ST.GALLEN SYMPOSIUM

Global Essay Competition 2026

Title: Knowability by Design - Chemical Transparency for Ageing Societies

Essay:

Abstract

Modern industrial chemistry has made lives longer and safer, but it has also normalised chronic, low-level exposure to endocrine-active substances from everyday products. At the same time, many countries face below-replacement fertility and population ageing. When these trends meet, the result is not only a health issue but a dispersed governance problem. The facts that matter - what products contain, how exposures accumulate and when action should occur - do not move through institutions at the speed of the toxic treadmill of production. This essay treats endocrine-disrupting chemicals (EDCs) and population ageing as one problem at the junction of technology, politics and demography. It argues for a paradigm shift from rule-making that waits for perfect proof to policy that designs knowability - recording composition upstream, turning population-level signals into public intelligence and aligning authorisations with biological and demographic stakes. Digital tools such as Digital Product Passports and population-level sensing (e.g., wastewater-based epidemiology) make this shift feasible. A compact intervention - the Fertility & Chemical Transparency Accord (FaCTA) - shows how to practically operationalise the approach. I use vignettes to translate the design to relatable, everyday decisions and civic stakeholders; while a final section addresses risks and trade-offs and explains why actively learning institutions are the right long-term strategy under uncertainty (Bergman et al., 2012; OECD, 2024a; OECD, 2024b).

Introduction

Modern chemistry has extended and improved life, yet it has also embedded endocrine-active substances in everyday goods. In ageing, low-fertility societies, this yields a specific disruption: an information - accountability shock, where the key facts about product composition and cumulative exposure do not travel fast enough or far enough to guide timely action. The central claim here is that the most effective long-run response is not simply “more regulation,” but the deliberate design of knowability - institutions that record composition upstream, translate population signals into public intelligence, and align regulatory time with biological and demographic stakes (Bergman et al., 2012; OECD, 2024a; OECD, 2024b).

Across the OECD, the total fertility rate has more than halved since 1960 - from roughly 3.3 children per woman to around 1.5 in 2022 - with several Southern European countries near 1.2 and South Korea around 0.7. Without adaptation, ageing is expected to dampen income growth and place burdens on future generations (OECD, 2024a; OECD, 2024b). These figures do not prescribe private choices, but they define a horizon in which small, diffuse physiological frictions can scale into macro-effects over decades.

EDCs are a plausible source of such friction. Endocrine-disrupting chemicals are exogenous substances that mimic, block, or otherwise modulate hormones central to development, metabolism, and reproduction; critically, some effects occur at low doses and during sensitive windows (pre-conception, gestation, infancy) (Bergman et al., 2012). Evidence links exposure to common EDCs with endpoints that matter for reproductive capacity (e.g. impaired semen quality, reduced ovarian reserve, altered outcomes in assisted reproduction) while magnitudes and mechanisms remain contested (Tzouma et al., 2025).

The demographic link is structural, not determinist. First, when childbearing is postponed (a widespread pattern), more conceptions occur in biologically narrower windows, raising the payoff to avoiding subtle physiological drags. Second, in ageing societies, small average shifts in fecundity or time-to-pregnancy compound across cohorts, influencing intended family size over time. Third, exposure is socially patterned (housing, products, work), risking unequal reproductive burdens that intersect with broader demographic challenges. For these reasons, this essay treats EDC exposure

and demographic ageing as interconnected - not as proof that chemistry “causes” low fertility, but as a governance problem where cumulative, uncertain and unequally distributed risks meet long demographic timeframes (Bergman et al., 2012; OECD, 2024a).

In consumer environments, four families recur: phthalates and bisphenols (packaging, food-contact plastics), PFAS (persistent water-/stain-repellent chemistries in textiles, cookware and beyond) and flame retardants (brominated and organophosphate compounds in furnishings/electronics). The main routes are ingestion (migration into food; hand-to-mouth transfer), inhalation (indoor air and resuspended dust) and dermal absorption (personal-care products and treated textiles). Indoor house dust acts as a reservoir integrating emissions over time; PFAS add dietary pathways and persistence challenges (Mitro et al., 2016, 2024; ECHA, n.d.; Dewapriya et al., 2023; Yang et al., 2025). Because ordinary routines create aggregate exposure, decisive levers sit upstream of individual consumer or household choice.

These features - diffuse sources, cumulative pathways and excessive lag-times between design decisions and health endpoints - make linear hazard-by-hazard control ill-suited to the task. Planning scholars (e.g. Rittel & Webber, 1973) have described such conditions as “wicked problems”, where problems resist definitive formulation, lack stopping rules and yield better-or-worse rather than true-or-false answers; interventions shift the very systems they target. Toxicology premised on “one substance-one dose-one effect” also strains under mixtures and non-monotonic dose-responses at low levels (Vandenberg et al., 2012). The resulting difficulty is a political economy of knowledge that rewards opacity and builds regulatory latency into outcomes. While the complexity of this harm might seem particularly binding, the good news is that (through holistic policy intervention, facilitated by cutting-edge information technology) we can redesign what is knowable, when and by whom. Instead of waiting for perfect, single-chemical proof downstream, I posit that we can move verification upstream (record what products contain), widen our view (read population-level signals early) and align decisions to biological time (review approvals on a predictable clock). Two existing rails make this shift feasible today: digital product passports and population-scale sensing.

Designing knowability: the information architecture

If the binding constraint is knowability - who can see which facts, when and with what authority - then changing outcomes requires changing the information architecture. Two developments make this practical.

1. Digital Product Passports (DPPs): Under the EU’s Ecodesign for Sustainable Products Regulation, DPPs provide a persistent, machine-readable identity carrying composition and lifecycle data through supply chains, with relevant fields accessible to authorities and other actors - finally letting verified composition travel with the product (European Commission, 2024; data.europa.eu, 2024).

2. Population-level sensing: A One Health approach is being institutionalised and wastewater-based epidemiology (WBE) has matured as a city-scale tool tracking chemicals and biomarkers; these complement clinical biomonitoring by offering earlier, population-level visibility on trends and hotspots (ECDC et al., 2024; EFSA, 2024; Carneiro et al., 2025; Kasprzyk-Hordern et al., 2023).

Together, these rails support the paradigm shift in chemical governance I aim to enact: record composition once in a form others can read; translate municipal signals into public knowledge; and shorten the interval between early evidence and upstream change. I argue that FaCTA stitches these rails into a single, predictable operating model.

The Bold Idea: The Fertility & Chemical Transparency Accord (FaCTA)

FaCTA uses those rails to maximise benefits and contain risks over the long term. It comprises four mutually reinforcing moves, each aimed at a specific source of delay or uncertainty.

1. Provenance as a public good: For high-exposure categories - infant goods, food-contact materials, furnishings, cleaners, cosmetics - producers would record a cryptographically signed, machine-readable bill of substances (including concentration ranges and supplier attestations) in the DPP. By turning composition into an inspectable claim, provenance reduces the most basic epistemic uncertainty (what a product actually contains) while discouraging regrettable substitutions and enabling independent comparison and testing (European Commission, 2024; data.europa.eu, 2024).

2. Civic sense-making: A public-facing civic toxicity twin would convert DPP data and municipal sensors (air, WBE) into neighbourhood dashboards and household-readable summaries, with model cards and error bounds. Consolidating fragmented measures into shared, auditable signals addresses situational uncertainty about where and when exposures concentrate, supports targeted inspections and procurement switches and creates early alerts before clinical problems surface (ECDC et al., 2024; Carneiro et al., 2025).

3. Time aligned with stakes: For designated endocrine-active classes where evidence is suggestive but incomplete, time-limited authorisations ("use-by-data") would be renewed only on the strength of independent, pre-registered studies that meet agreed standards. Predictable review cycles counter regulatory drift, bring evidence clocks forward and encourage earlier, safer substitution without freezing innovation (Tzouma et al., 2025).

4. Equity integral to design: Provenance and dashboards would be paired with public procurement switches (schools, early-years settings, public housing) and targeted assistance where exposures are highest. Shifting decisions upstream while underwriting safer defaults prevents transparency from leaving households to cope alone with exposure. This way, we ensure that benefits of this policy are not gated by income or time (ECDC et al., 2024).

Vignettes

Consider four points of contact. A parent scans an infant-mattress QR code and sees a plain-language summary, a structured bill of substances and the product's renewal date - choosing the line with verified low chemical risk and a longer authorisation. A headteacher receives a termly notice that her school's furniture carries higher flame-retardant loads than peers; the dashboard links to compliant, lower-exposure alternatives and a framework contract for phased replacement. A city officer spots a three-month rise in a phthalate class on the wastewater map; by overlaying DPP-based product profiles, the city targets inspections and procurement nudges and the signal stabilises. A manufacturer, facing a public renewal deadline, pre-registers an independent study and brings forward reformulation to a verified substitute, winning share as public buyers prioritise low-exposure lines. In each case, FaCTA shortens the path from signal to upstream change, embedding vigilance as systemic rather than an unfair private burden.

Evaluation

FaCTA improves knowability at three levels: upstream composition becomes inspectable; city-scale signals become intelligible; and permissions track evidence over time. Good actors can demonstrate safer chemistry; laggards face fewer places to hide. In the long-term, these shifts should reduce avoidable physiological headwinds in reproductive health - one contributory factor among many in ageing societies.

However, it is important to seriously consider the risks and trade-offs of such a reform. For instance, causality (when thinking about the crisis in macro-fertility) is complex: reflecting a plethora of factors including housing, childcare, labour markets and norms. FaCTA does not claim to "fix" chemical-driven "fertility" risks, however, it would reduce a plausible physiological drag (OECD, 2024a; OECD, 2024b), while simultaneously enacting cultural change on health literacy. Another trade-off is the significant administrative cost burden of such a reform (particularly on regulators). The remedy is to ride existing rails as stated earlier in this essay (DPP; One Health; WBE) and focus on high-exposure chemical exposure routes (e.g. household cleaning products) to keep scope proportionate. Another critical consideration is privacy - as the civic twin would primarily use public product data and municipal

sensors. As such, any individual inputs should be opt-in, privacy-preserving and limited to neighbourhood-level outputs with published error bounds.

Having considered these risks (suggesting relevant mitigation measures to ensure this intervention's efficacy), this essay argues that under deep uncertainty, institutions that are set up to learn - measure early, publish openly and revise on schedule - outperform the science-to-policy-interface status quo of acting only once proof is perfect. The decisive question is whether institutions can learn quickly and course-correct. FaCTA should serve less as a 'silver bullet' or a 'simple-fix'; rather, it aims to establish an adaptable learning architecture to tackle layered socio-technical issues under uncertain conditions. Within it, time-limited authorisations create evidence cycles; transparent composition enables independent testing; population-level sensing closes the gap between ambient signals and targeted action; and equity levers keep benefits from being gated by income or time.

Conclusion

This essay began from a concrete disruption: in ageing, low-fertility societies, endocrine-active substances embedded in everyday goods create an information-accountability gap in which the facts that matter do not travel at the speed of production. I linked the demographic baseline of sub-replacement fertility and ageing with exposure science that finds low-dose, time-sensitive endocrine effects (Bergman et al., 2012; OECD, 2024a; OECD, 2024b; Tzouma et al., 2025). I showed how diffuse sources, cumulative pathways and long lags generate the conditions that planning scholars have called wicked problems, while mixture effects and non-monotonic responses complicate single-agent proof (Rittel & Webber, 1973; Vandenberg et al., 2012). On that foundation, I argued for a paradigm shift from "prove then act" to designing knowability and identified two enabling rails (Digital Product Passports and population-level sensing) that make the shift feasible today. The proposed FaCTA translated the stance into practice: provenance to expose composition and deter regrettable substitution; civic sense-making to turn measurement into shared intelligence; time-aligned authorisations to keep permissions in step with evolving evidence; and equity levers to prevent vigilance from becoming an individualised burden.

Widening the lens, the argument is not about chemical governance alone. It offers a governance template for complex socio-technical risks where accountability trails production: AI provenance (verifiable training data and content integrity), antimicrobial resistance (action on early signals before clinical failure cascades) and data-driven welfare (auditable models with public reasons) are obvious candidates. Across these domains, the organising commitments hold: make facts inspectable, turn signals into shared intelligence, align time with stakes and hard-wire fairness. This is how to preserve the innovative upside of modern technology while constraining the downside in systems that change faster than our institutions typically learn.

The long-term bet, then, is not on certainty but on designed capability. The capability to see earlier, test publicly and revise safely. In a world where technological innovation can outspeed institutions and demography, knowability by design is the quiet radicalism that keeps benefits high and risks bounded. It replaces the false comfort of silver bullets with institutions that improve by being used; precisely the kind of statecraft ageing societies need.

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ChatGPT	Generation of structure for abstract Formatting of Reference List into standardised Harvard-style Used to come up with relevant vignettes to describe how the policies would materialise (but not used to write the section) Brainstorming Titles – to be clear, my chosen title is AI-generated	Abstract Reference List Vignettes Title
Perplexity AI via Comet Browser	Used for research – to find specific policies on chemical governance in OECD	Not in text, in research stage

Word Count (essay text only): (1973/2100)