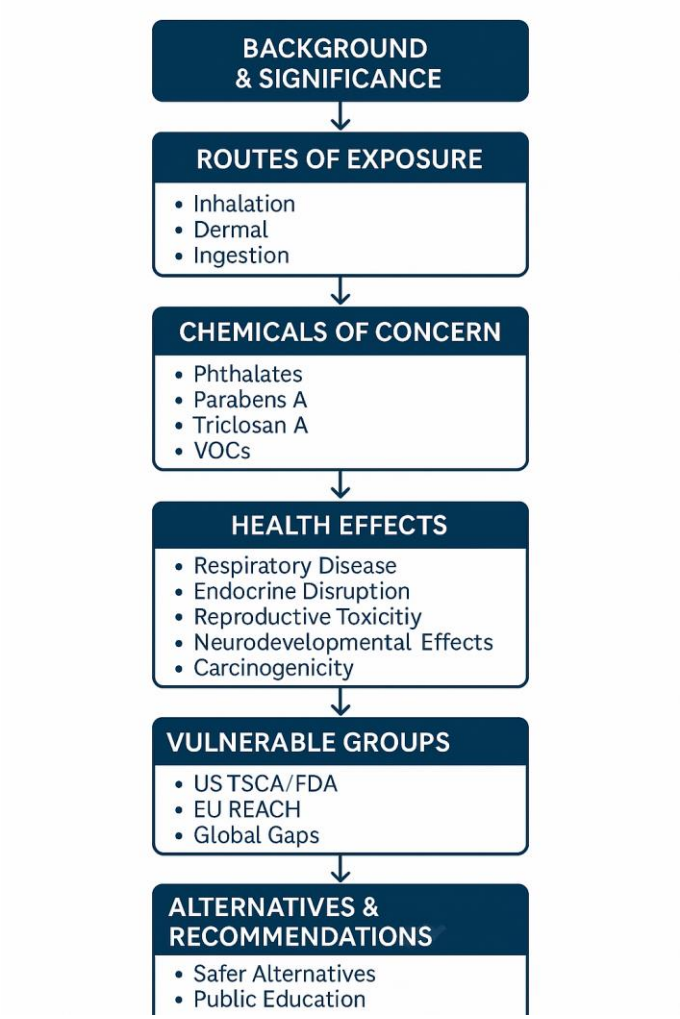

Figure 1 Schematic Flowchart

Substances such as BPA, commonly found in plastic containers and can liners, and pesticide residues on produce are readily introduced into the human body through dietary intake. BPA and similar chemicals, including BPS and BPF, exhibit estrogen-mimicking effects and have been linked to metabolic, reproductive, and cardiovascular disorders, as well as developmental abnormalities (8). National biomonitoring programs have reported the presence of these chemicals in the vast majority of urine samples collected from diverse populations, indicating widespread and ongoing exposure (2). Research has also documented the prevalence of microplastics in seafood, table salt, and even drinking water, raising concerns about the potential for these particles to act as vectors for other environmental toxins (8). Cooking and storage practices, such as heating food in plastic containers, further increase the likelihood of chemical leaching. Children are at heightened risk due to greater dietary intake per unit body weight and developing detoxification systems. Consequently, ingestion presents a complex and multifaceted threat that warrants rigorous regulatory oversight, safer packaging innovations, and robust public education initiatives to promote safer food handling and storage practices.

Overall, these intertwined routes of exposure—inhalation, dermal absorption, and ingestion—collectively shape the landscape of human contact with hazardous chemicals. Addressing these risks requires a comprehensive approach that includes policy reform, industry accountability, improved product labeling, and targeted interventions for populations at increased risk of harm.

EFFECTS OF DAILY USE CHEMICALS ON HUMAN HEALTH

Chemicals present in household and personal care products are recognized contributors to a range of respiratory conditions, particularly within indoor environments where air exchange is limited. Compounds such as volatile organic compounds (VOCs), ammonia, bleach, and quaternary ammonium compounds (quats), which are frequently found in cleaning sprays, air fresheners, and disinfectants, are associated with both acute and chronic respiratory symptoms. These include coughing, wheezing, airway inflammation, and the exacerbation or development of asthma. The health risks are further amplified in poorly ventilated homes and occupational settings, such as janitorial services, where individuals experience sustained exposure to chemical aerosols. A landmark longitudinal study established that women using cleaning sprays regularly suffered a decline in lung function equivalent to smoking a pack of cigarettes daily for two decades, and were at higher risk for chronic obstructive pulmonary disease (COPD). This decline in respiratory capacity was especially marked in women and children, emphasizing the role of repeated low-dose exposure in disease pathogenesis and the urgent need for safer cleaning alternatives and protective measures (6).

The pervasive presence of endocrine-disrupting chemicals (EDCs) in daily-use products—including plastics, detergents, and food wrappers—poses significant risks to hormonal health. Common EDCs such as bisphenol A (BPA), phthalates, parabens, and triclosan are able to mimic or antagonize natural hormones, particularly estrogen, testosterone, and thyroid hormones. Even at low doses, these substances can disrupt endocrine signaling during

sensitive periods of development, including fetal growth, childhood, and puberty. Epidemiological and experimental research links exposure to these chemicals with early puberty, reduced sperm quality, infertility, obesity, diabetes, and hormone-sensitive cancers such as those of the breast and prostate. The second scientific statement by the Endocrine Society synthesized findings from hundreds of studies, concluding that EDCs play a causal role in metabolic, reproductive, and oncological diseases. Importantly, these chemicals do not always follow predictable dose–response patterns, as very low exposure levels may exert maximal biological effects—challenging the assumptions of traditional toxicology. Routine detection of EDCs in urine, blood, and breast milk highlights population-wide exposure and underscores the need for precautionary policies, safer product choices, and improved regulatory standards (4).

In addition to respiratory and endocrine effects, daily-use chemicals are increasingly implicated in reproductive toxicity, neurodevelopmental disabilities, and carcinogenesis. Phthalates, for instance, are associated with reduced testosterone production, diminished sperm quality, and adverse pregnancy outcomes such as polycystic ovary syndrome (PCOS), irregular menstruation, and miscarriage. BPA exposure is similarly linked to reproductive dysfunctions and has demonstrated the potential to alter brain structure and function, particularly with prenatal or early-life exposure. Neurotoxicants such as lead, organophosphates, and flame retardants (e.g., polybrominated diphenyl ethers, PBDEs) disrupt brain development and have been tied to lower intelligence quotients, behavioral disorders, and attention deficits in children. These adverse neurodevelopmental outcomes can be irreversible when exposures occur during critical windows of brain maturation. Chronic contact with carcinogenic substances like benzene and formaldehyde, often present in household and personal care products, has been correlated with leukemia, breast cancer, and other malignancies. Notably, a pivotal review articulated the accumulating evidence connecting EDCs to reproductive, developmental, and cancer risks, calling for global action and a precautionary approach to chemical regulation (10).

Vulnerable groups such as children and pregnant women are particularly susceptible to the harmful health effects of daily-use chemicals. Children, due to their developing organ systems, behavioral tendencies (e.g., hand-to-mouth activity), and higher exposure relative to body weight, face greater risks from EDCs and other hazardous compounds found in plastic toys, flame retardants, pesticides, and personal care products. Critical periods of brain and immune system development are especially sensitive to chemical insults. A prominent cohort study demonstrated strong associations between prenatal exposure to organophosphate pesticides and developmental delays, such as lower IQ scores and attention deficits in school-aged children (11). The immaturity of detoxification pathways in children further amplifies their risk. Similarly, pregnant women experience increased vulnerability to chemicals like phthalates, BPA, and parabens, which can cross the placental barrier and disrupt fetal growth, leading to outcomes such as low birth weight, preterm birth, and long-term health effects in offspring. Maternal exposure to triclosan has been linked to altered thyroid hormone levels and adverse birth outcomes, reinforcing the need for public health interventions and targeted education for women of reproductive age (12, 13).

Older adults and occupationally exposed workers represent additional high-risk populations. Aging is accompanied by decreased metabolic and excretory function, which may heighten susceptibility to the toxic effects of chemicals such as formaldehyde, solvents, heavy metals, and pesticides. Among healthcare workers and cleaners, chronic occupational exposure to disinfectants and cleaning products is linked to elevated rates of asthma, respiratory disease, and hormonal disturbances. A significant study among healthcare professionals documented an increased incidence of chronic respiratory symptoms and asthma in those with frequent disinfectant exposure, underlining the importance of improved workplace safety protocols and access to less hazardous alternatives (14).

Collectively, the mounting evidence highlights that the health impacts of daily-use chemicals are multifaceted, spanning respiratory, endocrine, reproductive, neurodevelopmental, and oncological domains. The ubiquity and persistence of these chemicals in the environment and in biological systems make complete avoidance impractical; thus, risk mitigation requires a combination of informed consumer choices, stricter regulatory measures, ongoing biomonitoring, and effective public health education to reduce unnecessary exposures and protect vulnerable populations.

REGULATORY FRAMEWORK AND SAFETY STANDARDS

Robust chemical safety legislation is essential for safeguarding human health against the risks posed by chemicals ubiquitous in modern life. In the United States, oversight is primarily divided between the Environmental Protection Agency (EPA), which enforces the Toxic Substances Control Act (TSCA), and the Food and Drug Administration (FDA), which regulates chemicals in food, drugs, and cosmetics. Despite these regulatory mechanisms, the U.S. system has been widely criticized for

being reactive rather than precautionary. Thousands of chemicals in commercial use remain insufficiently tested for chronic or cumulative toxicity, in part due to regulatory loopholes and the shifting of the burden of proof from manufacturers to regulatory bodies (15). By contrast, the European Union has adopted a more rigorous, precautionary model through the Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH) framework. REACH requires manufacturers to demonstrate chemical safety prior to market entry and has resulted in the restriction or banning of several hazardous substances, including certain phthalates and flame retardants. The EU approach encourages data sharing and promotes alternatives to animal testing, emphasizing independent scientific evaluation. However, such proactive policies are not globally harmonized, and significant disparities persist between developed and developing regions, often allowing products banned in Europe to remain available elsewhere (15).

Despite the presence of these regulatory structures, substantial gaps in enforcement and scientific rigor undermine the effectiveness of chemical safety standards worldwide. In the United States, the 2016 update to TSCA through the Frank R. Lautenberg Chemical Safety Act was designed to enhance toxicity testing and regulatory oversight. Nonetheless, resource constraints and political challenges have slowed progress, and regulatory agencies often rely on safety data supplied by industry, which can be incomplete or biased (16). Weak post-market surveillance, particularly for chemicals in cosmetics, cleaning agents, and food packaging, leaves consumers vulnerable to exposures not adequately monitored or controlled. Furthermore, most regulations focus on individual chemicals rather than accounting for real-world exposures to mixtures—an omission that fails to capture the true scope of potential health risks. Analyses have demonstrated that the lack of robust regulatory enforcement, especially regarding endocrine-disrupting chemicals, contributes to preventable diseases and significant economic costs. For instance, one major review estimated that the burden of disease and lost productivity due to EDC exposure costs the U.S. healthcare system hundreds of billions of dollars annually, underscoring the urgent need for mandatory pre-market testing, ongoing biomonitoring, and transparent risk communication (17).

Another critical challenge in global chemical governance is the absence of consistent and harmonized safety standards across countries. While industrialized nations may have advanced chemical legislation, many low- and middle-income countries lack the resources, infrastructure, or regulatory authority to enforce even basic protections. This discrepancy enables multinational corporations to market hazardous products in less regulated markets, perpetuating global health inequities. Furthermore, even in settings with comprehensive regulation, there are gaps regarding the assessment of chemical mixtures, nanomaterials, and emerging pollutants such as microplastics and per- and polyfluoroalkyl substances (PFAS), which persist in the environment and human tissues with potentially serious, yet poorly understood, long-term effects (5). Political and economic interests often impede the timely adoption and enforcement of stronger standards, especially where chemical manufacturing represents a significant economic sector. The precautionary principle, central to REACH, is not consistently applied, and regulatory action frequently lags behind the accumulation of scientific evidence.

Recent policy reviews have emphasized the need for a unified global approach to chemical safety, integrating public health, environmental sustainability, and economic considerations. International conventions such as the Stockholm and Rotterdam Conventions provide some frameworks for the regulation of persistent organic pollutants and hazardous chemicals, but their reach and enforcement remain limited by uneven ratification and inadequate mechanisms for compliance (18).

Some experts have called for the establishment of an independent global agency under the United Nations to coordinate chemical safety assessment, data sharing, and regulatory harmonization, particularly as global chemical production is projected to increase dramatically in the coming decades. Narrowing regulatory gaps between countries is not only essential for reducing the global disease burden from chemical exposures but also critical for achieving environmental justice and sustainable development goals.

Ultimately, the current landscape of chemical regulation demonstrates both progress and persistent shortcomings. While certain countries and regions have advanced toward more protective frameworks, enforcement remains inconsistent, and vast numbers of chemicals enter commerce with insufficient safety evaluation. Addressing these challenges requires greater transparency, independent science, robust biomonitoring, and genuine international cooperation to protect public health from the rising tide of chemical exposures.

ALTERNATIVES AND RECOMMENDATIONS

In response to mounting evidence linking conventional consumer products to adverse health effects, there is a growing interest in natural and eco-friendly alternatives that can mitigate chemical exposure risks. Many personal care products, cleaning agents, and packaged foods still contain

hazardous substances such as parabens, phthalates, triclosan, and formaldehyde, all associated with endocrine disruption, carcinogenicity, and allergic reactions. As awareness spreads, consumer demand for biodegradable, plant-based, and certified organic products—free from synthetic additives—has increased. For instance, simple natural cleaning agents like vinegar, baking soda, and lemon juice offer effective disinfection with minimal toxicity, while organic cosmetics and shampoos formulated without artificial fragrances or preservatives reduce skin absorption of harmful compounds. Notably, intervention studies demonstrate that switching to eco-friendly alternatives can significantly decrease the body burden of chemical exposures. In one example, adolescent girls who replaced conventional personal care products with options free of phthalates, parabens, triclosan, and benzophenone-3 experienced substantial reductions in urinary levels of these chemicals after only a few days, underscoring the feasibility of exposure reduction through short-term behavior change (13). However, broader adoption of safe alternatives faces practical barriers, including higher costs, limited product availability, and a lack of standardized labeling. Effective public education is therefore critical for empowering consumers to make informed choices. Educational campaigns that clearly communicate the risks of chemical exposures, practical strategies for avoidance, and the benefits of safer alternatives can promote healthier habits and reduce disease risk. Community workshops, school-based curricula, and outreach via healthcare providers—such as pediatricians and obstetricians—can increase the reach and credibility of these messages, especially for vulnerable groups like pregnant women and children. Importantly, regulatory oversight is necessary to prevent "greenwashing," where misleading marketing claims exaggerate a product's environmental or health benefits without substantive evidence. Educational interventions tailored to specific cultural and socioeconomic contexts have demonstrated statistically significant improvements in consumer behavior, such as choosing safer food storage practices and reducing use of fragranced products (19). To support equity in chemical safety, subsidies and incentives for non-toxic products can help ensure access across all income levels.

Policy reform remains essential to shifting from a reactive to a precautionary approach in chemical regulation. Current systems often restrict or ban harmful chemicals only after substantial evidence of harm accumulates, resulting in decades of preventable exposure. A more protective framework would require manufacturers to demonstrate product safety prior to market release, prioritize the development and approval of green chemistry alternatives, and invest in national and international biomonitoring programs. Further, research priorities should include longitudinal studies on low-dose, cumulative, and mixture exposures, as well as studies targeting susceptible populations such as children, pregnant women, and the elderly. Global policy reviews have highlighted that the absence of robust regulation for endocrine-disrupting chemicals has led to preventable diseases and billions in healthcare costs worldwide (17). There is a growing call for an international agreement—akin to the World Health Organization's Framework Convention on Tobacco Control—to establish binding global standards, transparent data sharing, and coordinated accountability for chemical safety. Integrating environmental health into medical education, public health curricula, and industrial standards will also be vital for a more sustainable and health-protective future (18).

Ultimately, lasting change requires collaboration among civil society, academia, industry, and governments. Regulatory reform, public education, and industrial innovation must proceed hand in hand to ensure that science-based solutions translate into tangible improvements in public and environmental health.

CONCLUSION

The pervasive use of synthetic chemicals in personal care products, cleaning agents, food packaging, and other household items has introduced a spectrum of health risks that extend from respiratory and endocrine disorders to neurodevelopmental and carcinogenic outcomes. Robust evidence from toxicological and epidemiological studies underscores that chronic, low-dose exposure to chemicals such as phthalates, parabens, bisphenol A, and triclosan can have serious health consequences, particularly among vulnerable groups like children, pregnant women, and those with underlying medical conditions (4, 6, 10). While some regions, notably the European Union, have enacted precautionary frameworks to restrict or ban certain hazardous substances, global implementation remains fragmented and inadequate, with many chemicals reaching consumers with insufficient safety evaluation (15, 18).

There is an urgent need for comprehensive regulatory reform that mandates pre-market safety assessments, encourages data transparency, and ensures ongoing surveillance of chemical exposures in the general population. Strengthening international cooperation and harmonizing standards are vital steps toward closing regulatory gaps and achieving global health equity. Integrating interdisciplinary research from toxicology, epidemiology, and environmental sciences will be crucial to filling knowledge gaps and guiding future policy. In parallel, expanding biomonitoring initiatives and improving labeling requirements can help consumers

make safer choices and reduce unnecessary exposures (2, 16).

Equally important is the role of public education in building the capacity for informed decision-making and promoting the adoption of safer, eco-friendly alternatives. Supporting innovation in green chemistry and fostering open collaboration between industry, civil society, and governments are necessary to drive systemic change. Ultimately, protecting human health from the mounting risks of everyday chemical exposures demands a science-based, coordinated response—one that combines regulatory vigilance, ongoing research, effective public health outreach, and sustained industrial transformation. Only through such integrated and proactive strategies can we ensure the long-term sustainability of both environmental and human health (17, 18).

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