


ToxPoint: Chemical risks and children's health—building on progress based on science, not panic

Samuel M. Cohen ^{1,*}, Ivonne M.C.M. Rietjens², Len Levy³, Alliance of Scientists for Evidence-Based Risk Assessment[†]

¹Department of Pathology, Microbiology, and Immunology, University of Nebraska Medical Center, Omaha, NE 68198-3135, United States

²Wageningen University, The Netherlands

³Cranfield University, United Kingdom

*Corresponding author: Department of Pathology, Microbiology, and Immunology, University of Nebraska Medical Center, Omaha, NE 68198-3135, United States. Email: scohen@unmc.edu.

[†]Full list in [Supplemental Materials](#).

It was recently suggested that an increase in noncommunicable diseases (NCDs) among children over the last half century may be attributed to exposure to synthetic chemicals and plastics and that this indicates the need for precautionary regulatory reforms (Wirth et al. 2025). Although protecting children's health is commendable, this is a complex issue. Wirth et al. (2025) conflate correlation with causation, focus only on hazard identification, overlook substantial progress in regulatory frameworks and scientific understanding, and raise unnecessary alarm (Freeman and Spiegelhalter 2018). We contend that public health, including that of children, can best be protected by evidence-based approaches without the need to forego the necessary benefits that manufactured chemicals bring to modern society. In this article, we identify key gaps in linking NCDs with chemical exposure, with an emphasis on how current regulatory systems support their safety in use.

Progress in chemical risk regulation

It was suggested that current chemical regulations are insufficient to protect children from harm (Wirth et al. 2025). This notion is not supported by decades of progress in regulatory science and risk management (National Research Council (NRC) (US) 1993). For example, regulatory frameworks, including the U.S. Toxic Substances Control Act (TSCA), the Food Quality Protection Act (FQPA), and the European Union's Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) programs, have strengthened chemical safety standards by prioritizing premarket testing, post-market surveillance, and stricter exposure limits. Wirth et al. (2025) suggest that the efforts of regulatory bodies are inadequate, as only a limited number of chemicals have been restricted or banned. However, this analysis has inherent bias; it neglects numerous chemicals that had been discontinued during development because of possible toxicity concerns or identified as requiring risk management restrictions. Major developments over the past several decades have led to ongoing improvements in science-based frameworks such as the International Programme on Chemical Safety (IPCS) mode of action/human relevance framework

(Boobis et al. 2006, 2008), the related adverse outcome pathways approach (Villeneuve et al. 2014), and Risk21 (Embry et al. 2014).

Notable successes in restricting or banning the use of particularly toxic chemicals, leading to marked reductions in systemic levels over subsequent years, also underscore the impact of current regulatory frameworks. Considerable technological and biomedical progress has contributed to a deeper, biologically based approach to risk assessment, including a more informed evaluation of the human relevance of experimental studies. For these reasons, we do not agree that a regulatory “paradigm shift” is warranted.

Association vs. Causation

Although identifying associations between exposures and outcomes in human populations is important, this does not establish causation. Associations can arise from unmeasured confounders, including socioeconomic factors, healthcare disparities, lifestyle changes, reverse causation, or chance (Boffetta et al. 2008). Statistical associations in epidemiology studies do not causally link chemical exposures to NCDs in children. Whereas numerous publications, such as Wirth et al. (2025), suggest that such statistical associations demonstrate a causal link between NCDs in children and chemical exposure, newer data analysis methods were not used. Moreover, this view is not supported by systematic reviews or assessment of the weight of evidence. For example, increases in autism spectrum disorder diagnoses may reflect changes in diagnostic criteria, greater awareness, and genetic factors, rather than exposures to environmental chemicals (Kuodza et al. 2024). Modern causal inference methods in epidemiology—such as Directed Acyclic Graphs, quantitative bias analysis, and Mendelian randomization—can better identify causal pathways and reduce bias more effectively than traditional methods. Formal approaches for evidence integration and grading, to address issues of reproducibility, multiple comparisons, and quality scoring have become the current standard (VanderWeele et al. 2021).

Risk trade-offs and the unintended consequences of regulatory overreach

Superficially, a precautionary approach might seem to have advantages because there can be no effect without exposure. However, sweeping precautionary measures as suggested by others can cause unintended trade-offs. For example, replacing regulated chemicals with poorly studied alternatives has historically resulted in unforeseen risks. The replacement of bisphenol A (BPA) with bisphenol S, based on poor quality, non-reproducible studies served as a cautionary tale. In contrast to the numerous publications purporting to show adverse effects with BPA, no adverse effects were identified for BPA when the studies were performed under Good Laboratory Practices (GLP) (CLARITY-BPA Core Study Research Report, CLARITY-BPA Grantee Studies data, and CLARITY-BPA Compendium Report),

Such overregulation can also stifle innovation and divert resources from addressing more pressing and real public health threats. Synthetic chemicals play a critical role in improving public health and quality of life. For example, advances in healthcare products (vaccines, pacemakers, etc.), construction materials, textiles, and packaging depend on innovation. A socially acceptable regulatory approach must weigh these societal benefits against true potential risks and distinguish this risk potential from unsubstantiated perceived or implied concerns.

Contributions of the chemical industry and modern safety science

It is important to note that before modern regulations were implemented, chemical manufacturers advanced the fields of toxicology and pharmacology with investments in safety testing. Programs such as the CDC-funded NHANES as well as other programs, often co-funded by industry and government, monitor exposures and help identify potential hazards.

Modern initiatives exemplify how collaboration among academia, government, and industry drives innovation in chemical safety. Integrating mode of action-directed, well-performed animal and in vitro studies, high throughput screening, computational modeling, and adverse outcome pathways enable efficient, science-based hazard identification (Begley and Ellis 2012). However, hazard identification is not sufficient (Doe et al. 2022). Dose and time/duration of exposure are critical. For example, 100% oxygen produces blindness in newborn premature infants (Chen et al. 2021), but oxygen at lower concentrations remains essential. Vitamin A is a known teratogen (Rothman et al. 1995) but is an essential vitamin. Science-based risk assessment is required, incorporating dose-response, quantitative exposure assessment, and human relevance.

A balanced path forward

To continue to ensure adequate protection of all potentially exposed groups, we recommend the following:

1. *Prioritize high-risk chemicals:* For existing chemicals, focus regulatory efforts on chemicals and exposure scenarios that pose the highest risks, using weight of evidence for causations to guide interventions.
2. *Apply modern tools:* In addition to critical evaluation of well-performed animal and epidemiology studies, new approach methodologies (NAMs), while not a panacea for toxicity assessment, provide opportunities for improved mode of action-based assessment of the human relevance of

observations from toxicity studies (Vinggaard et al. 2023, Schmeisser et al. 2023). Expand NAMs, including computational approaches, to enhance the precision, efficiency, scalability, and human relevance of chemical safety assessments. Apply advanced techniques in epidemiology to enhance its contribution to causal inference.

3. *Continue to promote transparency:* Continue to encourage open-access chemical databases and standardized reporting to foster collaboration and public trust.
4. *Mitigate impact on society:* Base regulatory decisions on causal evidence, while avoiding sweeping precautionary measures lacking clear justification, mitigating the stress and psychological impact of unnecessary alarm and stifling of innovation.
5. *Strengthen collaborations:* Foster partnerships among regulatory agencies, academic institutions, and industry to advance safer chemical design while maintaining rigorous safety standards.

Conclusion

Protection of children's health is a societal priority best pursued through proportionate, evidence-based policies. Sweeping precautionary measures may raise undue alarm and do not account for progress in science-based approaches that have transformed chemical risk management. By building on existing frameworks and integrating modern scientific tools, we can continue to minimize risks while preserving the benefits of chemical innovation. We believe that a balanced approach, grounded on sound science, is the best path forward for protecting public health, including that of children, and fostering sustainable progress.

Supplementary material

[Supplementary material](#) is available at *Toxicological Sciences* online.

Funding

No funding was provided for the preparation of this manuscript.

Conflicts of interest. The viewpoints expressed in this article are those of the authors and do not reflect the journal or any institution or organization. Several of the authors have served on government committees and panels, have consulted for government, academia, and industry, and have served as experts in litigation testimony.

References

- Begley CG, Ellis LM. 2012. Drug development: raise standards for pre-clinical cancer research. *Nature*. 483:531–533.
- Boffetta P, McLaughlin JK, La Vecchia C, Tarone RE, Lipworth L, Blot WJ. 2008. False-positive results in cancer epidemiology: a plea for epistemological modesty. *J Natl Cancer Inst*. 100:988–995.
- Boobis AR, Cohen SM, Dellarco V, McGregor D, Meek ME, Vickers C, Willcocks D, Farland W. 2006. IPCS framework for analyzing the relevance of a cancer mode of action for humans. *Crit Rev Toxicol*. 36:781–792.
- Boobis AR, Doe JE, Heinrich-Hirsch B, Meek ME, Munn S, Ruchirawat M, Schlatter J, Seed J, Vickers C. 2008. IPCS framework for analyzing the relevance of a noncancer mode of action for humans. *Crit Rev Toxicol*. 38:87–96.
- Chen JS, Anderson JE, Coyner AS, Ostrno S, Sonmez K, Erdogmus D, Jordan BK, McEvoy CT, Dukhovny D, Schelonka RL, et al. 2021. Quantification of early neonatal oxygen exposure as a risk factor

- for retinopathy of prematurity requiring treatment. *Ophthalmol.* 1:100070.
- Doe JE, Boobis AR, Cohen SM, Dellarco VL, Fenner-Crisp PA, Moretto A, Pastoor TP, Schoeny RS, Seed JG, Wolf DC. 2022. A new approach to the classification of carcinogenicity. *Arch Toxicol.* 96:2419–2428.
- Embry MR, Bachman AN, Bell DR, Boobis AR, Cohen SM, Dellarco M, Dewhurst IC, Doerr NG, Hines RN, Moretto A, et al. 2014. Risk assessment in the 21st century: roadmap and matrix. *Crit Rev Toxicol.* 44 Suppl 3:6–16.
- Freeman ALJ, Spiegelhalter DJ. 2018. Communicating health risks in science publications: time for everyone to take responsibility. *BMC Med.* 16:207.
- Kuodza GE, Kawai R, LaSalle JM. 2024. Intercontinental insights into autism spectrum disorder: a synthesis of environmental influences and DNA methylation. *Environ Epigenet.* 10:dvae023.
- National Research Council (NRC) (US). 1993. Committee on pesticides in the diets of infants and children. Washington (DC): National Academies Press (US).
- Rothman KJ, Moore LL, Singer MR, Nguyen US, Mannino S, Milunsky A. 1995. Teratogenicity of high vitamin a intake. *N Engl J Med.* 333:1369–1373.
- Schmeisser S, Miccoli A, Von Bergen M, Berggren E, Braeuning A, Busch W, Desaintes C, Gourmelon A, Grafström R, et al. 2023. New approach methodologies in human regulatory toxicology—Not if, but how and when! *Environ Int.* 178:108082.
- VanderWeele TJ, Lash TL, Haneuse S, Rothman KJ. 2021. Causal inference and scientific reasoning. In: Lash, et al. editors. *Modern epidemiology*. 4th ed. Philadelphia (PA): Wolters Kluwer.
- Villeneuve DL, Crump D, Garcia-Reyero N, Hecker M, Hutchinson TH, LaLone CA, Landesmann B, Lettieri T, Munn S, Nepelska M, et al. 2014. Adverse outcome pathway (AOP) development I: strategies and principles. *Toxicol Sci.* 142:312–320.
- Wirth DA, Cropper M, Axelrad DA, Bald C, Bhatnagar A, Birnbaum LS, Burke TA, Chiles TC, Geiser K, et al. 2025. (The consortium for children's environmental health), manufactured chemicals and children's health—the need for new law. *N Engl J Med.* 392:299–305.