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# Prioritizing chemical additives in plastic toys to support a circular economy

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## Abstract:

**Introduction:** Numerous chemicals are used as additives in plastics, including toys, fulfilling certain functions, such as plasticizers, flame-retardants, or colorants. However, several additives may pose risks to children via various exposure pathways. Moreover, in recycled plastics supporting a circular economy, several additive residuals can end up in recyclates, leading to additional exposures [1]. The combination of harmful additives and residues constitute a challenge to be urgently addressed for implementing a circular economy for plastics [2]. Key is the identification of priority chemicals targeted for reduced use in virgin and recycled plastic toys.

**Methods:** We identify chemicals reported to occur in virgin and recycled plastic toys. For these chemicals, we combine concentrations in plastics with toy consumption data. We then estimate related cancer and non-cancer risks for children by adapting a high-throughput exposure framework combined with toxicity information [3, 4]. From ranking the risks, we produce prioritization lists of chemicals in toys, determine the contribution of possible residues from previous uses, and compare our results with other lists.

**Results:** Children's risks from exposure to chemicals in plastic toys are dominated by additives (mainly phthalate plasticizers and some brominated flame-retardants), with cancer and non-cancer risks exceeding acceptable levels for multiple chemicals. Risks from residues in recycled toys are substantially lower and often negligible. While some of our priority chemicals appear in other lists, we also identified additional priority chemicals that are not yet covered elsewhere and require further attention. For ensuring full coverage and reduce uncertainty, it is key to obtain high-quality and comprehensive data on chemical content in plastics and recyclates, and to ensure the applicability to other chemical classes, e.g. metals.

**Conclusions:** We recommend deriving maximum allowable concentrations for hazardous chemicals in toys, to ensure that both remaining cancer and non-cancer risks are below acceptable risk levels for children. This will enable producers to test whether a certain grade of recycled plastic is usable for toys manufacturing. Chemical ingredients, such as some plasticizers, whose effective content at which they fulfil their function is above these maximum allowable concentrations, should be avoided or possibly banned when also reported in other priority lists, or further scrutinized otherwise. Our approach can help identify priority chemicals also in other products (e.g. food contact and building materials) and should be applied to screen chemicals already in material design [5], to boost a viable circular economy for plastic toys.

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