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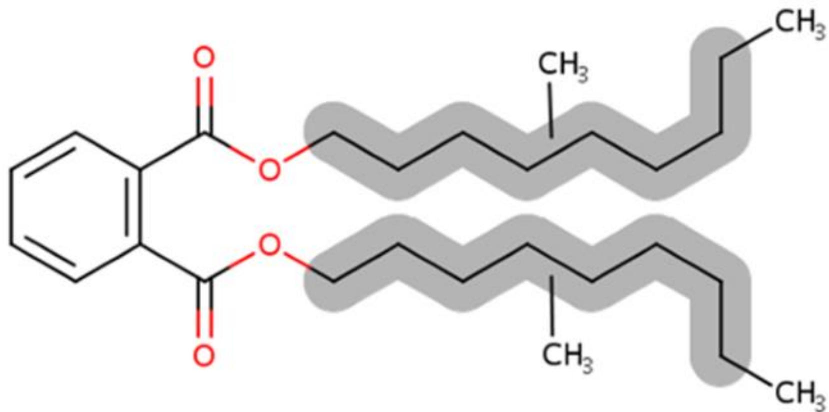
Pollution Prevention

Draft Consumer and Indoor Dust Exposure Assessment for Diisodecyl Phthalate (DIDP)

Technical Support Document for the Draft Risk Evaluation

CASRNs: 26761-40-0 and 68515-49-1



(Representative Structure)

May 2024

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ABBREVIATIONS AND ACRONYMS

ACC	American Chemical Council
ADR	Average dose rate
ATBC	Acetyl-tri-n-butylcitrate
BBP	Benzyl butyl phthalate
CADD	Chronic Average Daily Dose
CDC	Center for Disease Control and Prevention
CDR	Chemical Data Reporting
CEM	Consumer Exposure Model
CHAP	Chronic Hazard Advisory Panel
CPSC	Consumer Product Safety Commission
CPSIA	Consumer Product Safety Improvement Act
COU	Condition of use
DBP	Dibutyl phthalate
DCHP	Dicyclohexyl phthalate
DEHP	Di-(2-ethylhexyl) phthalate
DHEXP	Di-n-hexyl phthalate
DIBP	Diisobutyl phthalate
DIDP	Diisodecyl phthalate
DINP	Diisononyl phthalate
DIY	Do-it-yourself
DPENP	Di-n-pentyl phthalate
MCCEM	Multi-Chamber Concentration and Exposure Model
OCSPP	Office of Chemical Safety and Pollution Prevention
OPPT	Office of Pollution Prevention and Toxics
PCD	Participant-Collected Dust
PVC	Polyvinyl chloride
SDS	Safety data sheet
SVOC	Semi volatile organic compound
TSCA	Toxic Substances Control Act
VSD	Vacuum sampler dust

SUMMARY

This technical document is in support of the TSCA *Draft Risk Evaluation for Diisodecyl Phthalate (DIDP)* (U.S. EPA, 2024b). DIDP is a common chemical name for the category of chemical substances that includes the following substances: 1,2-benzenedicarboxylic acid, 1,2-diisodecyl ester (CASRN 26761-40-0) and 1,2-benzenedicarboxylic acid, di-C9-11-branched alkyl esters, C10-rich (CASRN 68515-49-1). Both CASRNs contain mainly C10 dialkyl phthalate esters. See the draft risk evaluation for a complete list of all the technical support documents for DIDP.

This document provides detailed descriptions of DIDP consumer and indoor exposure assessment. This assessment considers human exposure to DIDP in consumer products resulting from Toxic Substances Control Act (TSCA) conditions of use (COUs). The major routes of exposure considered were ingestion via mouthing, ingestion of suspended dust, ingestion of settled dust, inhalation, and dermal exposure. Chemical weight fractions were gathered from safety data sheets (SDSs), and other sources specified in Section 2.1.1.1, and used to tailor COU-specific consumer exposure scenarios for products and articles identified in the consumer market.

For inhalation and ingestion exposures, EPA used the Consumer Exposure Model (CEM) to estimate acute and chronic exposures to consumer users and bystanders. Intermediate exposures were calculated from the CEM daily exposure outputs for applicable scenarios outside of CEM because the exposure duration for intermediate scenarios is outside the 60-day modeling period CEM uses. Acute exposures are for an exposure duration of one day, chronic exposures are for an exposure duration of one year, and intermediate are for an exposure duration of 30 days (roughly a month). Confidence in the estimates were robust and moderate depending on product or article scenario. For each scenario high, medium, and low exposure scenarios were developed in which values for duration of use, frequency of use, and surface area were determined based on reasonably available information and professional judgment. Dermal exposures for both liquid products and solid articles were calculated in a spreadsheet outside of CEM, see *Draft Consumer Exposure Analysis for Diisodecyl Phthalate (DIDP)* (U.S. EPA, 2024c). CEM dermal modeling uses a dermal model approach that assumes infinite DIDP migration from product to skin without considering saturation which would result in greatly overestimations of dose and subsequent risk, see Section 2.2 for a detailed explanation. Low, medium, and high exposure scenarios were developed for each product and article scenario by varying values for duration of dermal contact and area of exposed skin. Confidence in the dermal exposure estimates were robust to moderate depending on uncertainties associated with input parameters.

1 BACKGROUND

DIDP is assigned two CASRNs that contain C10 dialkyl phthalate esters: 1,2-benzenedicarboxylic acid, 1,2-diisodecyl ester (CASRN 26761-40-0) and 1,2-benzenedicarboxylic acid, di-C9-11-branched alkyl esters, C10-rich (CASRN 68515-49-1). DIDP is primarily used as a plasticizer in polyvinyl chloride (PVC) in consumer, commercial, and industrial applications. The migration of DIDP from consumer products and articles has been identified as a potential source of exposure. However, the relative contribution of various consumer goods to overall exposure to DIDP has not been well characterized. Information contained in the submission requesting the risk evaluation for DIDP along with Chemical Data Reporting (CDR) reporting and other sources used in this assessment indicate DIDP may be present in several consumer products and articles, Table 1-1. These uses can result in exposures to consumers and bystanders (non-product users that are incidentally exposed to the product). For all the DIDP containing consumer products identified, the approach involves addressing the inherent uncertainties by modeling high, medium, and low exposure scenarios. Due to the lack of comprehensive data on various parameters and the expected variability in exposure pathways, these scenarios allow for a robust exploration of the estimated risks associated with DIDP across conditions of use (COUs) to various age groups.

Because PVC products are ubiquitous in modern indoor environments, DIDP is found in residential dust. Exposure to compounds through dust ingestion, dust inhalation, and dermal absorption is a particular concern for young children between the ages of 6 months and 2 years, as they crawl on the ground and pull up on ledges which increases hand-to-dust contact, and they often place their hands and objects in their mouths. Age groups above 2 years are assessed and compared with infants and toddler results.

269 **Table 1-1. Consumer Conditions of Use Table**

Life Cycle Stage[a]	Category[b]	Subcategory[c]	References (CASRN 26761-40-0)	References (CASRN 68515-49-1)
Consumer uses	Automotive, fuel, agriculture, outdoor use products	Automotive products, other than fluids[d]	EPA-HQ-OPPT-2018-0435-0005; EPA-HQ-OPPT-2018-0435-0022	EPA-HQ-OPPT-2018-0435-0005; EPA-HQ-OPPT-2018-0435-0022
		Lubricants[d]	EPA-HQ-OPPT-2018-0435-0005; U.S. EPA (2020); ACC Letter (2023)	EPA-HQ-OPPT-2018-0435-0005; U.S. EPA (2020); ACC Letter (2023)
	Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)[d]	EPA-HQ-OPPT-2018-0435-0005; U.S. EPA (2020)	EPA-HQ-OPPT-2018-0435-0005; U.S. EPA (2020); U.S. EPA 2020 CDR
		Building/construction materials covering large surface areas including stone, plaster, cement, glass and ceramic articles (wire or wiring systems; joint treatment)[d]	EPA-HQ-OPPT-2018-0435-0005	EPA-HQ-OPPT-2018-0435-0005
		Electrical and electronic products[d, f]	EPA-HQ-OPPT-2018-0435-0005	EPA-HQ-OPPT-2018-0435-0005; U.S. EPA (2020)
		Paints and coatings[d]	U.S. EPA (2020)	U.S. EPA (2020)
	Furnishing, cleaning, treatment/care products	Fabrics, textiles, and apparel (as plasticizer)	ACC Letter (2023)	U.S. EPA 2020 CDR; ACC Letter (2023)
	Packaging, paper, plastic, hobby products	Arts, crafts, and hobby materials (crafting paint applied to craft)		U.S. EPA (2020); U.S. EPA 2020 CDR
		Ink, toner, and colorant products[d]	EPA-HQ-OPPT-2018-0435-0005; EPA-HQ-OPPT-2018-0435-0022; ACC Letter (2023)	EPA-HQ-OPPT-2018-0435-0005; EPA-HQ-OPPT-2018-0435-0022; ACC Letter (2023)
		PVC film and sheet	EPA-HQ-OPPT-2018-0435-0022	EPA-HQ-OPPT-2018-0435-0022
		Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses)[d]	EPA-HQ-OPPT-2018-0435-0005; EPA-HQ-OPPT-2018-0435-0022; ACC Letter (2023)	EPA-HQ-OPPT-2018-0435-0005; U.S. EPA (2020); ACC Letter (2023)
		Toys, playgrounds, and sporting equipment[d]	EPA-HQ-OPPT-2018-0435-0005; ACC Letter (2023)	EPA-HQ-OPPT-2018-0435-0005; U.S. EPA (2020); ACC Letter (2023)

Life Cycle Stage[a]	Category[b]	Subcategory[c]	References (CASRN 26761-40-0)	References (CASRN 68515-49-1)
	Other	Novelty Products	UC Berkeley (2013); NIH (2023)	UC Berkeley (2013); NIH (2023)
Disposal	Disposal	Disposal[e]		

[a] Life Cycle Stage Use Definitions (40 CFR 711.3)

- "Industrial use" means use at a site at which one or more chemicals or mixtures are manufactured (including imported) or processed.
- "Commercial use" means the use of a chemical or a mixture containing a chemical (including as part of an article) in a commercial enterprise providing saleable goods or services.
- "Consumer use" means the use of a chemical or a mixture containing a chemical (including as part of an article, such as furniture or clothing) when sold to or made available to consumers for their use.
- Although EPA has identified both industrial and commercial uses here for purposes of distinguishing scenarios in this document, the Agency interprets the authority over "any manner or method of commercial use" under TSCA section 6(a)(5) to reach both.

[b] These categories of conditions of use appear in the Life Cycle Diagram, reflect CDR codes, and broadly represent conditions of use of DIDP in industrial and/or commercial settings.

[c] These subcategories reflect more specific conditions of use of DIDP.

[d] Circumstances on which ACC HPP is requesting that EPA conduct a risk evaluation. DIDP was limited in toys to less than 0.1% until 2017 by the CPSC. EPA will evaluate risk from toys in commerce and legacy toys. In addition, DIDP processing into sporting equipment is ongoing.

[e] Identified in EPA's Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States (EPA-600-R-16-236Fb), December 2016 document to be a chemical reported to be detected in produced water.

[f] New CDR reporting codes of machinery, mechanical appliances, electrical/electronic articles and other machinery, mechanical appliances, electronic/electronic articles are represented under the electrical and electronic articles reporting code, so for commercial and consumer uses these conditions of use are combined.

2 CONSUMER EXPOSURE APPROACH AND METHODOLOGY

Consumer products or articles containing DIDP were matched with the identified consumer COUs. Table 2-1 summarizes the consumer exposure scenarios by COU for each product example(s), the exposure routes, which scenarios are also used in the indoor dust assessment, and whether the analysis was done qualitatively or quantitatively. The indoor dust assessment uses consumer products information for selected articles with the goal of recreating the indoor environment. The subset of consumer articles used in the indoor dust assessment were selected for their potential to have large surface area for dust collection.

When a quantitative analysis was conducted, exposure from the consumer COUs was estimated by modeling. Exposure via inhalation and ingestion routes were modeled using EPA's CEM Version 3.2 (U.S. EPA, 2023). Dermal exposure to DIDP-containing consumer products was carried out using a computational framework implemented within a spreadsheet environment. Refer to Dermal Modeling Approach in Section 2.2 for a detail description of dermal approaches, rationale for doing outside CEM, and consumer specific dermal parameters and assumptions for exposure estimates. For each exposure route, EPA used the 10th percentile, average, and 95th percentile value of an input parameter (*e.g.*, weight fraction, surface area and others) where possible to characterize low-end, central tendency, and high-end exposure for a given condition of use. Should only a range be reported as the minimum, average, and maximum, EPA used these as the low-end, central tendency, and high-end respectively. All CEM and dermal spreadsheet calculations inputs, sources of information, assumptions, and exposure scenario descriptions are available in the *Draft Consumer Exposure Analysis for Diisodecyl Phthalate (DIDP)* (U.S. EPA, 2024c).

Based on reasonably available information from the systematic review process on consumer conditions of use and indoor dust DIDP concentrations, inhalation of DIDP is possible through inhalation of DIDP emitted from products and articles and DIDP sorbed to indoor dust and particulate matter. A detailed discussion of indoor dust references, sources, and concentrations is available in Sections 3, 4.2, 4.3, and 4.4. DIDP's low volatility is expected to result in negligible gas-phase inhalation exposures. However, sorption to suspended and settled dust is likely based on monitoring indoor data, hence inhalation and ingestion of suspended and settled dust is considered in this assessment. Oral exposure to DIDP is possible through incidental ingestion during use, transfer of chemical from hand-to-mouth, or mouthing of articles. Dermal exposure may occur via direct contact with liquid products and solid articles during use. Based on these potential sources and pathways of exposures that may result from the conditions of use identified for DIDP, oral, dermal, and inhalation exposures to consumers and inhalation exposures to bystanders were assessed.

EPA assessed acute, chronic, and intermediate exposures to DIDP from consumer COUs. For the acute dose rate calculations, an averaging time of 1 day is used representing the maximum timE−integrated dose over a 24-hour period during the exposure event. The chronic dose rate is calculated iteratively at a 30-second interval during the first 24 hours and every hour after that for 60 days. Professional judgment and product use descriptions were used to estimate events per day and per month for the calculation of the intermediate dose.

Table 2-1. Summary of Consumer COUs, Exposure Scenarios, and Exposure Routes

Consumer Use Category	Consumer Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes					
				Inhalation	Dermal	Ingestion			Qualitative / Quantitative / None
						Dust (Air)	Dust (Surface)	Mouthing	
Automotive, fuel, agriculture, outdoor use products	Automotive products, other than fluids	Products are like synthetic leather fabrics in furniture	See synthetic leather furniture scenarios. Use patterns for dermal exposure to automotive synthetic leather fabric has same considerations than for furniture	✗	✓	✗	✗	✗	Quantitative
Automotive, fuel, agriculture, outdoor use products	Lubricants	Auto transmission conditioner	Direct contact during use; inhalation of emissions resulting from small spill of product	✓	✓	✗	✗	✗	Quantitative
Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Construction Adhesive for Small Scale Projects	Use of product in DIY[c] small-scale home repair and hobby activities. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗	Quantitative
Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Construction Sealant for Large Scale Projects	Use of product in DIY[c] small-scale home repair and hobby activities. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗	Quantitative
Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Epoxy Floor Patch	Use of product in DIY[c] home repair and hobby activities. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗	Quantitative
Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Lacquer Sealer (Non-Spray)	Application of product in house via roller or brush. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗	Quantitative
Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Lacquer Sealer (Spray)	Application of product in house via spray. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗	Quantitative
Construction, paint, electrical, and metal products	Building/construction materials covering large surface areas including stone, plaster, cement, glass and ceramic	Solid flooring	Direct contact, inhalation of emissions / ingestion of dust adsorbed chemical	✓[a]	✓	✓[a]	✓[a]	✗	Quantitative

Consumer Use Category	Consumer Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes: Inhalation	Evaluated Routes: Dermal	Evaluated Routes: Ingestion: Dust (Air)	Evaluated Routes: Ingestion: Dust (Surface)	Evaluated Routes: Ingestion: Mouthing	Qualitative / Quantitative / None
	articles (wire or wiring systems; joint treatment								
Construction, paint, electrical, and metal products	Electrical and Electronic Products	Wire Insulation	Direct contact, inhalation of emissions / ingestion of dust adsorbed chemical, mouthing by children	✓ [a]	✓	✓ [a]	✓ [a]	✓	Quantitative
Construction, paint, electrical, and metal products	Paints and coatings	Paint products/articles were not identified. For coatings, lacquers and sealants were used as their use patterns are similar.	See lacquers and sealants	See lacquers and sealants					Quantitative
Furnishing, cleaning, treatment/care products	Fabrics, textiles, and apparel (as plasticizer)	See synthetic leather furniture and clothing	See synthetic leather furniture and clothing	See synthetic leather furniture and clothing					Quantitative
Packaging, paper, plastic, hobby products	Arts, crafts, and hobby materials (crafting paint applied to craft)	Rubber Eraser	Direct contact during use; rubber particles may be inadvertently ingested during use. Eraser may be mouthed by children	✗ [b]	✓	✗	✗	✓	Quantitative
Packaging, paper, plastic, hobby products	Arts, crafts, and hobby materials (crafting paint applied to craft)	Crafting paint applied to craft	Current products were not identified. Foreseeable uses were matched with the lacquers, and sealants (small and large projects) because similar use patterns are expected.	See lacquers and sealants (small and large projects)					Quantitative
Packaging, paper, plastic, hobby products	Ink, toner, and colorant products	No consumer products identified.	Current products were not identified. Foreseeable uses were matched with the lacquers, and sealants (small and large projects) because similar use patterns are expected.	See lacquers and sealants (small and large projects)					Quantitative
Packaging, paper,	PVC film and sheet	Miscellaneous coated	Direct contact during use	✗ [b]	✓	✗	✗	✗	Quantitative

Consumer Use Category	Consumer Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes					Qualitative / Quantitative / None
				Inhalation	Dermal	Ingestion			
						Dust (Air)	Dust (Surface)	Mouthing	
plastic, hobby products		textiles: truck awnings							
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Shower Curtain	Direct contact during use; inhalation of emissions / ingestion of dust adsorbed chemical while hanging in place	✓ [a]	✓	✓ [a]	✓ [a]	✗	Quantitative
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Wallpaper	Direct contact during installation (teenagers and adults) and while in place; inhalation of emissions / ingestion of dust adsorbed chemical	✓ [a]	✓	✓ [a]	✓ [a]	✗	Quantitative
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Foam Flip Flops	Direct contact during use	✗ [b]	✓	✗	✗	✗	Quantitative
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Synthetic Leather Furniture	Direct contact during use; inhalation of emissions / ingestion of airborne particulate; ingestion by mouthing	✓ [a]	✓	✓ [a]	✓ [a]	✓	Quantitative
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Synthetic Leather Clothing	Direct contact during use	✗ [b]	✓	✗	✗	✗	Quantitative
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Bags	Direct contact during use	✗ [b]	✓	✗	✗	✗	Quantitative
Packaging, paper,	Toys, playgrounds, and	Fitness Ball	Direct contact during use	✗	✓	✗	✗	✗	Quantitative

Consumer Use Category	Consumer Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes					
				Inhalation	Dermal	Ingestion			Qualitative / Quantitative / None
						Dust (Air)	Dust (Surface)	Mouthing	
plastic, hobby products	sporting equipment								
Packaging, paper, plastic, hobby products	Toys, Playground, and Sporting Equipment	Children's Toys (new)	Collection of toys. Direct contact during use; inhalation of emissions / ingestion of airborne PM; ingestion by mouthing	✓[a]	✓	✓[a]	✓[a]	✓	Quantitative
Packaging, paper, plastic, hobby products	Toys, Playground, and Sporting Equipment	Children's Toys (legacy)	Collection of toys. Direct contact during use; inhalation of emissions / ingestion of airborne particulate; ingestion by mouthing	✓[a]	✓	✓[a]	✓[a]	✓	Quantitative
Other	Novelty Products	Adult Toys	Direct contact during use, ingestion by mouthing	✗[b]	✓	✗	✗	✓	Quantitative
Disposal	Disposal	Down the drain products and articles	Down the drain and releases to environmental media	✗	✗	✗	✗	✗	Qualitative Discussion

✓ Scenario is considered either qualitatively or quantitatively in this assessment.

✓[a] Scenario used in Indoor Dust Exposure Assessment in Section 3. These indoor dust articles scenarios consider the surface area from multiple articles such as toys and wire insulation, while furniture, curtains, flooring and wallpaper already have large surface areas in which dust can deposit and contribute to significantly larger concentration of dust than single small articles and products.

✗ Scenario was deemed unlikely based low volatility and small surface area, likely negligible gas and particle phase concentration for inhalation, low possibility of mouthing based on product use patterns and targeted population age groups, and low possibility of dust on surface due to barriers or low surface area for dust ingestion.

✗[b] Scenario was deemed unlikely based low volatility and small surface area and likely negligible gas and suspended particle phase concentration.

DIY [c] – Do-it-yourself

EPA did not perform quantitative assessments of the COU summarized in Table 2-2 due to lack of reasonably available information, monitoring data, and modeling tools. A qualitative discussion using physical and chemical properties and monitoring data for environmental media to support conclusions about down the drain and disposal practices and releases to the environment.

Table 2-2. COUs and Products or Articles without a Quantitative Assessment

Consumer Use Category	Consumer Use Subcategory	Product/Article	Comment
Disposal	Disposal	Down the drain products and articles	Qualitative discussion – Due to limited information on source attribution of the consumer COUs.

Environmental releases may occur from consumer products and articles containing DIDP via the end-of-life disposal and demolition of consumer products and articles in the built environment, as well as from the associated down-thE−drain release of DIDP. It is difficult for EPA to quantify these ends-of-life and down-thE−drain exposures due to limited information on source attribution of the consumer COUs. In previous assessments, EPA has considered down-thE−drain analysis for consumer products scenarios where there is reasonably foreseen exposure scenario where it can be assumed the consumer product (*e.g.*, drain cleaner, lubricant, oils) will be discarded directly down-thE−drain. Although EPA acknowledges that there may be DIDP releases to the environment via the cleaning and disposal of adhesives, sealants, lacquers, and coatings, the Agency did not quantitatively assess these scenarios due to limited information, monitoring data, or modeling tools. Adhesives, sealants, lacquers, and coatings can be disposed down-thE−drain while users wash their hands, brushes, sponges, and other product applying tools. In addition, these products can be disposed when users no longer have use for them or have reached the product shelf life and taken to landfills.

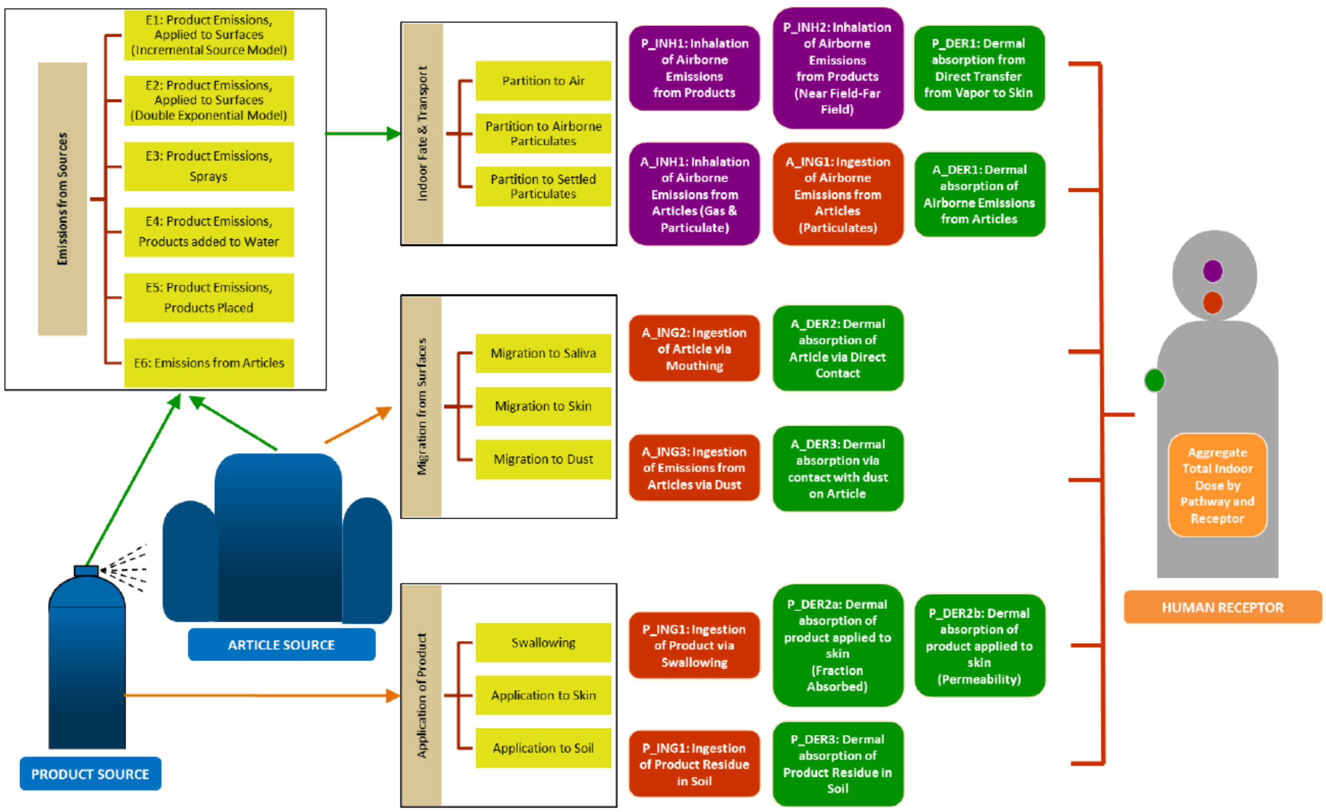
All other solid products and articles in Table 2-1 can be removed and disposed in landfills, or other waste handling locations that properly manage the disposal of products like adhesives, sealants, lacquers, and coatings. EPA did not identified data for DIDP in drinking water in the U.S. Based on the low water solubility and log K_{OW}, DIDP in water it is expected to mainly partition to suspended solids present in water. The available information suggest that the use of flocculants and filtering media could potentially help remove DIDP during drinking water treatment by sorption into suspended organic matter, settling, and physical removal. While there is limited measured data on DIDP in landfill leachates, the data suggest that DIDP is unlikely to be present in landfill leachates. Further, the small amounts of DIDP that could potentially be in landfill leachates will have limited mobility and are unlikely to infiltrate groundwater due to high affinity of DIDP for organic compounds that would be present in receiving soil and sediment (U.S. EPA, 2024a).

2.1 Consumer Exposure Model (CEM)

The CEM Version 3.2 (U.S. EPA, 2023) was selected for the consumer exposure modeling as the most appropriate model to use based on the type of input data available for DIDP-containing consumer products. The advantages of using CEM to assess exposures to consumers and bystanders are as follows:

- CEM model has been peer reviewed;
- CEM accommodates the distinct inputs available for the products containing DIDP; and
- CEM uses the same calculation engine to compute indoor air concentrations from a source as the higher-tier Multi-Chamber Concentration and Exposure Model (MCCEM) but does not require measured chamber emission values (which are not available for DIDP).

CEM has capabilities to model exposure to DIDP in both products and articles. Products are generally consumable liquids, aerosols, or semi-solids that are used a given number of times before they are exhausted. Articles are generally solids, polymers, foams, metals, or woods, which are present within indoor environments for the duration of their useful life, which may be several years. Figure 2-1 displays the embedded models within CEM 3.2.



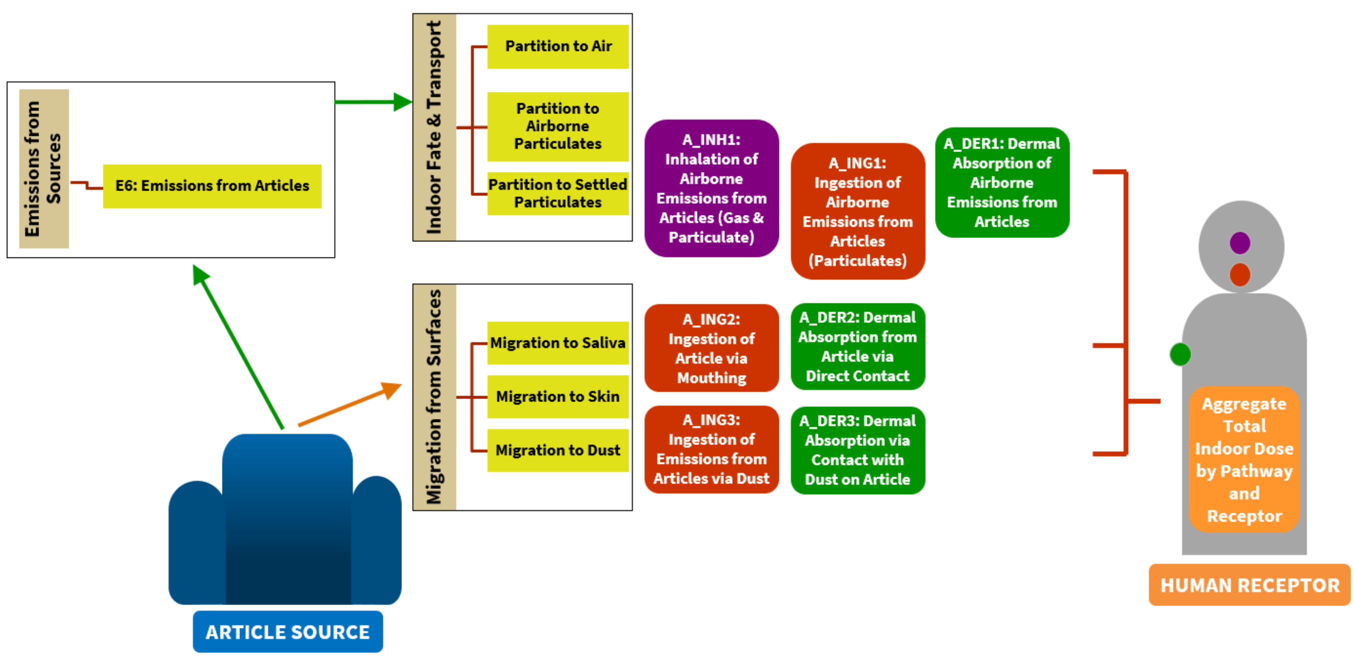


Figure 2-1. Consumer Pathways and Routes Evaluated in this Assessment

CEM 3.2 generates exposure estimates based on user-provided input parameters and various assumptions (or defaults). The model contains a variety of prE−populated scenarios for specific product and article categories and allows the user to define generic categories for any product and article in instances where the prepopulated scenarios are not adequate. User inputs for physical and chemical properties of products and articles are utilized to calculate emission profiles of SVOCs. There are six emission calculation profiles within CEM (E1–E6) that represent specific use conditions and properties of various products and articles. A description of these models is summarized in the CEM user guide and associated appendices https://www.epa.gov/tsca-screening-tools.

The calculated emission rates are then used in a deterministic, mass balance calculation of indoor air concentrations. However, CEM employs different models for products and articles. For products, CEM 3.2 uses a two-zone representation of the building of use when predicting indoor air concentrations. Zone 1 represents the room where the consumer product is used. Zone 2 represents the remainder of the building. Each zone is considered well-mixed. The model allows for further division of Zone 1into a near field and far field to accommodate situations where a higher concentration of product is expected very near the product user during the period of use. Zone 1-near field represents the breathing zone of the user at the location of the product use, while Zone 1-far field represents the remainder of the Zone 1 room. The modeled concentrations in the two zones are a function of the timE−varying emission rate in Zone 1, the volumes of Zones 1 and 2, the air flows between each zone and the outdoor, and the air flows between the two zones. CEM 3.2 models exposure to SVOCs emitted from products via inhalation of gas-phase SVOCs Based on zones and prE−defined activity patterns. The product user and bystander is placed within Zone 1 and Zone 2, respectively, for the duration of product use. Following product use, the user and bystander follow one of three prE−defined activity patterns as determined by the CEM modeler. The activity pattern takes the user and bystander in and out of Zone 1 and Zone 2 for the period of simulation. The user and bystander inhale airborne concentrations with these zones, which will vary over time, resulting in the overall estimated exposure for each individual. For the "Stay-at-Home" activity pattern used in these analyses, both users and bystanders are assumed to be in the home the majority of the day (20 hours). In addition, exposure via incidental ingestion of products during use may also be modeled.

For articles, the model comprises an air compartment (including gas phase, suspended particulates) and a floor compartment (containing settled particulates). SVOCs emitted from articles partition between indoor air, airborne particles, settled dust, and indoor sinks over time. Multiple articles can be incorporated into one room over time based on the total exposed surface area of articles present within a room. CEM 3.2 models exposure to SVOCs emitted from articles via inhalation of airborne gas- and particlE−phase SVOCs, ingestion of previously inhaled particles, dust ingestion via hand-to-mouth contact, and ingestion exposure via mouthing.

CEM 3.2 estimates acute dose rates and chronic average daily doses for inhalation, ingestion, and dermal exposures of consumer products and articles. CEM 3.2 acute exposures are for an exposure duration of 1 day, and chronic exposures are for an exposure duration of 1 year. The model provides exposure estimates for various lifestages. EPA made some adjustments to match CEM's lifestages to those listed in the Center for Disease Control and Prevention (CDC) guidelines (CDC, 2021) and *EPA's A Framework for Assessing Health Risks of Exposures to Children* (U.S. EPA, 2006). CEM lifestages are rE−labeled from this point forward as follows:

- Adult (≥21 years) → Adult
- Youth 2 (16 to 20 years) → Teenager
- Youth 1 (11 to 15 years) → Young teen
- Child 2 (6 to 10 years) → Middle childhood

- Child 1 (3 to 5 years) → Preschooler
- Infant 2 (1to 2 years) → Toddler
- Infant 1 (<1 year) → Infant

Exposure inputs for these various lifestages are provided in the EPA's CEM Version 3.2 Appendices.

2.1.1 Acute, Chronic, and Intermediate Dose Rate Equations

2.1.1.1 Acute Dose Rate

Acute dose rate for inhalation of product used in an environment (CEM P_INH1 model) was calculated as follows:

Equation 2-1. Acute Dose Rate for Inhalation of Product Used in an Environment

$$ADR = \frac{C_{air} \times Inh \times FQ \times D_{ac} \times ED}{BW \times AT \times CF_1}$$

Where:

ADR	=	Acute Dose Rate (mg/kg-day)
C_{air}	=	Concentration of DIDP in air (mg/m^3)
Inh	=	Inhalation rate (m^3/hr)
FQ	=	Frequency of product use (events/day)
D_{ac}	=	Duration of use (min/event), acute
ED	=	Exposure duration (days of product usage)
BW	=	Body weight (kg)
AT	=	Averaging time (days)
CF_1	=	Conversion factor (60 min/hr)

For the ADR calculations, an averaging time of 1 day is used; the ADR therefore represents the maximum timE−integrated dose over a 24-hour period during the exposure event. The airborne concentration in the above equation is calculated using the high-end consumer product weight fraction, duration of use, and mass of product used. CEM calculates all possible ADRs, over the 60-day modeling period, as running 24-hour integrations (*i.e.*, hours 1 to 24, 2 to 25, etc.), and then reports the highest of these computed values as the ADR.

Acute dose rate for inhalation from article placed in environment (CEM A_INH1 model) was calculated as follows:

Equation 2-2. Acute Dose Rate for Inhalation from Article Placed in Environment in Air

$$ADR_{Air} = \frac{C_{gas\_max} \times FracTime \times InhalAfter \times CF_1}{BW \times CF_2}$$

Equation 2-3. Acute Dose Rate for Inhalation from Article Placed in Environment in Particulate

$$ADR_{Particulate} = \frac{DIDPRP_{air\_max} \times RP_{air\_avg} \times FracTime \times InhalAfter \times CF_1}{BW \times CF_2}$$

Equation 2-4. Total Acute Dose Rate for Inhalation of Particulate and Air

$$ADR_{total} = ADR_{Air} + ADR_{Particulate}$$

Where:

ADR_{Air}	=	Acute Dose Rate, air (mg/kg-day)
$ADR_{Particulate}$	=	Acute Dose Rate, particulate (mg/kg-day)
ADR_{total}	=	Acute Dose Rate, total (mg/kg-day)
C_{gas_max}	=	Maximum gas phase concentration (µg/m^3)
$DIDPRP_{air\_max}$	=	Maximum DIDP in respirable particle (RP) concentration, air (µg/mg)
RP_{air_max}	=	Maximum respirable particle concentration, air (mg/m^3)
$FracTime$	=	Fraction of time in environment (unitless)
$InhalAfter$	=	Inhalation rate after use (m^3/hr)
CF_1	=	Conversion factor (24 hrs/day)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (1,000 µg/mg)

Acute dose rate for ingestion after inhalation (CEM A_ING1 model) was calculated as follows:

Equation 2-5. Acute Dose Rate from Ingestion after Inhalation

$$ADR_{IAI} = \frac{\left[\left(DIDPRP_{air\_max} \times RP_{air\_max} \times IF_{RP}\right) + \left(DIDPDust_{air\_max} \times Dust_{air\_max} \times IF_{Dust}\right) + \left(DIDPAbr_{air\_max} \times Abr_{air\_max} \times IF_{Abr}\right)\right] \times InhalAfter \times CF_1}{BW \times CF_2}$$

Where:

ADR_{IAI}	=	Acute Dose Rate from Ingestion and Inhalation (mg/kg-day)
$DIDPRP_{air\_max}$	=	Maximum DIDP in respirable particles (RP) concentration, air (µg/mg)
RP_{air_max}	=	Maximum RP concentration, air (mg/m^3)
IF_{TSP}	=	RP ingestion fraction (unitless)
$DIDPDust_{air\_max}$	=	Maximum DIDP in dust concentration, air (µg/mg)
$Dust_{air\_max}$	=	Maximum dust concentration, air (mg/m^3)
IF_{Dust}	=	Dust ingestion fraction (unitless)
$DIDPAbr_{air\_avg}$	=	Maximum DIDP in abraded particle concentration, air (µg/mg)
Abr_{air_avg}	=	Maximum abraded particle concentration, air (mg/m^3)
IF_{Abr}	=	Abraded particle ingestion fraction (unitless)
$InhalAfter$	=	Inhalation rate after use (m^3/hr)
CF_1	=	Conversion factor (24 hrs/day)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (1,000 mg/g)

Acute daily dose rate for ingestion of article mouthed (CEM A_ING2 model) was calculated as follows:

Equation 2-6. Acute Dose Rate for Ingestion of Article Mouthed

$$ADR = \frac{MR \times CA \times D_m \times ED_{ac} \times CF_1}{BW \times AT_{ac} \times CF_2}$$

Where:

ADR = Acute Dose Rate (mg/kg-day)
MR = Migration rate of chemical from article to saliva (mg/cm^2/hr)
CA = Contact area of mouthing (cm^2)
D_m = Duration of mouthing (min/hr)
ED_{ac} = Exposure duration, acute (days)
CF_1 = Conversion factor (24 hrs/day)
BW = Body weight (kg)
AT_{ac} = Averaging time, acute (days)
CF_2 = Conversion factor (60 min/hr)

See Section 2.1.2.1 for migration rate inputs and determination of these values.

Acute dose rate for incidental ingestion of dust (CEM A_ING3 model) was calculated as follows:

The article model named E6 in CEM calculates DIDP concentration in small particles, termed respirable particles (RP), and large particles, termed dust, that are settled on the floor or surfaces. The model assumes these particlE–bound to DIDP are available via incidental dust ingestion assuming a daily dust ingestion rate and a fraction of the day that is spent in the zone with the DIDP-containing dust. The model uses a weighted dust concentration, shown in Equation 2-6.

Equation 2-7. Acute Dust Concentration

$$Dust_{ac\_wgt} = \frac{(RP_{floor\_max} \times DIDPRP_{floor\_max}) + (Dust_{floor\_max} \times DIDPDust_{floor\_max}) + (AbArt_{floor\_max} \times DIDPAbArt_{floor\_max})}{(TSP_{floor\_max} + Dust_{floor\_max} + AbArt_{floor\_max})}$$

Where:

$Dust_{ac\_wgt}$ = Acute weighted dust concentration (µg/mg)
RP_{floor_max} = Maximum RP mass, floor (mg)
$DIDPRP_{floor\_max}$ = Maximum DIDP in RP concentration, floor (µg/mg)
$Dust_{floor\_max}$ = Maximum dust mass, floor (mg)
$DIDPDust_{floor\_max}$ = Maximum DIDP in dust concentration, floor (µg/mg)
$AbArt_{floor\_max}$ = Maximum abraded particles mass, floor (mg)
$DIDPAbArt_{floor\_max}$ = Maximum floor dust DIDP concentration (µg/mg)

Equation 2-8. Acute Dose Rate for Incidental Ingestion of Dust

$$ADR = \frac{Dust_{ac\_wgt} \times FracTime \times DustIng}{BW \times CF}$$

Where:

ADR = Acute Dose Rate (mg/kg-day)
$Dust_{ac\_wgt}$ = Acute weighted dust concentration (µg/mg)
$FracTime$ = Fraction of time in environment (unitless)
$DustIng$ = Dust ingestion rate (mg/day)
BW = Body weight (kg)
CF = Conversion factor (1,000 µg/mg)

The above equations assume DIDP can volatilize from the DIDP-containing article to the air and then partition to dust. Alternately, DIDP can partition directly from the article to dust in direct contact with the article. This is also estimated in A_ING3 model assuming the original DIDP concentration in the article is known, and the density of the dust and dust-air and solid-air partitioning coefficients are either known or estimated as presented in E6. The model assumes partitioning behavior dominates, or instantaneous equilibrium is achieved. This is presented as a worst-case or upper bound scenario.

Equation 2-9. Concentration of DIDP in Dust

$$C_d = \frac{C_{0\_art} \times K_{dust} \times CF}{K_{solid}}$$

Where:

C_d	=	Concentration of DIDP in dust (mg/mg)
C_{0_art}	=	Initial DIDP concentration in article (mg/cm^3)
K_{dust}	=	DIDP dust-air partition coefficient (m^3/mg)
CF	=	Conversion factor (10^6 cm^3/m^3)
K_{solid}	=	Solid air partition coefficient (unitless)

Once DIDP concentration in the dust is estimated, the acute dose rate can be calculated. The calculation relies on the same upper end dust concentration.

Equation 2-10. Acute Dose Rate from Direct Transfer to Dust

$$ADR_{DTD} = \frac{C_d \times FracTime \times DustIng}{BW}$$

Where:

ADR_{DTD}	=	Acute Dose Rate from direct transfer to dust (mg/kg-day)
C_d	=	Concentration of DIDP in dust (mg/mg)
$FracTime$	=	Fraction of time in environment (unitless)
$DustIng$	=	Dust ingestion rate (mg/day)
BW	=	Body weight (kg)

Acute dose rate for ingestion of product swallowed (CEM P_ING1 module) was calculated as follows:

Equation 2-11. Acute Dose Rate for Ingestion of Product Swallowed by Mouthing

$$ADR = \frac{FQ_{ac} \times M \times WF \times F_{ing} \times CF_1 \times ED_{ac}}{BW \times AT_{ac}}$$

Where:

ADR	=	Acute Dose Rate (mg/kg-day)
FQ_{ac}	=	Frequency of use, acute (events/day)
M	=	Mass of product used (g)
WF	=	Weight fraction of chemical in product (unitless)
F_{ing}	=	Fraction of product ingested (unitless)
CF_1	=	Conversion factor (1,000 mg/g)
ED_{ac}	=	Exposure duration, acute (days)
AT_{ac}	=	Averaging time, acute (days)
BW	=	Body weight (kg)

The model assumes that the product is directly ingested as part of routine use, and the mass is dependent on the weight fraction and use patterns associated with the product.

2.1.1.2 Non-cancer Chronic Dose

Chronic average daily dose rate for inhalation of product used in an environment (CEM P_INH1 model) was calculated as follows:

Equation 2-12. Chronic Average Daily Dose Rate for Inhalation of Product Used in an Environment

$$CADD = \frac{C_{air} \times Inh \times FQ \times D_{cr} \times ED}{BW \times AT \times CF_1 \times CF_2}$$

Where:

$CADD$	=	Chronic Average Daily Dose (mg/kg-day)
C_{air}	=	Concentration of chemical in air (mg/m^3)
Inh	=	Inhalation rate (m^3/hr)
FQ	=	Frequency of use (events/year)
D_{cr}	=	Duration of use (min/event), chronic
ED	=	Exposure duration (years of product usage)
BW	=	Body weight (kg)
AT	=	Averaging time (years)
CF_1	=	Conversion factor (365 days/year)
CF_2	=	Conversion factor (60 min/hr)

CEM uses two different inhalation rates, one when the person is using the product and another after the use has ended. Table 2-3 shows the inhalation rates by receptor age category for during and after product use.

Table 2-3. Inhalation Rates Used in CEM Product Models

Lifestage	Inhalation Rate During Use (m^3/hr) [a]	Inhalation Rate After Use (m^3/hr) [b]
Adult (≥21 years)	0.74	0.61
Youth (16–20 years)	0.72	0.68
Youth (11–15 years)	0.78	0.63
Child (6–10 years)	0.66	0.5
Small Child (3–5 years)	0.66	0.42
Infant (1–2 years)	0.72	0.35
Infant (<1 year)	0.46	0.23

[a] Table 6-2, light intensity values (U.S. EPA, 2011a)
[b] Table 6-1 (U.S. EPA, 2011a)

The inhalation dose is calculated iteratively at a 30-second interval during the first 24 hours and every hour after that for 60 days, taking into consideration the chemical emission rate over time, the volume of the house and each zone, the air exchange rate and interzonal airflow rate, and the exposed individual's locations and inhalation rates during and after product use.

Chronic average daily dose rate for inhalation from article placed in environment (CEM A_INH1 model) was calculated as follows:

Equation 2-13. Chronic Average Daily Dose Rate for Inhalation from Article Placed in Environment in Air

$$CADD_{Air} = \frac{C_{gas\_avg} \times FracTime \times InhalAfter \times CF_1}{BW \times CF_2}$$

Equation 2-14. Chronic Average Daily Dose Rate for Inhalation from Article Placed in Environment in Particulate

$$CADD_{Particulate} = \frac{DIDPRP_{air\_avg} \times RP_{air\_avg} \times (1 - IF_{RP}) FracTime \times InhalAfter \times CF_1}{BW \times CF_2}$$

Equation 2-15. Total Chronic Average Daily Dose Rate for Inhalation of Particulate and Air

$$CADD_{total} = CADD_{Air} + CADD_{Particulate}$$

Where:

$CADD_{Air}$	=	Chronic Average Daily Dose, air (mg/kg-day)
$CADD_{Particulate}$	=	Chronic Average Daily Dose, particulate (mg/kg-day)
$CADD_{total}$	=	Chronic Average Daily Dose, total (mg/kg-day)
C_{gas_avg}	=	Average gas phase concentration (µg/m^3)
$DIDPRP_{air\_avg}$	=	Average DIDP in respirable particles (RP) concentration, air (µg/mg)
RP_{air_avg}	=	Average RP concentration, air (mg/m^3)
IF_{RP}	=	RP ingestion fraction (unitless)
$FracTime$	=	Fraction of time in environment (unitless)
$InhalAfter$	=	Inhalation rate after use (m^3/hr)
CF_1	=	Conversion factor (24 hrs/day)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (1,000 µg/mg)

Chronic average daily dose rate for ingestion after inhalation (CEM A_ING1 model) was calculated as follows:

The CEM article model, E6, estimates DIDP concentrations in small and large airborne particles. While these particles are expected to be inhaled, not all will be able to penetrate the lungs and will be trapped in the upper airway and subsequently swallowed. The model estimates the mass of DIDP bound to airborne small particles, respirable particles (RP), and large particles (*i.e.*, dust) that will be inhaled and trapped in the upper airway. The fraction that is trapped in the airway is termed the ingestion fraction (IF). The mass trapped is assumed to be available for ingestion.

Equation 2-16. Chronic Average Daily Dose Rate from Ingestion after Inhalation

$$CADD_{IAI} = \frac{\left[\left(DIDPRP_{air\_avg} \times RP_{air_{avg}} \times IF_{RP}\right) + \left(DIDPDust_{air\_avg} \times Dust_{air_{avg}} \times IF_{Dust}\right) + \left(DIDPAbr_{air\_avg} \times Abr_{air\_avg} \times IF_{Abr}\right)\right] \times InhalAfter \times CF_1}{BW \times CF_2}$$

Where:

$CADD_{IAI}$	=	Chronic Average Daily Dose from ingestion after inhalation (mg/kg-day)
$SVOCRP_{air\_avg}$	=	Average DIDP in RP concentration, air (µg/mg)
RP_{air_avg}	=	Average RP concentration, air (mg/m^3)
IF_{RP}	=	RP ingestion fraction (unitless)
$SVOCDust_{air\_avg}$	=	Average DIDP dust concentration, air (µg/mg)
$Dust_{air\_avg}$	=	Average dust concentration, air (mg/m^3)
IF_{Dust}	=	Dust ingestion fraction (unitless)
$SVOCAbr_{air\_avg}$	=	Average DIDP in abraded particle concentration, air (µg/mg)
Abr_{air_avg}	=	Average abraded particle concentration, air (mg/m^3)
IF_{Abr}	=	Abraded particle ingestion fraction (unitless)
$InhalAfter$	=	Inhalation rate after use (m^3/hr)
CF_1	=	Conversion factor (24 hrs/day)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (1000 mg/g)

Chronic average daily dose rate for ingestion of article mouthed (CEM A_ING2 model) was calculated as follows:

The model assumes that a fraction of the chemical present in the article is ingested via object-to-mouth contact or mouthing where the chemical of interest migrates from the article to the saliva. See Section 2.1.2.1 for migration rate inputs and determination of these values.

Equation 2-17. Chronic Average Daily Dose Rate for Ingestion of Article Mouthed

$$CADD = \frac{MR \times CA \times D_m \times ED_{cr} \times CF_1}{BW \times AT_{cr} \times CF_2}$$

Where:

$CADD$	=	Chronic Average Daily Dose (mg/kg-day)
MR	=	Migration rate of chemical from article to saliva (mg/cm^2/hr)
CA	=	Contact area of mouthing (cm^2)
D_m	=	Duration of mouthing (min/hr)
ED_{cr}	=	Exposure duration, chronic (years)
CF_1	=	Conversion factor (24 hrs/day)
AT_{cr}	=	Averaging time, chronic (years)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (60 min/hr)

Chronic average daily rate for incidental ingestion of dust (CEM A_ING3 model) was calculated as follows:

The article model in CEM E6 calculates DIDP concentration in small particles, termed respirable particles (RP), and large particles, termed dust, that are settled on the floor or surfaces. The model assumes these particlE–bound to DIDP are available via incidental dust ingestion assuming a daily dust ingestion rate and a fraction of the day that is spent in the zone with the DIDP-containing dust. The model uses a weighted dust concentration, shown in Equation 2-18.

Equation 2-18. Chronic Dust Concentration

$$Dust_{cr\_wgt} = \frac{(RP_{floor\_avg} \times DIDPRP_{floor\_avg}) + (Dust_{floor\_avg} \times DIDPDust_{floor\_avg}) + (AbArt_{floor\_avg} \times DIDPAbArt_{floor\_avg})}{(RP_{floor\_avg} + Dust_{floor\_avg} + AbArt_{floor\_avg})}$$

Where:

$Dust_{cr\_wgt}$	=	Chronic weighted dust concentration (µg/mg)
RP_{floor_avg}	=	Average RP mass, floor (mg)
$DIDPRP_{floor\_avg}$	=	Average DIDP in RP concentration, floor (µg/mg)
$Dust_{floor\_avg}$	=	Average dust mass, floor (mg)
$DIDPDust_{floor\_avg}$	=	Average DIDP in dust concentration, floor (µg/mg)
$AbArt_{floor\_avg}$	=	Average abraded particles mass, floor (mg)
$DIDPAbArt_{floor\_avg}$	=	Average floor dust DIDP concentration (µg/mg)

Equation 2-19. Chronic Average Daily Dose Rate for Incidental Ingestion of Dust

$$\boldsymbol{CADD = \frac{Dust_{cr\_wgt} \times FracTime \times DustIng}{BW \times CF}}$$

Where:

$CADD$	=	Chronic Average Daily Dose (mg/kg-day)
$Dust_{cr\_wgt}$	=	Chronic weighted dust concentration (µg/mg)
$FracTime$	=	Fraction of time in environment (unitless)
$DustIng$	=	Dust ingestion rate (mg/day)
BW	=	Body weight (kg)
CF	=	Conversion factor (1,000 µg/mg)

The above equations assume DIDP can volatilize from the DIDP-containing article to the air and then partition to dust. Alternately, DIDP can partition directly from the article to dust in direct contact with the article. This is also estimated in the A_ING3 model assuming the original DIDP concentration in the article is known, and the density of the dust and dust-air and solid-air partitioning coefficients are either known or estimated as presented in the E6 CEM model. The model assumes partitioning behavior dominates, or instantaneous equilibrium is achieved. This is presented as a worst-case or upper bound scenario.

2.1.1.3 Intermediate Average Daily Dose

The intermediate doses were calculated from the average daily dose, ADD, (µg/kg-day) CEM output for that product using the same inputs summarized in Table 2-11 for inhalation and Table 2-13 for dermal. EPA used professional judgment and product use descriptions to estimate events per day and per month for the calculation of the intermediate dose:

Equation 2-20. Intermediate Average Daily Dose Equation

$$Intermediate\ Dose\ = \frac{ADD \times Event\ per\ Month}{Events\ per\ Day}$$

Where:

$Intermediate\ Dose$	=	Intermediate average daily dose, µg/kg-month
ADD	=	Average Daily Dose, µg/kg-day
$Event\ per\ Month$	=	Events per month, $month^{-1}$, see Table 2-4
$Event\ per\ Day$	=	Events per day, day^{-1}, see Table 2-4

Table 2-4. Short-Term Event per Month and Day Inputs

Product	Events Per Day	Event Per Month
Construction Adhesive for Small Scale Projects	3	4
Construction Sealant for Large Scale Projects	1	3
Lacquer Sealer (Non-spray)	1	2
Lacquer Sealer (Spray)	1	2

2.1.2 CEM Modeling Inputs and Parameterization

The COUs that were evaluated for DIDP consisted of both products and articles. The embedded models within CEM 3.2 that were used for DIDP are listed in Table 2-5. As dermal exposure was modeled separately, only inhalation and ingestion routes were evaluated in CEM.

Table 2-5. CEM 3.2 Model Codes and Descriptions

Model Code	Description
E1	Emission from Product Applied to a Surface Indoors Incremental Source Model
E2	Emission from Product Applied to a Surface Indoors Double Exponential Model
E3	Emission from Product Sprayed
E6	Emission from article placed in environment
A_INH1	Inhalation from article placed in environment
A_ING1	Ingestion after inhalation
A_ING2	Ingestion of article mouthed
A_ING3	Incidental ingestion of dust
P_ING1	Ingestion of Product Swallowed
P_INH2	Inhalation of Product Used in an Environment

Table 2-6 presents a crosswalk between the COU subcategories with either a predefined or generic scenario. Models were generated to reflect specific use conditions as well as physical and chemical properties of identified products and articles. In some cases, one COU mapped to multiple scenarios, and in other cases one scenario mapped to multiple COUs. Table 2-6 provides data on emissions model and exposure pathways modeled for each exposure scenario. Emissions models were selected based upon physical and chemical properties of the product or article and application use method for products.

Exposure pathways were selected to reflect the anticipated use of each product or article. The article model Ingestion of article mouthed (A_ING2) was only evaluated for the COUs where it was anticipated that mouthing of the product could occur. For example, it is unlikely that a child will mouth flooring or wallpaper, hence the A_ING2 Model was deemed inappropriate for estimating exposure for these COUs. Similarly, solid articles with small surface area are not anticipated to contribute significantly to inhalation or ingestion of DIDP sorbed to dust/PM and were therefore not modeled for these routes (A_ING1, A_ING3). For articles not assessed in CEM, dermal modeling was performed outside of CEM as described in Section 2.2.

Table 2-6. Crosswalk of COU Subcategories, CEM 3.2 Scenarios, and Relevant CEM 3.2 Models Used for Consumer Modeling

Product/Article	CEM Scenario (PrE−loaded Saved Analysis)	Emission Model	Exposure Pathway Model
Auto Transmission Conditioner	Generic P1 E1	E1	P-INH2 (Near-field)
Adult Toys	Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)	E6	A_ING2
Bags	Not Assessed in CEM. Spreadsheet used for dermal modeling.	N/A	N/A
Children's Toys (legacy)	Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)	E6	A_INH1, A_ING1, A_ING2, A_ING3
Children's Toys (new)	Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)	E6	A_INH1, A_ING1, A_ING2, A_ING3
Construction Adhesive for small scale projects	Glue and adhesives (small scale)	E1	P-INH2 (Near-field)
Construction Sealant for large scale projects	Glue and adhesives (large scale)	E1	P-INH2 (Near-field)
Epoxy floor Patch	Generic P1 E1	E1	P-INH2 (Near-field)
Fitness Ball	Not Assessed in CEM. Spreadsheet used for dermal modeling.	N/A	N/A
Lacquer Sealer (Non-Spray)	Generic P1 E1	E1	P-INH2 (Near-field)
Lacquer Sealer (Spray)	Generic P3 E3	E3	P-INH2 (Near-field)
PVC foam flip flops	Not Assessed in CEM. Spreadsheet used for dermal modeling.	N/A	N/A
Rubber Eraser	Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)	E1	A_ING2
Shower curtain	Plastic articles: other objects with potential for routine contact (toys, foam blocks, tents)	E6	A_INH1, A_ING1, A_ING3
Solid flooring	Plastic articles: vinyl flooring	E6	A_INH1, A_ING1, A_ING3
Synthetic Leather Clothing	Not Assessed in CEM. Spreadsheet used for dermal modeling.	N/A	N/A
Synthetic Leather Furniture	Leather Furniture	E6	A_INH1, A_ING1, A_ING2, A_ING3
Wallpaper	Fabrics: curtains, rugs, wall coverings	E6	A_INH1, A_ING1, A_ING3

In total, the specific products representing three (3) COUs categories and seven (7) subcategories for

DIDP were mapped to 19 scenarios. Relevant consumer behavioral pattern data (*i.e.*, use patterns) and product-specific characteristics were applied to each of the scenarios and are summarized in Section 2.1.2.1 and Section 2.1.2.2.

2.1.2.1 Key Parameters for Articles Modeled in CEM Sources and Descriptions

Key input parameters for articles modeled in CEM 3.2 are shown in Table 2-7. If a pathway-specific parameter was not needed because the pathway was not modeled for the article, the parameter is flagged in the table as N/A. Brief descriptions of the key input parameter data sources and assumptions are provided in Table 2-8, with more detailed descriptions following the summary tables. One key parameter, mouthing duration, is described in detail Table 2-10, as the values vary by article and age group. Sources and input parameters, along with calculations and results are also available in *Draft Consumer Exposure Analysis for Diisodecyl Phthalate (DIDP)* (U.S. EPA, 2024c).

Generally, and when possible, model parameters were determined based on specific articles identified in this assessment and CEM defaults were only used where specific information was not available.

801 **Table 2-7. Summary of Key Parameters for Articles Modeled in CEM 3.2**

Article	Exposure Scenario Level	Weight Fraction [a]	Initial Conc. (g/cm^3) [a]	Density (g/cm^3) [a]	Article Surface Area (m^2) [a]	Surface Layer Thickness (cm) [a]	Chemical Migration Rate to Saliva ($\mu g/cm^2$-hr)	Area Mouthed (cm^2) [b]	Use Environment and Volume (m^3) [a]	Interzone Ventilation Rate (m^3/h) [a]
Adult toys	High	N/A	N/A	N/A	N/A	N/A	44.8	100	N/A	N/A
	Medium	N/A	N/A				13.3			
	Low	N/A	N/A				1.61			
Children's toys (new) [c]	High	0.001	0.0014	1.4	9.45	0.01	44.8	10	Bedroom; 36	1.07E02
	Medium	0.001	0.0014		2.32		13.3			
	Low	0.001	0.0014		0.28		1.61			
Children's toys (legacy) [d]	High	0.26	0.364	1.4	9.45	0.01	44.8	10	Bedroom; 36	1.07E02
	Medium	0.23	0.322		2.32		13.3			
	Low	0.2	0.28		0.28		1.61			
Rubber eraser	High	N/A	N/A	N/A	N/A	N/A	44.8	10	N/A	N/A
	Medium	N/A	N/A				13.3			
	Low	N/A	N/A				1.61			
Shower curtain	High	0.086	0.1204	1.4	6.5	0.01	N/A	N/A	Bathroom; 15	1.07E02
	Medium	0.086	0.1204		6.5					
	Low	0.086	0.1204		6.5					
Solid flooring	High	0.019	0.0266	1.4	202	0.01	N/A	N/A	Whole house; 492	1.00E−30
	Medium	0.019	0.0266		202					
	Low	0.019	0.0266		202					
Synthetic leather furniture	High	0.35	0.49	1.4	20.9	0.01	44.8	10	Living Room; 50	1.09E02
	Medium	0.3	0.42		14.7		13.3			
	Low	0.25	0.35		9.6		1.61			
Wallpaper	High	0.26	0.364	1.4	200	0.01	N/A	N/A	Whole house; 492	1.00E−30
	Medium	0.245	0.343		100					
	Low	0.23	0.322		50					
Wire insulation	High	0.5	0.7	1.4	3.7	0.01	44.8	10	Whole house; 492	1.00E−30
	Medium	0.38	0.532		1.9		13.3			

Article	Exposure Scenario Level	Weight Fraction [a]	Initial Conc. (g/cm^3) [a]	Density (g/cm^3) [a]	Article Surface Area (m^2) [a]	Surface Layer Thickness (cm) [a]	Chemical Migration Rate to Saliva (μg/cm^2-hr)	Area Mouthed (cm^2) [b]	Use Environment and Volume (m^3) [a]	Interzone Ventilation Rate (m^3/h) [a]
	Low	0.25	0.35		1.4		1.61			

[a] Parameter is relevant only for modeling exposure via inhalation and/or dust ingestion.
[b] Parameter is relevant only for modeling exposure via mouthing.
[c] New toys scenarios consider a potential future application of the U.S. Consumer Product Safety Commission (CSPC) final phthalates rule established in 2017 (16 CFR part 1307) that bans children's toys and childcare articles from containing more than 0.1% of five other phthalates (not DIDP).
[d] Legacy toys scenarios consider weight fractions in toys that are not limited to 0.1% and are older than the 2017 CSPC phthalate rule, 16 CFR part 1307.

803 **Table 2-8. Summary of Key Parameter Sources and Descriptions for Articles Modeled in CEM 3.2**

Article and Scenario	Weight Fraction	Initial Conc.	Density	Article Surface Area	Surface Layer Thickness	Chemical Migration Rate	Area Mouthed	Use Environment and Volume	Interzone Ventilation Rate
Adult Toys: Direct contact during use, ingestion by mouthing	ECHA (2013a) [Contextual purposes only]	N/A	N/A	N/A	N/A	Mean DINP values (as surrogate) under mild, medium, and harsh assay conditions used for low, medium, and high exposure scenario levels, respectively (Danish EPA, 2016)	Approx. half the surface area of an adult mouth ((Assy et al., 2020; Collins and Dawes, 1987))	N/A	N/A
Childrens Toy (new): Direct contact during use; inhalation of emissions, ingestion of airborne particulate; ingestion by mouthing	U.S. CPSC (2014)	CEM Estimator using density and weight fractions	Standard PVC density from various sources	Estimated 5 small size toys (15x10x5 cm), 15 medium size toys (20x15x8 cm), and 30 large size toys (30x25x15 cm) per room for low, medium, and high exposure levels, respectively (professional judgement)	Professional judgment for soft to moderately hard PVC	Mean DINP values (as surrogate) under mild, medium, and harsh assay conditions used for low, medium, and high exposure scenario levels, respectively (Danish EPA, 2016)	CEM default (Med)	Room selected based on professional judgement; associated volume is CEM default	CEM default based on room selected
Childrens Toy (legacy): Direct contact during use; inhalation of emissions, ingestion of airborne particulate; ingestion by mouthing	U.S. CPSC (2001)	CEM Estimator using density and weight fractions	Standard PVC density from various sources	Same as Childrens Toy (new)	Professional judgment for soft to moderately hard PVC	Mean DINP values (as surrogate) under mild, medium, and harsh assay conditions used for low, medium, and high exposure scenario levels, respectively (Danish EPA, 2016)	CEM default (Med)	Room selected based on professional judgement; associated volume is CEM default	CEM default based on room selected
Rubber Eraser: Direct contact during use, ingestion by	ECHA (2012) [Contextual purposes only]	N/A	N/A	N/A	N/A	Mean DINP values (as surrogate) under mild, medium, and harsh assay conditions used for low,	CEM default (Med)	N/A	N/A

Article and Scenario	Weight Fraction	Initial Conc.	Density	Article Surface Area	Surface Layer Thickness	Chemical Migration Rate	Area Mouthed	Use Environment and Volume	Interzone Ventilation Rate
mouthing						medium, and high exposure scenario levels, respectively (Danish EPA, 2016)			
Solid flooring: Direct contact during use; inhalation of emissions / ingestion of dust adsorbed chemical	ECHA (2012)	CEM Estimator using density and weight fractions	Standard PVC density from various sources	Floor area calculated from a 492 m^3 volume house with 8 ft ceilings	Professional judgment for soft to moderately hard PVC	N/A	N/A	Room selected based on professional judgement; associated volume is CEM default	CEM default based on room selected
Shower curtain: Direct contact during use; inhalation of emissions / ingestion of dust adsorbed chemical	ECHA (2012)	CEM Estimator using density and weight fractions	Standard PVC density from various sources	Double sided surface area of a large size shower curtain (1.8 m x 1.7 m per manufacture specifications)	Professional judgment for soft to moderately hard PVC	N/A	N/A	Room selected based on professional judgement; associated volume is CEM default	CEM default based on room selected
Synthetic Leather Furniture: Direct contact during use; inhalation of emissions, ingestion of airborne particulate; ingestion by mouthing	ACC HPP (2023)	CEM Estimator using density and weight fractions	Standard PVC density from various sources	Estimated for one couch and one loveseat in living room, assuming small, medium, and large sizes for the low, medium, and high exposure scenarios levels, respectively (professional judgment)	Professional judgment for soft to moderately hard PVC	Mean DINP values (as surrogate) under mild, medium, and harsh assay conditions used for low, medium, and high exposure scenario levels, respectively (Danish EPA, 2016)	CEM default (Med)	Room selected based on professional judgement; associated volume is CEM default	CEM default based on room selected
Wallpaper: Direct contact during use; inhalation of emissions / ingestion of dust	ECHA (2012)	CEM Estimator using density and weight fractions	Standard PVC density from various sources	Single sided surface area of wallpaper in a residence per Exposure Factors Handbook Table	Professional judgment for soft to moderately hard PVC	N/A	N/A	Room selected based on professional judgement; associated	CEM default based on room selected

Article and Scenario	Weight Fraction	Initial Conc.	Density	Article Surface Area	Surface Layer Thickness	Chemical Migration Rate	Area Mouthed	Use Environment and Volume	Interzone Ventilation Rate
adsorbed chemical				19-13 ((U.S. EPA, 2011c)) used for medium exposure scenario level. Scaled up and down for the high and low exposure levels (professional judgement)				volume is CEM default	
Wire Insulation: Direct contact during use; ingestion by mouthing	ECHA (2012)	CEM Estimator using density and weight fractions	Standard PVC density from various sources	Estimated 70, 96, and 184 meters of various cord types in home for low, medium, and high estimates (professional judgement) and assumed cord diameter of 6.36 mm (manufacturer wire insulation specifications)	Professional judgment for soft to moderately hard PVC	Mean DINP values (as surrogate) under mild, medium, and harsh assay conditions used for low, medium, and high exposure scenario levels, respectively (Danish EPA, 2016)	CEM default (Med)	Room selected based on professional judgement; associated volume is CEM default	CEM default based on room selected

[a] PVC densities compiled from the following references: (iPolymer, 2024; Aurisano et al., 2022; Ansys, 2021; Li et al., 2018)

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Chemical Migration Rate

Phthalates added to plastic products are not chemically bound to the polymer matrix, allowing for migration through the material and release into saliva during mouthing. The rate of phthalate migration and release to saliva depends upon several factors, including physicochemical properties of the article polymer matrix, phthalate concentration in the polymer, physical mechanics of the individual's mouth during mouthing (*e.g.*, sucking, chewing, biting, etc), and chemical makeup of saliva. In addition, physicochemical properties of the specific phthalate such as size, molecular weight, and solubility have a strong impact on migration rate to saliva.

While there has been considerable investigation of chemical migration rates of phthalates from plastic articles to saliva, rate measurements of DIDP specifically have not been extensively studied. However, chemical migration rates for DINP are better characterized and may be used as a surrogate. The physical and chemical characteristics of DIDP and DINP known to affect chemical migration rates are similar, but the larger size, higher molecular weight, and lower solubility of DIDP as compared to DINP can be expected to result in a slower rate of migration through the polymer matrix and less partitioning to saliva for DIDP. Thus, using chemical migration rates for DINP to calculate the DIDP dose received during mouthing will provide a health protective estimate. This decision is further supported by a small amount of data on the chemical migration rate of DIDP from PVC to artificial saliva, which were in the same range as the chemical migration rate of DINP observed in the same study (Simoneau and Hannaert, 2009).

Chemical migration rates of phthalates to saliva may be measured by *in vitro* or *in vivo* methods. While measurement assays may be designed to mimic mouthing conditions, there is not a consensus on what constitutes standard mouthing behavior. As a result, there is considerable variability in assay methods, which is also expected to affect the results. Because of the aggregate uncertainties arising from variability in physical and chemical composition of the polymer, assay methods for *in vitro* measurements, and physiological and behavioral variability in *in vivo* measurements, migration rates observed in any single study were not considered adequate for estimating this parameter. The chemical migration rate of DIDP was estimated based on data compiled in a review published by the Denmark Environmental Protection Agency in 2016 (Danish EPA, 2016). For this review, data were gathered from existing literature for *in vitro* migration rates from soft PVC to artificial sweat and artificial saliva, as well as *in vivo* tests when such studies were available. The authors used 87 values from four studies (Babich et al., 2020; Niino et al., 2003; Bouma and Schakel, 2002; Fiala et al., 2000) for chemical migrations rates of DINP to saliva from a variety of consumer goods measured with varying analytical methods. These values were then subdivided into mild, medium, and harsh categories based on the analytical method used to estimate migration as shown in Table 2-9. While there is considerable variability in the measured migration rates, there was not a clear correlation between weight fraction of DINP and chemical migration rate.

As such, the same chemical migration rates were applied to all articles regardless of DIDP weight fraction. Mean values for chemical migration rates of DINP under mild, medium, and harsh assay conditions were used in the low, medium, and high exposure scenarios, respectively.

Table 2-9. Chemical Migration Rates Observed for DINP Under Mild, Medium, and Harsh Extraction Conditions

Analytical Method	Migration Rate (μg/cm²/hr)		
	Min	Mean (Standard Deviation)	Max
Mild	0.09	1.61 (2.80)	13.3
Medium	1.5	13.3 (6.44)	29.1
Harsh	7.8	44.8 (33.4)	124.8

Mouthing Duration

Mouthing durations were obtained from the EPA *Exposure Factors Handbook* Table 4-23 (U.S. EPA, 2011c) which provides mean mouthing durations for children between 1 month and 5 years of age, broken down by lifestages expected to be behaviorally similar. Values are provided for toys, pacifiers, fingers, and other objects. For this assessment, values for toys were used for legacy and new children's toys. Values for other object were used for all other items assessed for mouthing by children (*i.e.*, insulated wire, synthetic leather furniture, and rubber erasers). The data provided in the Exposure Factors Handbook was broken down into more lifestages than CEM. For example, it provides different mouthing durations for infants 12-15 months, 15-18 months, 18-21 months, and 21-24 months of age; CEM, in contrast, has only one lifestage for infants under 1 year of age. To determine the mouthing duration in CEM, all relevant data in the Exposure Factors Handbook table were considered together. The minimum value by item type within each lifestage was used in the low exposure scenario, maximum value was used in the high exposure scenario, and the mean value (average across the lifestages provided in the Exposure Factors Handbook) was used in the medium exposure scenario as shown in Table 2-10. For mouthing of adult toys, values of 60, 30, and 15 min per day were used in the high, medium, and low exposure scenarios, respectively. As there were no available data for these values, they were chosen to encompass the range of expected mouthing durations based on professional judgement.

Table 2-10. Mouthing Durations for Children for Toys and Other Objects

	Estimated Mean Daily Mouthing Duration Values from Table 4-23 in Exposure Factors Handbook (min/day)				Mouthing Durations for CEM Lifestages (min/day)		
Item Mouthed	Reported Lifestage				CEM Lifestage: Infants <1 year		
	1 to 3 months	3 to 6 months	6 to 9 months	9 to 12 months	High Exposure Scenario	Med Exposure Scenario	Low Exposure Scenario
Toy	1.0	28.3	39.2	23.07	39.2	22.9	1.0
Other Object	5.2	12.5	24.5	16.42	24.5	14.7	5.2
Item Mouthed	Reported Lifestage				CEM Lifestage: Infants 1-2 years		
	12-15 months	15-18 months	18-21 months	21-24 months	High Exposure Scenario	Med Exposure Scenario	Low Exposure Scenario
Toy	15.3	16.6	11.1	15.8	16.6	14.7	11.1
Other Object	12.0	23.0	19.8	12.9	23.0	16.9	12.0
Item Mouthed	Reported Lifestage				CEM Lifestage: Small Child 3-5 years		
	2 yr	3 yr	4 yr	5 yr	High Exposure Scenario	Med Exposure Scenario	Low Exposure Scenario
Toy	12.4	11.6	3.2	1.9	12.4	7.3	1.9
Other Object	21.8	15.3	10.7	10.0	21.8	14.4	10.0

Adult Toys

Exposure to adult toys was modeled using CEM's saved analysis " Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)" with modifications for some key parameters as shown in Table 2-7 through Table 2-10. The exposure route assessed in CEM was mouthing only.

While weight fraction or initial concentration in article is not an input for mouthing (or dermal) estimates, it is discussed here for contextual purposes and confirmation that DIDP is used in these products. (ECHA, 2013a) reported the presence of DIDP in adult toys but did not report DIDP concentrations. The study reported DINP concentration up to 60 percent w/w in soft PVC sex toys, and although weight fractions are not input parameters for mouthing or dermal exposure assessments, the DINP concentration is used as a surrogate for DIDP.

Object mouthing is not commonly observed behavior in adults, and as such there were no available estimates for mouthing surface area. To determine a reasonable upper boundary for mouthing surface area, EPA identified two studies that reported the surface area of the entire oral cavity in adults (Assy et al., 2020; Collins and Dawes, 1987). The mean surface area reported in Collins et al. (1987) was 215 cm^2 and the mean value reported in Assy et al. (2020) was 173 cm^2. Based on these data, EPA assumes ~200 cm^2 is a reasonable estimate for the total surface are in the oral cavity. However, this value accounts for all surface area, including teeth, gums, the ventral surface of the tongue, and mouth floor, which is a significant overestimation of surface area which would be in contact with an object. As such, it was assumed that 50% of the total surface area might reasonably represent mouthing surface area, and a value of 100 cm^2 was used for this parameter. This corresponds approximately with a one ended cylinder having a radius of 2 cm and length of 7 cm. This value is similar, though slightly lower than the value of 125 cm^2 used for adult toy mouthing area in the ECHA assessment.

Children Toys (New and Legacy)

Exposures to new and legacy toys present in a bedroom were modeled using CEM's saved analysis" Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)", with modifications for some key parameters as shown in Table 2-7 through Table 2-10. The exposure routes assessed in CEM were inhalation, dust ingestion, and mouthing.

The U.S. Consumer Product Safety Commission (CSPC) final phthalates rule established in 2017 (16 CFR part 1307) bans children's toys and childcare articles from containing more than 0.1 percent of five specific phthalate chemicals: diisononyl phthalate (DINP), di-n-pentyl phthalate (DPENP), di-n-hexyl phthalate (DHEXP), dicyclohexyl phthalate (DCHP), and diisobutyl phthalate (DIBP). The rule is based on recommendations from a Chronic Hazard Advisory Panel (CHAP) (U.S. CPSC, 2014), which examined the health effects of phthalates in children's toys and childcare articles. Based on the CHAP's report, CPSC determined that these five phthalate chemicals cause harmful effects on male reproductive development.

Three other phthalates were previously permanently prohibited by Congress in the Consumer Product Safety Improvement Act of 2008 (CPSIA). CPSIA prohibits concentrations of more than 0.1% in children's toys and childcare articles for di-(2-ethylhexyl) phthalate (DEHP), dibutyl phthalate (DBP), and benzyl butyl phthalate (BBP) (computed for *each* phthalate individually). The CPSIA also established an interim prohibition on DIDP, as well as DINP and DNOP, in children's toys at concentrations no more than 0.1 percent. However, the interim prohibition for DIDP and DNOP was lifted when the final phthalate rule took effect in 2018. Between CPSIA and the final phthalates rule, a total of eight phthalates are currently restricted from use in children's toys and childcare articles at concentrations of more than 0.1 percent. While DIDP is not one of the eight phthalates, should a restriction of DIDP at ≤ 0.1 percent be implemented, EPA used this concentration to estimate exposures to DIDP from new children's toys as an exploratory exercise.

Legacy toys concentrations were obtained from the CPSC 2001 DINP assessment (U.S. CPSC, 2001) which reported DINP + DIDP weight fraction data in toys from a 1998 Danish study (Rastogi, 1998). Concentrations of DINP + DIDP were detected in four teethers samples at 32-40 percent and in 2 of 3 doll samples at ~20 and 26 percent. These values are conservative for DIDP because they include DINP due to the overlap of isomeric peaks in the gas chromatography analysis. The reported concentrations may no longer be expected in new toys; however, EPA is using old reports and concentrations to assess scenarios in which older toys are passed down to children and adults to play or as collectibles. In both scenarios, toys can be accessible to children and adults for direct dermal contact and for children to put in their mouths. EPA is not considering teethers and the reported concentrations because these products are not likely to be passed down.

The surface area of new and legacy toys was varied for the low, medium, and high exposures based on EPA's professional judgment of the number and size of toys and size of toys collected in a bedroom. Low, medium, and high estimates, respectively, were based on 5 small toys measuring 15cm x 10cm x 5 cm, 20 medium toys measuring 20cm x15cm x 8cm, or 30 large toys measuring 30cm x 25cm x15cm. In this scenario, the surface area of article exposed is a key parameter that can result in significantly different dose estimates for the inhalation and dust routes.

Rubber Eraser

Exposure to rubber erasers was modeled using CEM's saved analysis " Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)" with modifications for some key parameters as shown in Table 2-7 through Table 2-10. The exposure route assessed in CEM was mouthing only.

While weight fraction or initial concentration in article is not an input for mouthing (or dermal) estimates, it is discussed here for contextual purposes. Weight fractions were reported in (ECHA, 2012) for erasing rubber made of PVC. In one sample from a 2006 Danish investigation, the combination of DINP and DIDP was reported as 32 percent. The sample, furthermore, revealed traces (<1%) of DEHP and DBP. The weight fraction value used in this assessment (32%) is of one reported value and not an average or median.

Shower Curtains

Exposure to shower curtains present in the bathroom was modeled using CEM's saved analysis "fabric article (curtains, rugs, wall coverings)", with modifications for some key parameters as shown in Table 2-7 through Table 2-8. The exposure routes assessed in CEM were inhalation and dust ingestion.

The surface area of a shower curtain is relatively large when considering both sides. It is expected to continuously release some amount of DIDP, which will then be available to partition into dust and migrate throughout the home. EPA used manufacturer specifications for a shower curtain's dimensions (1.83 m × 1.78 m) to estimate surface area and multiplied by 2 to account for both sides. Table 2-11Weight fraction values were reported in (ECHA, 2012) from a Danish study that analyzed the content of phthalates in three shower curtains in 2001. The analyses show that all three shower curtains contain DEHP in concentrations between 6.7 and 22 percent, and that one of the curtains also contained DINP and DIDP, the total concentration was 8.6 percent. The weight fraction value used in this evaluation (8.6%) is a single reported value not representing an average or median. In this scenario, the surface area of article exposed is a key parameter that can result in significantly different dose estimates for the inhalation and dust routes.

Solid Flooring

Exposure to solid flooring installed throughout a whole house was modeled using CEM's saved analysis "plastic article: vinyl flooring", with modifications for some key parameters as shown in Table 2-7 through Table 2-8. The exposure routes assessed in CEM were inhalation and dust ingestion.

The weight fraction was reported in (ECHA, 2012), which used a German study conducted in 2003 (verbal communication). A total of 25 different PVC flooring products marketed in Germany were analyzed to contain all the following phthalates: DIBP, DBP, BBP, DEHP, DINP, DIDP, DIHP and DIOP. The total concentration of phthalates registered in the products was in the range of approximately 6.3 to 36.5 percent. The content of the individual phthalates was registered as follows: DIBP, ≤6.9 percent; DBP, 1.3 percent; BBP, ≤6.8 percent; DEHP, ≤13.6 percent; DIHP, ≤33.0 percent; DIOP, ≤1.1 percent; DINP, ≤22.0 percent; and DIDP, ≤1.9 percent. Most products contained a mixture of different phthalates. The weight fraction value (1.9%) used for this evaluation is a single value.

The surface area of solid flooring in the house was back-calculated from the CEM house volume (492 m^3) and an assumed ceiling height of 8 ft. In this scenario, the surface area of article exposed is a key parameter that can result in significantly different dose estimates for the inhalation and dust routes.

Synthetic Leather Furniture

Exposure to synthetic leather furniture present in the living room was modeled using CEM's saved analysis "Leather Furniture", with modifications for some key parameters as shown in Table 2-7 through Table 2-10. The exposure routes assessed in CEM were inhalation, ingestion of dust, and mouthing.

Each scenario consisted of a couch and loveseat set were modeled in all scenarios, but the surface area was varied in low, medium, and high exposure scenarios to reflect the variability observed in standard sizes available for purchase. The low, medium, and high surfaces areas, respectively, are based on prisms measuring 60" × 30" × 25", 80" × 36" × 30", and 100" × 42" × 35" for a couch and 48" × 30" × 25", medium 60" × 36" × 30", and 72" × 42" × 35" for a loveseat. EPA added the low estimates for couch and loveseat to estimate exposures to smaller furniture in the low-end scenario, and similarly for the medium and high estimates. Weight fraction values were reported in (ACC HPP, 2023) as a range, where the value used as a high-end is the maximum, the low-end is the minimum, and the central tendency is the average of the reported maximum and minimum.

Wallpaper

Exposure to wallpaper installed throughout a whole house was modeled using CEM's saved analysis " Fabrics: curtains, rugs, wall coverings", with modifications for some key parameters as shown in Table 2-7 through Table 2-8. The exposure routes assessed in CEM were inhalation and dust ingestion.

ECHA (2012) reported a 2001 study of four PVC wallpapers that measured the concentration of phthalates. Two wallpaper samples had a content of DINP and DIDP between 23 and 26 percent, and the other two had a content of DEHP between 6.9 and 9 percent. In a survey from 2010 used by (ECHA, 2012), 15 wallpaper samples were analyzed for DEHP, DBP, DIBP and BBP. The analysis showed all wallpapers had three phthalates (DEHP, DBP and DIBP) each at less than 0.1 percent. In addition, 10 of the wallpapers contained DINP, but the content of DINP was not quantified. BBP was not detected in any of the analyzed wallpapers. EPA decided to use 0.1 percent as the lower bound of the reported range and use DINP concentrations as a proxy for DIDP in wallpaper. The range of weight fractions used is 0.1 to 26 percent, using the lower bound for the low-end exposure estimate, and the upper bound for the high-end exposure estimates. The average of 0.1 and 26 percent was used for the central tendency exposure estimates.

In this scenario, the surface area of article exposed is a key parameter that can result in significantly different dose estimates for the inhalation and dust routes. The surface area of wallpaper in a residence was varied for the low, medium, and high exposures. The medium value of 100 m^2 is based on Exposure Factors Handbook Table 9-13. This value was scaled to 200 and 50 m^2 for the high and low exposure levels based on professional judgment.

Wire Insulation

Exposure to wire insulation present in the whole house was modeled using CEM's saved analysis "plastic article with potential for routine contact", with modifications for some key parameters as shown in Table 2-7 through Table 2-10. The exposure routes assessed in CEM were inhalation, dust ingestion, and mouthing.

In this scenario, the surface area of article exposed is a key parameter that can result in significantly different dose estimates for the inhalation and dust routes. Surface area of wire insulation in the home was calculated using a typical circumference of wire insulation for cords (6.36 mm based on manufacturer specifications for 6 AWG wire size), typical length of cord (2 m, professional judgement), and estimated number of cords for various applications (appliances, electrical devices, internet, etc.) in a 1-, 2-, or 6-person household. The EPA estimated number of cords is 35, 48, and 92 for the low, medium, and high-end scenarios, respectively, which is supported by a 2014 Korean study (Won and Hong, 2014) that reports an average number of home appliances as 10.6 for single households, 13.8 for 2-person households and 17.5 for households with 6 persons. Weight fraction concentrations were reported in (ECHA, 2012) where the high and low for "cables and wires" were reported based on average plasticizer content of 25 to 50 percent. The medium is the average between these values.

2.1.2.2 Key Parameters for Products Modeled in CEM Sources and Descriptions

Key input parameters for products modeled in CEM 3.2 for the inhalation route are shown in Table 2-11. Brief descriptions of the key input parameter data sources and assumptions are provided in Table 2-12, with more detailed descriptions following the summary tables. Sources and input parameters, along with calculations and results are also available in *Draft Consumer Exposure Analysis for Diisodecyl Phthalate (DIDP)* (U.S. EPA, 2024c).

Generally, and when possible, model parameters were determined based on specific products identified in this assessment and CEM defaults were only used where specific information was not available.

1052 **Table 2-11. Summary of Key Parameters for Products Modeled in CEM 3.2**

Product	Exposure Scenario Level	Weight Fraction	Density (g/cm³) [a]	Duration of Use (hr)	Product Mass Used (g)	Freq. of Use (year^{-1})	Freq. of Use (day^{-1})	Use Environ. and Volume (m³) [b]	Air Exchange Rate, Zone 1 and Zone 2 (hr^{-1}) [b]	Interzone Ventilation Rate (m³/h)
Auto Transmission Conditioner	High	0.07	N/A	0.25	150	1	1	Garage; 90	0.45	1.09E2
	Medium	0.05		0.17	100					
	Low	0.03		0.08	50					
Construction Adhesive for small scale projects	High	0.3	N/A	1.00	30	52	3	Utility Room; 20	0.45	1.07E2
	Medium	0.12		0.33	10					
	Low	0.01		0.17	5					
Construction Sealant for large scale projects	High	0.4	N/A	4.00	5000	3	1	Garage; 90	0.45	1.09E2
	Medium	0.1		2.00	500					
	Low	0.001		1.00	100					
Epoxy floor Patch	High	0.24	2.058	0.25	500	1	1	Garage; 90	0.45	1.09E2
	Medium	0.12		0.17	250					
	Low	0.001		0.08	125					
Lacquer Sealer (Spray)	High	0.02	0.88	8.00	18000	2	1	Whole House; 492	0.45	1.00E−30
	Medium			3.00	5000					
	Low			2.00	2500					
Lacquer Sealer (Non-Spray)	High	0.02	0.88	8.00	18000	2	1	Whole House; 492	0.45	1.00E−30
	Medium			3.00	5000					
	Low			2.00	2500					

[a] Density is only required for scenarios which product mass is calculated from a product volume.
[b] For all scenarios, the near-field modeling option was selected to account for a small personal breathing zone around the user during product use in which concentrations are higher, rather than employing a single well-mixed room. A near-field volume of 1 m³ was selected.

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1054 **Table 2-12. Summary of Key Parameter Sources and Descriptions for Products Modeled in CEM 3.2**

Product	Weight Fraction	Density	Duration of Use	Product Mass Used	Frequency of Use (year $^{-1}$)	Frequency of Use (day $^{-1}$)	Use Environment and Volume	Interzone Ventilation Rate
Auto Transmission Conditioner	Use Report, 1 product identified	N/A	CEM default values (high, med, low) for anti-freeze saved analysis.	CEM default values (high, med, low) for anti-freeze saved analysis.	Professional judgement based on product use description.	Professional judgement based on product use description.	Room selected based on professional judgement; associated volume is CEM default	CEM default based on room selected
Construction Adhesive for small scale projects	Use Report, 7 products identified	N/A	CEM default values (high, med, low) for Glue and adhesives (small scale) saved analysis.	CEM default values (high, med, low) for Glue and adhesives (small scale) saved analysis.	CEM default (Med). Details below this table.	CEM default.	Room selected based on professional judgement; associated volume is CEM default	CEM default based on room selected
Construction Sealant for large scale projects	Use Report, 16 products identified	N/A	CEM default values (high, med, low) for Glue and adhesives (large scale) saved analysis.	CEM default values (high, med, low) for Glue and adhesives (large scale) saved analysis.	CEM default (Med).	CEM default.	Room selected based on professional judgement; associated volume is CEM default	CEM default based on room selected
Epoxy floor Patch	Use Report, 2 products identified	Product SDS, 1 product	Professional judgement based on product use description. Assume product dries rapidly after mixing components.	Professional judgement. Assumes repair activities only.	Professional judgement based on product use description.	Professional judgement based on product use description.	Room selected based on professional judgement; associated volume is CEM default	CEM default based on room selected
Lacquer Sealer (Spray)	Use Report, 1 product identified	CEM default for vanish and floor finish	Professional judgement. Details below this table.	Based on label application rate and professional judgement on surface area applied. Details below this table.	Professional judgement based on product use description. A value of 2 was selected to account for possible 2 coats of product	Professional judgement based on product use description. Assumed a DIYer would apply a single coat in a day for larger surface	Indoor/outdoor product but assumed application to floors inside house is reasonable. Associated volume is CEM	CEM default based on room selected

Product	Weight Fraction	Density	Duration of Use	Product Mass Used	Frequency of Use (year $^{-1}$)	Frequency of Use (day $^{-1}$)	Use Environment and Volume	Interzone Ventilation Rate
					applied.	areas.	default.	
Lacquer Sealer (Non-Spray)	Use Report, 1 product identified	CEM default for vanish and floor finish	Professional judgement. Details below this table.	Based on label application rate and professional judgement on surface area/number of rooms applied. Details below this table.	Professional judgement based on product use description. A value of 2 was selected to account for possible 2 coats of product applied.	Professional judgement based on product use description. Assumed a DIYer would apply a single coat in a day for larger surface areas.	Indoor/outdoor product but assumed application to floors inside house is reasonable. Associated volume is CEM default.	CEM default based on room selected
Air exchange rate (zone 1 and 2) and interzonal air flow input parameters are explained below this table								

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Air Exchange Rates and Interzonal Air Flow Inputs

CEM default air exchange rates for the building are from the Exposure Factors Handbook (U.S. EPA, 2011c). The default interzonal air flows are a function of the overall air exchange and volume of the building as well as the openness of the room, which is characterized in a regression approach for closed rooms and open rooms (U.S. EPA, 2023). Kitchens, living rooms, and the garage area are considered more open, and an interzonal ventilation rate of 109 m^3/hour is applied in these rooms. Bedrooms, bathrooms, laundry rooms, and utility rooms are considered less open, and an interzonal ventilation rate of 107 m^3/hour is applied. In instances where the whole house is selected as the room of use, the entire building is considered zone 1, and the interzonal ventilation rate is therefore equal to the negligible value of 1E−30 m^3/hour. In instances where a product might be used in several rooms of the house, air exchange rate was considered in the room of use to ensure that effects of ventilation were captured.

Auto Transmission Conditioner

Exposure to Auto Transmission Conditioner was modeled in the garage using CEM's saved analysis "Generic P1 E1" with modifications for some key parameters as shown in Tables 2-11 through 2-12.

Product instructions state to use 6, 11, and 32 oz for small, medium, and large transmission capacities, respectively. Because the product is typically poured into a closed receptable, inhalation exposure is expected to be minimal. However, spills or overfilling during use may result in puddles of product which may freely emit to the environment. To account for this possibility, 25 percent of the total used mass were assumed to be exposed to air, resulting in mass applied (assuming a density of 0.91 g/cm^3 per SDS) of 40, 74, and 215 g. These values are similar to the CEM defaults for antifreeze (50, 100, 150 g), which is a product in the same use category (automobile care) with a similar application pattern. Thus, the CEM defaults for the anti-freeze saved analysis were selected for this scenario.

The frequency of use was limited to one event per day and one event per year due to the infrequent occurrence of automotive transmission changes even if multiple cars are in a single household.

Construction Adhesive for Small Scale Projects

Exposure to Construction Adhesive for small scale projects was modeled in the utility room using CEM's saved analysis " Glue and adhesives (small scale)" with modifications for some key parameters as shown in Table 2-11 and Table 2-12.

The decision to use 52 events a year (the CEM med default) may be high since these products are for occasional small repair projects. However, these adhesives may also be used for routine arts and craft projects. Since there is no evidence for or against its use as arts and crafts, EPA decided to use the CEM default.

Construction Sealant for Large Scale Projects

Exposure to Construction Sealant for large scale projects was modeled in the garage using CEM's saved analysis "Glue and adhesives (large scale)" with modifications for some key parameters as shown in Table 2-11 and Table 2-12.

The product use description suggests that this product is mostly applied for concrete joints, windows, roofs, and masonry. There is no evidence of its use in bathrooms or kitchens, thus EPA assumed primarily outdoor application and opted for the garage as the room of use based on potential for garage concrete floor repair and a high end CEM default use amount which corresponds to approximately six tubes of caulk.

Epoxy Floor Patch

Exposure to Epoxy Floor Patch was modeled in the garage using CEM's saved analysis "Generic P1 E1" with modifications for some key parameters as shown in Table 2-11 and Table 2-12.

The product identified is a two-part kit consisting of an activator and hardener that produces a quick curing putty used to repair cracks in concrete walls and floors. As the use is limited to repair and the product hardens quickly after mixing, the amount of product modeled was limited to 125 to 500 g and the duration of use was limited to 5 to 15 minutes.

Lacquer Sealer (Spray and Non-spray)

The lacquer sealer products identified may be applied to concrete, stone, and stucco surfaces through rolling or spraying application techniques. As such, the exposure to lacquer sealer was modeled in the whole house assuming that some or all of the finished floor of house is concrete. For the rolling application (non-spray) the CEM's saved analysis "Generic P2 E2" was used and for the spray application the CEM saved analysis "Generic P3 E3" was used. Modifications were made for some key parameters as shown in Table 2-11 and Table 2-12.

Duration of use and mass of product used were determined based on instructions for use and technical specification specific to identified products. The mass of product used per event was estimated based on an application rate of 400 sq. ft/gallon, density of 0.88 g/cm^3, and application to 1 room, 2 rooms, or whole house (300, 600, or 2,140 sq ft). The duration of use was assumed to be 480, 180, and 120 min/day for the high, medium, and low exposure scenarios.

The frequency of use was set to one event per day. As multiple coats may be applied, the frequency per year was increased to two.

2.2 Dermal Modeling Approach

Dermal modeling was done outside of CEM for liquid and solid products. However, for solid products EPA used CEM steady-state permeability coefficient equations in a computational approach outside CEM that bypassed the need for certain inputs required by CEM, like weight fractions and migration rates. For liquid products, the concentration of DIDP often exceeds its saturation concentration because DIDP molecules form weak chemical bonds with polymer chains in the product/article which favors migration out of the polymer. During direct dermal contact DIDP can migrate to the aqueous phase available in the skin surface or be weakly bound to the polymer. The fraction of DIDP associated with polymer chains is less likely to contribute to dermal exposure as compared to the aqueous fraction of DIDP because the chemical is strongly hydrophobic. As such, use of the CEM model for dermal absorption which relies on total concentration rather than aqueous saturation concentration would greatly overestimate exposure to DIDP in liquid chemicals.

Dermal absorption data related to DIDP are limited. Specifically, EPA identified only one study directly related to the dermal absorption of DIDP (Elsisi et al., 1989), which was an *in vivo* absorption study using male F344 rats. For each *in vivo* dermal absorption experiment, neat DIDP was applied to a freshly shaven area of 1.3 cm^2 in doses ranging from 5 to 8 mg/cm^2 and the site of application was covered with a perforated cap. Urine and feces were collected and analyzed every 24 hours for a duration of 7 days, and at the end of the seventh day, each rat was killed and all remaining contents (tissues, organs, *etc.*) were analyzed. Results of the study showed the average percent absorption of DIDP (both into and through the skin) over the 7-day period was 1.5 percent and the average material recovery was 82 percent. However, OECD 156 (2022) guidelines suggest that material recovery from dermal absorption testing of non-volatile compounds should be 90 to 110 percent. Because the material recovery of DIDP fell outside the recommended recovery range, OECD 156 (2022) guidelines suggest the following normalization of the percent absorption:

Normalized Percent Absorption of DIDP = (100/82) × (1.5%) = **1.8%**

OECD 156 (2022) states that this approach of normalizing percent absorption assumes that losses occurred in all matrices equally, which is reasonable considering the duration of the experiment and the fact that the cap was perforated.

Though there are no direct points of comparison for absorption of neat DIDP, there was an analogous *in vivo* dermal absorption study conducted for neat DINP (Midwest Research Institute, 1983). For each *in vivo* dermal absorption experiment, neat DINP was applied to a freshly shaven area of 3 cm x 4 cm at a dose of 8 mg/cm^2 and the site of application was covered with a styrofoam cup lined with aluminum foil. After 7 days of monitoring, the average percent absorption of DINP (both through and into the skin) was 3.06 percent and the average material recovery was 96.55 percent. Because it is expected that DINP is slightly more absorptive than DIDP due to the slightly shorter alkyl chain length of DINP compared to DIDP, the results of the study from the Midwest Research Institute (1983) provide additional credence to the results of DIDP absorption from Elsisi (1989).

With respect to interpretation of the DIDP dermal absorption data reported in Elsisi (1989), it is important to consider the relationship between the applied dermal load and the rate of dermal absorption. Specifically, the work of Kissel (2011) suggests the dimensionless term N_{derm} to assist with interpretation of dermal absorption data. The term N_{derm} represents the ratio of the experimental load (*i.e.*, application dose) to the steady-state absorptive flux for a given experimental duration as shown in the following equation.

Equation 2-21. Relationship Between Applied Dermal Load and Rate of Dermal Absorption

$$N_{derm} = \frac{Experimental\ load\ (\frac{mass}{area})}{Steady - State\ Flux\ \left(\frac{mass}{area * time}\right) \times Experimental\ duration\ (time)}$$

Kissel (2011) indicates that high values of N_{derm} (>> 1) suggest that supply of the material is in surplus and that the dermal absorption is considered "flux-limited," whereas lower values of N_{derm} indicate that absorption is limited by the experimental load and would be considered "delivery-limited." Furthermore, Kissel (2011) indicates that values of percent absorption for flux-limited scenarios are highly dependent on the dermal load and should not be assumed transferable to conditions outside of the experimental conditions. Rather the steady-state absorptive flux should be utilized for estimating dermal absorption of flux-limited scenarios. The application of N_{derm} to the DIDP dermal absorption data reported in Elsisi (1989) is shown below.

Equation 2-22. Ratio of the Experimental Dermal Load to Steady-State Flux Calculation

$$N_{derm} = \frac{8\ mg/cm^2}{\frac{8\frac{mg}{cm^2} \times 1.8\%}{7\ days \times \frac{24\ hrs}{day}} \times 7\ days \times \frac{24\ hrs}{day}} = 56$$

Because N_{derm} >> 1 for the experimental conditions of Elsisi (1989), it is shown that the absorption of DIDP is considered flux-limited even at finite doses (*i.e.*, less than 10 µL/cm^2 (OECD, 2004)) and that percent absorption is less meaningful than the steady-state absorptive flux. Therefore, the dermal absorption of DIDP was estimated based on the flux of material rather than percent absorption. Using an estimate of 1.8 percent absorption of 5 to 8 mg/cm^2 of DIDP over a 7-day period, a range of potential steady-state fluxes of DIDP is calculated below.

Low-End Flux = (1.8%) × (5mg/cm^2) / (7days x 24hrs/day) = 5.36E−04 mg/cm^2/hr

Midpoint Flux = (1.8%) × (6.5mg/cm^2) / (7days x 24hrs/day) = 6.96E−04 mg/cm^2/hr

High-End Flux = (1.8%) × (8mg/cm^2) / (7days x 24hrs/day) = 8.57E−04 mg/cm^2/hr

The dermal dose of DIDP associated with use of both liquid products and solid articles was calculated in a spreadsheet outside of CEM. See *Draft Consumer Exposure Analysis for Diisodecyl Phthalate (DIDP)* (U.S. EPA, 2024c). For each product or article, high, medium, and low exposure scenarios were developed. Values for duration or dermal contact and area of exposed skin were determined based on reasonably expected use for each item. In addition, high, medium, and low estimates for dermal flux were calculated and applied in the corresponding scenario.

As dermal absorption of DIDP has not been tested in humans and test data for *in vitro* studies were not identified, dermal flux of DIDP was estimated based on an *in vivo* absorption study that applied neat DIDP to a freshly shaven area on male F344 rats (Elsisi et al., 1989). The equation used to estimate the dermal dose of DIPD associated with routine use of consumer liquid products and articles is as follows:

Equation 2-23. Dermal Dose Per Exposure Event for Liquid Products

$$Dose\ per\ Event = Flux\ \times Duration\ of\ Use\ \times\ DA\ \times \frac{SA}{BW}$$

Where,

$Dose\ per\ Event$	=	amount of chemical absorbed, mg/kg by body weight
$Flux$	=	steady-state absorptive flux, mg/cm^2-hr
$Duration\ of\ use$	=	extent of time specific product/article is in use, hr
SA	=	surface area of body parts in direct contact with product/article, cm^2
BW	=	body weight by lifestage, kg

It is expected that dermal exposure to solid matrices would result in far less absorption, but there are no studies that report dermal absorption of DIDP from a solid matrix. For cases of dermal absorption of DIDP from a solid matrix, EPA assumes that DIDP will first migrate from the solid matrix to a thin layer of moisture on the skin surface. Therefore, absorption of DIDP from solid matrices is considered limited by aqueous solubility and is estimated using an aqueous absorption model as described below.

The first step in determining the dermal absorption through aqueous media is to estimate the steady-state permeability coefficient, K_p (cm/hr). EPA utilized CEM (U.S. EPA, 2023) to estimate the steady-state aqueous permeability coefficient of DIDP. Next, EPA relied on Equation 3.2 from the *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual, (Part E: Supplemental Guidance for Dermal Risk Assessment)* (U.S. EPA, 2004) which characterizes dermal uptake (through and into skin) for aqueous organic compounds. Specifically, Equation 3.2 from U.S. EPA (2004) was used to estimate the dermally absorbed dose (DA_{event}, mg/cm^2) for an absorption event occurring some duration (t_{abs}, hours) as shown below.

Equation 2-24. Dermal Absorption Dose During Absorption Event for a Solid Product and Article

$$DA_{event} = 2 \times FA \times K_p \times S_W \times \sqrt{\frac{6 \times t_{lag} \times t_{abs}}{\pi}}$$

Where:

DA_{event} = Dermally absorbed dose during absorption event t_{abs} (mg/cm^2)
FA = Effect of stratum corneum on quantity absorbed = 0.68 [see Exhibit A-5 of U.S. EPA (2004)]
K_p = Permeability coefficient = 0.0071cm/hr (calculated using CEM (U.S. EPA, 2023))
S_w = Water solubility = 0.33 mg/L [Mean value determined from the following studies: (NLM, 2020; EC/HC, 2017; ECJRC, 2003a; NTP-CERHR, 2003; Letinski et al., 2002; Howard et al., 1985; SRC, 1983)]
t_{lag} = $0.105*10^{0.0056MW} = 0.105*10^{0.0056*446.68}$ = 33.3 hours [calculated from A.4 of U.S. EPA (2004)]
t_{abs} = Duration of absorption event (hours)

By dividing the dermally absorbed dose (DA_{event}) by the duration of absorption (t_{abs}), the resulting expression yields the average absorptive flux. Figure 2-2 illustrates the relationship between the average absorptive flux and the absorption time.

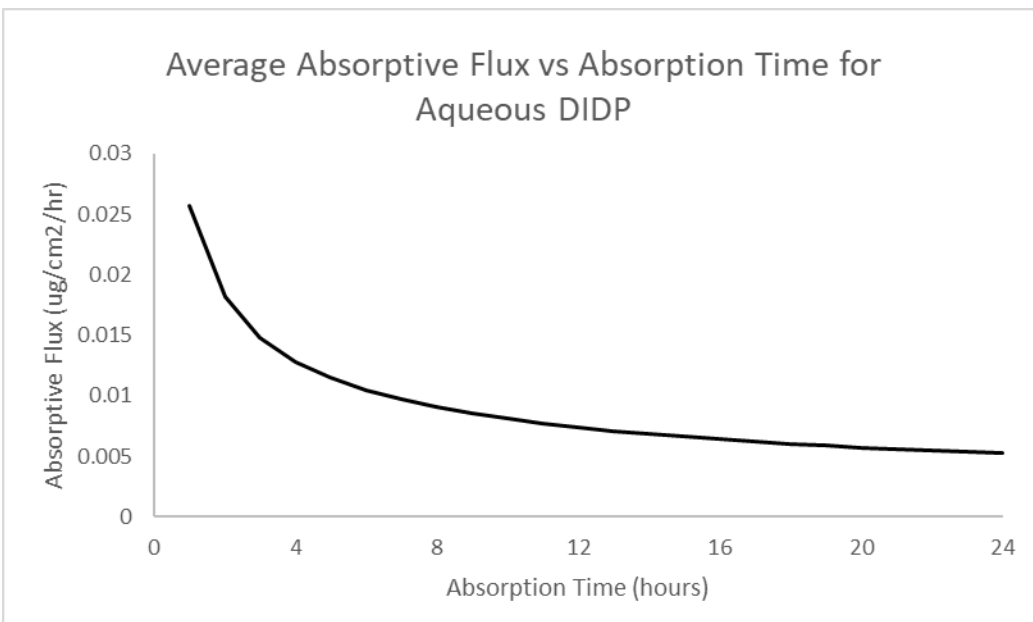

Figure 2-2. Average Absorptive Flux Absorbed into and through Skin as Function of Absorption Time

Figure 2-2 shows that the average absorptive flux for aqueous DIDP is expected to vary between 0.005 and 0.025 $\mu g/cm^2/hr$ for durations between 1-hour and 1-day, and the average absorptive flux for an 8-hr exposure is 0.00899 $\mu g/cm^2/hr$. The estimation of average flux of aqueous material through and into the skin is dependent on the duration of absorption and must be determined based on the scenario under assessment. The range of estimated steady-state fluxes of DIDP presented in this section, based on modeling from (U.S. EPA, 2004), is considered representative of dermal exposures to solid materials or articles containing DIDP.

After calculating dermal absorption dose per event for each lifestage, chronic average daily dose, acute average daily dose, and intermediate average daily dose were calculated as described below.

Acute dose rate for direct dermal contact with product or article was calculated as follows:

Equation 2-25. Acute Dose Rate for Dermal

$$ADR_{Dermal} = Dose\ per\ Event \times Acute\ Frequency$$

Where:

ADR_{Dermal} = acute dose rate for dermal contact, mg/kg-day by body weight,
$Dose\ per\ Event$ = amount of chemical absorbed per use, mg/kg by body weight, and
$Acute\ Frequency$ = acute frequency of use, day $^{-1}$, see Table 2-13 for input parameters.

Chronic average daily dose rate for direct dermal contact with product or article was calculated as follows:

Equation 2-26. Chronic Average Daily Dose Rate for Dermal

$$CADD_{Dermal} = Dose\ per\ Event \times Chronic\ Frequency$$

Where:

$CADD_{Dermal}$ = chronic dermal rate for dermal contact, mg/kg-day by body weight,
$Dose\ per\ Event$ = amount of chemical absorbed per use, mg/kg by body weight, and
$Chronic\ Frequency$ = chronic frequency of use, day $^{-1}$, see Table 2-13 for input parameters

2.2.1 Modeling Inputs and Parameterization

Key parameters for the dermal model are shown in Table 2-13. The subsections under Table 2-13 provide additional details on key parameters, assumptions, and sources of the information. Calculations, sources, input parameters and results are also available in *Draft Consumer Exposure Analysis for Diisodecyl Phthalate (DIDP)* (U.S. EPA, 2024c).

Table 2-13. Key Parameters Used in Dermal Models

Product	Scenario	Duration of Use (hr)	Frequency of Use (year^{-1})	Frequency of Use (day^{-1})	Dermal Absorption[a] or Flux[b] (mg/cm^2/hour)	Contact Area
Adult Toys	High	1	365	1	2.54E−05	Inside of one hand (palms, fingers)
	Medium	0.5	365	1	1.80E−05	
	Low	0.25	365	1	1.27E−05	
Auto Transmission Conditioner	High	0.25	1	1	2.54E−05	Inside of one hand (palms, fingers)
	Medium	0.17	1	1	1.80E−05	
	Low	0.08	1	1	1.27E−05	
Bags	High	1	365	1	2.54E−05	Inside of one hand (palms, fingers)
	Medium	0.5	365	1	1.80E−05	

Product	Scenario	Duration of Use (hr)	Frequency of Use (year^{-1})	Frequency of Use (day^{-1})	Dermal Absorption[a] or Flux[b] (mg/cm^2/hour)	Contact Area
	Low	0.25	365	1	1.27E−05	
Children's Toys (legacy)	High	2.28	365	1	2.54E−05	Inside of one hand (palms, fingers)
	Medium	1.47	365	1	1.80E−05	
	Low	0.40	365	1	1.27E−05	
Children's Toys (new)	High	2.28	365	1	2.54E−05	Inside of one hand (palms, fingers)
	Medium	1.47	365	1	1.80E−05	
	Low	0.40	365	1	1.27E−05	
Construction Adhesive for Small Scale Projects	High	1	52	3	8.57E−04	Inside of one hand (palms, fingers)
	Medium	0.33	52	3	6.96E−04	
	Low	0.17	52	3	5.36E−04	
Construction Sealant for Large Scale Projects	High	4	3	1	8.57E−04	Inside of one hand (palms, fingers)
	Medium	2	3	1	6.96E−04	
	Low	1	3	1	5.36E−04	
Epoxy Floor Patch	High	0.25	1	1	8.57E−04	Inside of one hand (palms, fingers)
	Medium	0.17	1	1	6.96E−04	
	Low	0.08	1	1	5.36E−04	
Fitness Ball	High	1	365	1	2.54E−05	Inside of two hands (palms, fingers)
	Medium	0.5	365	1	1.80E−05	
	Low	0.25	365	1	1.27E−05	
Foam Flip Flops	High	8	365	1	2.54E−05	Inside of two hands (palms, fingers)
	Medium	4	365	1	1.80E−05	
	Low	2	365	1	1.27E−05	
Lacquer Sealer (Non-Spray)	High	8	2	1	8.57E−04	Inside of one hand (palms, fingers)
	Medium	3	2	1	6.96E−04	
	Low	2	2	1	5.36E−04	
Lacquer Sealer (Spray)	High	8	2	1	8.57E−04	10% of Hands (some fingers)
	Medium	3	2	1	6.96E−04	
	Low	2	2	1	5.36E−04	
Miscellaneous Coated Textiles	High	1	365	1	2.54E−05	Inside of one hand (palms, fingers)
	Medium	0.5	365	1	1.80E−05	
	Low	0.25	365	1	1.27E−05	
Rubber Eraser	High	1	365	1	2.54E−05	10% of Hands (some fingers)
	Medium	0.5	365	1	1.80E−05	
	Low	0.25	365	1	1.27E−05	
Shower Curtain	High	1	365	1	2.54E−05	

Product	Scenario	Duration of Use (hr)	Frequency of Use (year^{-1})	Frequency of Use (day^{-1})	Dermal Absorption[a] or Flux[b] (mg/cm^2/hour)	Contact Area
	Medium	0.5	365	1	1.80E−05	Inside of one hand (palms, fingers)
	Low	0.25	365	1	1.27E−05	
Solid Flooring	High	2	365	1	2.54E−05	Inside of one hand (palms, fingers)
	Medium	1	365	1	1.80E−05	
	Low	0.5	365	1	1.27E−05	
Synthetic Leather Clothing	High	8	365	1	2.54E−05	50% of Entire Body Surface Area
	Medium	4	365	1	1.80E−05	25% of Face, Hands, and Arms
	Low	2	365	1	1.27E−05	10% of Hands (some fingers)
Synthetic Leather Furniture	High	8	365	1	2.54E−05	50% of Entire Body Surface Area
	Medium	4	365	1	1.80E−05	25% of Face, Hands, and Arms
	Low	2	365	1	1.27E−05	10% of Hands (some fingers)
Wallpaper (Routine Contact)	High	1	365	1	2.54E−05	Inside of one hand (palms, fingers)
	Medium	0.33	365	1	1.80E−05	
	Low	0.17	365	1	1.27E−05	
Wallpaper (Installation)	High	4	1	1	2.54E−05	Inside of two hands (palms, fingers)
	Medium	2	1	1	1.80E−05	
	Low	1	1	1	1.27E−05	
Wire Insulation	High	1	365	1	2.54E−05	Inside of one hand (palms, fingers)
	Medium	0.5	365	1	1.80E−05	
	Low	0.25	365	1	1.27E−05	

[a] Dermal Absorption (DA) for solid products and articles was calculated using Equation 2-24
[b] Flux for liquid products was calculated using Equation 2-23

Duration of Use/Article Contact Time

The same duration of use applied in CEM modeling for products was used for the spreadsheet dermal modeling. For articles, which do not use duration of use as an input in CEM, professional judgement was used to select the duration of use/article contact for the low, medium, and high exposure scenario levels. Values of 0.25, 0.5 and 1 hr were assigned to articles anticipated to have low durations of use (bags, fitness ball, miscellaneous coated textile, rubber eraser, shower curtain, and wire insulation). This was lowered slightly for routine contact with wallpaper (0.17, 0.33, and 1 hr) in which contact is less intentional. For the installation of wallpaper, however, values of 1, 2, and 4 hrs were selected based on professional judgement. Values of 2, 4 or 8 hrs were applied to flip flops, clothing and sofas which are articles intended to be worn or contacted for longer periods of time. Values for solid flooring are based on EPA's Standard Operating Procedures for Residential Pesticide Exposure Assessment for the high exposure level (2 hrs; time spent on hard surfaces), ConExpo for the medium exposure level (1 hr; time a child spends crawling on treated floor), and professional judgement for the low exposure level (0.5 hr)

(U.S. EPA, 2012).

Frequency of Use

The same frequency of use (per year and per day) that was applied in CEM modeling was used for the spreadsheet dermal modeling. For articles which were not modeled in CEM, it was assumed that the article could be used daily, every day of the year. For wallpaper installation, it was assumed that there would only be one event per day and one event per year.

Weight Fractions

The weight fraction information provided below is for contextual purposes only, as the dermal modeling methodology used does not incorporate weight fraction as a model input.

Bags

EPA did not identify information from manufacturers about the specific plasticizers used in making bags due to confidentiality. The actual producers of the PVC bags are also regarded as confidential, leaving no way to obtain further information about the production process. ECHA (2012) is a European assessment that investigated and reported the content of phthalates in bags in both 2001, 2007 and in 2010. The bags investigated in 2010 were bags for children. In 2001, three bags that were analyzed for phthalates contained DEHP in concentrations from 12 to 21 percent. One of the three bags also contained a mix of DINP and DIDP at 11 percent and BBP at less than 1 percent. The concentration of DIDP used (11%) is a mix of DINP and DIDP because it was impossible to apportion the contribution to the total concentration.

Flip Flops

ECHA (2012) reported a Swedish investigation that measured phthalate concentrations in the PVC of the tested footwear at up to 23.2 percent for DEHP, up to 9.6 percent for DBP, no BBP, up to 19.4 percent for DNOP, up to 3.2 percent for DINP, and up to 4.7 percent for DIDP. The investigation also showed that the phthalate content in shoes did not differ by the country in which the shoes were manufactured. No U.S. based information on footwear was identified. EPA used this report in lieu of U.S. specific imports.

Fitness Balls

Based on information from the manufacturers, European production of large plastic balls seems to be made of PVC without phthalates. However, information on the used plasticizers is confidential, and several manufacturers confirmed that the balls are made of or contain PVC. The plasticizers used are DINP or acetyl-tri-n-butylcitrate (ATBC). DIDP and DIOP are used together with DINP. One manufacturer informs that DEHP may be observed in small concentrations (< 0.1%). No other data on the concentration of plasticizers are available, thus EPA used 0.1 percent as the DIDP weight fraction in fitness balls.

ECHA (2012) reported on the concentration of several phthalates in 10 fitness balls in 2010. The analyses showed that two of the analyzed balls contained DEHP or DIBP in concentrations above 1 percent. DINP was detected in five balls, but the amount of the phthalates was not quantified. For soccer balls made of PVC, one manufacturer informs that the balls do not contain DINP, DNOP, DIDP, BBP, DBP and DIHP, but traces of DEHP (concentrations negligible) may be registered. Another large producer reported that DEHP and DBP are used in very low concentrations (<1%). In both cases, no information on the main plasticizers used was available.

Miscellaneous Coated Textile

ACC HPP (2023) reported on coated textiles, especially for outdoor applications like roofs for sports arenas and truck awnings, at 30 to 40 percent weight fraction.

3 INDOOR DUST EXPOSURE APPROACH AND METHODOLOGY

In this indoor exposure assessment, EPA considered modeling and monitoring data. Modeling data used in indoor dust assessment originated from the consumer exposure assessment, Section 2, to reconstruct major indoor sources of DIDP into dust and obtain COU and product specific exposure estimates for ingestion and inhalation. The monitoring data considered are from residential dust samples from studies conducted in countries with comparable standards of living to the United States. Measured DIDP concentrations were compared to determine consistency among data sets, and data from Canada were ultimately selected as the most representative of United States residential dust exposures. Given the complexity of source apportionment in exposure assessment for chemicals in indoor dust, EPA used several non-US monitoring studies to generate a moderate confidence estimate of overall DIDP exposure from ingestion of indoor dust. The monitoring studies and assumptions made to estimate exposure are described in Section 3.2.

3.1 Indoor Dust Modeling

The main objective in recreating the indoor environment using consumer products and articles commonly present in indoor spaces is to calculate exposure and risk estimates by COU, and if possible, byproduct and article from indoor dust ingestion and inhalation using the CEM outputs in Section 2. Because monitoring data can lack source apportionment, contributions from specific products and articles to the concentration of a chemical in dust may not be apparent. In the consumer exposure assessment, Section 2.1.2.1, EPA identified article specific information by COU to construct relevant and representative exposure scenarios. Exposure to DIDP via ingestion of dust was assessed for all articles expected to contribute significantly to dust concentrations due to high surface area (> ~1 m^2) for either a single article or collection of like articles as appropriate. This included

- solid flooring,
- wallpaper,
- synthetic leather furniture,
- shower curtains,
- children’s toys, both legacy and new, and
- wire insulation.

These exposure scenarios were modeled in CEM for inhalation, ingestion of suspended dust, and ingestion dust from surfaces. See Section 2.1.2.1 for CEM parameterization, input values, and article specific scenario assumptions and sources.

3.2 Indoor Dust Monitoring

Twenty studies containing potential residential indoor dust monitoring data for DIDP were identified during systematic review. No US data was identified in these monitoring studies; however, residential monitoring data from Canada, Belgium, Holland, Ireland, and Norway were identified in two studies (Giovanoulis et al., 2017) and (Christia et al., 2019). The remaining studies were not considered because they either did not have DIDP dust monitoring data or contained only non-residential DIDP dust monitoring data. The studies that contained residential DIDP dust monitoring data were compared to confirm that observed DIDP concentrations were reasonably similar to one another (within one order of magnitude) and to identify similarities and differences in sampled population and sampling methods. Evaluating the sampled population and sampling methods across studies was important to determine whether the residential monitoring data were comparable between studies; studies with broadly representative populations (*i.e.*, not focused on a particular subpopulation or geographic area) and similar sampling methods (*e.g.*, vacuum sampling versus dust-wipe sampling) were comparable.

Because no US indoor dust monitoring data for DIDP were identified, EPA evaluated non-US data. The primary data source was the Canadian House Dust Study, as reported in the Canadian 2015 State of the Science Report (EC/HC, 2015). The basis for the estimated daily DIDP ingestion dose (intake rate) for dust was from Kubwabo et al. (2013), in which 126 households were sampled as part of the Canadian House Dust Study. Table 3-1 summarizes the DIDP findings for Kubwabo et al. (2013).

Table 3-1. Detection and Quantification of DIDP in House Dust from Kubwabo et al. (2013)

	House Dust (Total)	Participant-Collected Dust (Paired)	Vacuum Sampler Dust (Paired)
N	126	38	38
Median (µg/g)	111	128	46
Min	5.3	5.4	11.6
Max	1428	602	159
Detection Frequency (%)	100	100	100

Total house dust samples were collected by the study participants themselves from their home vacuum cleaners. In a subset of households (n=38), paired dust samples (Vacuum Sampler Dust [VSD] & Participant-Collected Dust [PCD]) were collected in which VSD was collected by the researchers using a Pullman Holt vacuum sampler according to the VDI 4300 standard sampling protocol (VDI, 2001). This sampling method pulls the dust directly into the vacuum bag without coming into contact with any parts of the vacuum, minimizing cross-contamination. The paired samples showed significantly lower concentrations in the VSD samples than in the conventionally collected house dust samples (Wilcoxon rank sum test, $p<0.001$). The samples were not taken in identical locations, with the VSD samples taken from dry living areas only, avoiding kitchens, bathrooms, and workrooms. The authors note that "…differences in the [PCD] versus [VSD] samples most likely reflect the variability in spatial distribution of these compounds across different areas of the home." The EC/HC (2015) report used the total house dust values reported in Table 3-1.

Data from the Canadian House Dust Study were also compared with existing literature that fulfilled the following criteria: data collected 2010 or later, from a high-income country, and in a residence. After applying these filters to the data identified in systematic review, two studies were identified. They are summarized in Table 3-2.

Table 3-2. Comparator Studies with DIDP Concentrations in Residences

Study	Location	Year [a]	Residences	DIDP Concentration(s) (µg/g)
Giovanoulis et al. (2017)	Oslo, Norway	2013-2014	Floor samples: 60	Floor Dust: 50th percentile: 139.5 95th percentile: 806.3
			Vacuum samples: 58	Vacuum Cleaner Dust: 50th percentile: 140.2 95th percentile: 496.6
Christia et al. (2019)	Belgium	2017	18	Mean (SD): 52 (67) Median: 26 Min: 5.2 Max: 296
	Ireland	2017	6	Mean (SD): 84 (27) Median: 72 Min: 62 Max: 121
	Holland	2017	9	Mean (SD): 59 (49) Median: 34 Min: N.D. (less than LOQ) Max: 152

[a] The year data were collected.

These studies, representing samples from four European countries, show median DIDP concentrations in house dust that are well within an order of magnitude of the median total house dust value from Kubwabo et al. (2013). The range within an order of magnitude of the median total house dust value from Kubwabo et al. (2013) was 11.1 to 1110 µg/g, and the range of median values was from 26 µg/g in the Belgian samples from Christia et al. (2019), to 140.2 µg/g in the vacuum samples from Norway in Giovanoulis et al. (2017). The Dutch and Irish median values in Christia et al. (2019) were 34 µg/g and µg/g, respectively. Therefore, the concentrations from the Canadian House Dust Study are consistent with results from residents in similar income countries during a similar time period. It is thus appropriate to use this data as a surrogate for U.S. exposure.

The EC/HC (2015) report estimated daily intakes for DIDP for the general Canadian population (ages 0 to 60+ years, binned into age ranges of varying widths as shown in Table 3-3). The EC/HC (2015) report gives the central tendency (50th percentile) and upper bound (95th percentile) concentrations of DIDP as 111 µg/g and 433.9 µg/g respectively.

Table 3-3. EC/HC Estimates of Daily Intake for DIDP, µg/kg-day

0-0.5 years "Infant" [a]	0.5-4 years "Toddler"	5-11 years "Child"	12-19 years "Teen"	20-59 years "Adult"	60+ years "Senior"
0.562 (2.199) [b]	0.394 (1.540)	0.186 (0.728)	0.007 (0.026)	0.006 (0.025)	0.006 (0.024)

[a] Lifestage names correspond to those given in Wilson et al. (2013)
[b] Median (95th percentile)

Dust intakes in the EC/HC (2015) report were derived from Wilson et al. (2013). This study provides a range of dust ingestion rates by age based on the mixture of hard versus soft surfaces an individual contacts and whether a deterministic or probabilistic approach is used (Tables 3 and 4 in Wilson et al. (2013)). Using the given DIDP intake rates and assumed body weights by lifestage given in EC/HC

(2015), it was possible to determine the dust ingestion rates that were used (Equation 3-1).

Equation 3-1. Derivation of Dust Ingestion Rate

$$Dust\ ingestion\ \left(\frac{mg\ dust}{day}\right) = \frac{DIDP\ intake\ \left(\frac{\mu g\ DIDP}{kg\ bw \times day}\right) \times kg\ bw}{Dust\ concentration\ \left(\frac{\mu g\ DIDP}{g\ dust}\right)} \times \frac{1000\ mg}{1\ g}$$

EPA obtained more recent US sources for dust ingestion rate and body weights rather than using the Canadian values from the EC/HC (2015) report. Özkaynak et al. (2022) was published with several EPA co-authors and used the Stochastic Human Exposure Dose Simulation (SHEDS) model to estimate dust and soil ingestion for children ages 0-21 years old. The SHEDS model was parameterized with U.S. data, including the Consolidated Human Activity Database (CHAD) diaries. This most recent version incorporates new data for young children including pacifier and blanket use, which is important because dust and soil ingestion is higher in young children relative to older children and adults. Geometric mean and 95th percentile dust ingestion rates for ages 0 to 21 years were taken from Özkaynak et al. (2022) to estimate DIDP intakes in dust (Table 4-4). The geometric mean was used as the measure of central tendency because the distribution of intakes is skewed. It is worth noting that in Özkaynak et al. (2022), the authors compared the arithmetic mean of soil plus dust intake rates for children up to 11 years old with the arithmetic means from Wilson et al. (2013). This comparison showed that the values are similar: 48-56 mg/day in Özkaynak et al. (2022) and 55-61 mg/day in Wilson et al. (2013).

Body weights representative of the US population were taken from the Exposure Factors Handbook (U.S. EPA, 2011b). DIDP ingestion via dust was calculated according to Equation 3-1 for two scenarios: central tendency (GM dust ingestion, mean DIDP concentration in dust) and high end (GM dust ingestion, 95th percentile DIDP concentration in dust).

Equation 3-2. Calculation of DIDP Intake

$$DIDP\ intake\ \left(\frac{\mu g\ DIDP}{kg\ bw \times day}\right) = \frac{Dust\ ingestion\ \left(\frac{mg\ dust}{day}\right) \times Dust\ concentration\ \left(\frac{\mu g\ DIDP}{g\ dust}\right)}{kg\ bw} \times \frac{1\ g}{1000\ mg}$$

Özkaynak et al. (2022) did not estimate dust ingestion rates for ages beyond 21 years. However, the Exposure Factors Handbook does not differentiate dust or soil ingestion beyond 12 years old (U.S. EPA, 2017). Therefore, ingestion rates for 16 to 21 years, the highest age range estimated in Özkaynak et al. (2022), were used for ages beyond 21 years. Using body weight estimates from the Exposure Factors Handbook, estimates were calculated for DIDP intake for 21 to >80 years (Table 4-5).

4 RESULTS

4.1 Consumer Exposure Results

This section summarizes the dose estimates from inhalation, ingestion, and dermal exposure to DIDP in consumer products and articles. Exposure via the inhalation route occurs from inhalation of DIDP gas-phase emissions or when DIDP partitions to suspended particulate from direct use or application of products and articles. Exposure via the dermal route occurs from direct contact with products and articles. Exposure via ingestion depends on the product or article use patterns. It can occur via direct mouthing (*i.e.*, directly putting an article in mouth) or ingestion of suspended and/or settled dust when DIDP migrates from a product or article to dust or partitions from gas-phase to dust.

4.1.1 Acute Dose Rate Results, Conclusions, and Data Patterns

Table 4-1 summarizes all the high, medium, and low acute dose rate results from modeling in CEM and outside of CEM (dermal only) for all exposure routes and all lifestages. Products and articles marked with a dash (-) did not have dose results because the product or article was not targeted for that lifestage or exposure route. Dose results applicable to bystanders are flagged with †. Bystanders are people that are not in direct use or application of a product but can be exposed to DIDP by proximity to the use of the product via inhalation of gas-phase emissions or suspended dust. Dermal exposures from users are expected to have higher exposure concentrations than incidental dermal contact by bystanders. Some product scenarios were assessed for bystanders for children under 10 years and as users for older than 11 years because the products were not targeted for very young children (<10 yrs). In instances where a lifestage could reasonably be either a product user or bystander, the user scenarios inputs were selected as proximity to the product during use would result in larger exposure doses. The main purpose of Table 4-1 is to summarize acute dose rate results, show which products or articles did not have a quantitative result, and which results are used for bystanders. Data patterns are illustrated in figures after the table and includes summary descriptions of the patterns by exposure route and population or lifestage.

Table 4-1. Acute Dose Rate Results for All Exposure Routes for All Lifestages

Consumer COU Category and Subcategory	Product / Article	Exposure Route	Scenario	Acute Dose Rate (ADR) (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1-3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6-10 years)*	Young Teen (11-15 years)	Teenagers (16-20 years)	Adult (≥21 years)
Other: Novelty Products	Adult Toys	Dermal	H	-	-	-	-	-	7.4E−02	7.9E−02
			M	-	-	-	-	-	5.2E−02	5.6E−02
			L	-	-	-	-	-	3.7E−02	3.9E−02
		Ingestion by mouthing	H	-	-	-	-	-	2.8E−01	2.5E−01
			M	-	-	-	-	-	4.6E00	4.2E00
			L	-	-	-	-	-	3.1E01	2.8E01
Automotive, fuel, agriculture, outdoor use products: Lubricants	Auto Transmission Conditioner	Dermal	H	-	-	-	-	6.8E−01	6.2E−01	6.6E−01
			M	-	-	-	-	3.7E−01	3.4E−01	3.6E−01
			L	-	-	-	-	1.4E−01	1.3E−01	1.4E−01
		Inhalation† († bystander scenario)	H	2.3E−03†	2.2E−03†	1.8E−03†	1.2E−03†	9.4E−04	8.0E−04	6.4E−04
			M	1.1E−03†	1.0E−03†	8.4E−04†	5.9E−04†	4.5E−04	3.8E−04	3.1E−04
			L	3.3E−04†	3.1E−04†	2.5E−04†	1.8E−04†	1.4E−04	1.2E−04	9.3E−05
Packaging, paper, plastic, hobby products: Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Bags	Dermal	H	-	-	1.3E−01	1.0E−01	8.1E−02	7.4E−02	7.9E−02
			M	-	-	8.9E−02	7.2E−02	5.7E−02	5.2E−02	5.6E−02
			L	-	-	6.3E−02	5.1E−02	4.0E−02	3.7E−02	3.9E−02
Packaging, paper, plastic, hobby products: Toys, Playground, and Sporting Equipment	Legacy Children's Toys	Dermal	H	2.6E−01	2.2E−01	1.9E−01	1.5E−01	1.2E−01	1.1E−01	-
			M	2.1E−01	1.8E−01	1.5E−01	1.2E−01	9.8E−02	8.9E−02	-
			L	1.1E−01	9.2E−02	8.0E−02	6.4E−02	5.1E−02	4.7E−02	-
		Ingestion	H	9.5E−04	9.0E−04	7.3E−04	5.1E−04	3.6E−04	3.1E−04	2.5E−04

Consumer COU Category and Subcategory	Product / Article	Exposure Route	Scenario	Acute Dose Rate (ADR) (µg/kg-day)						
				Infant (<1 Year)*	**Toddler (1-3 Years)***	**Preschooler (3-5 years)***	**Middle Childhood (6-10 years)***	**Young Teen (11-15 years)**	**Teenagers (16-20 years)**	**Adult (≥21 years)**
		suspended dust**	M	5.6E−04	5.2E−04	4.3E−04	3.0E−04	2.1E−04	1.8E−04	1.4E−04
			L	4.1E−04	3.9E−04	3.2E−04	2.2E−04	1.5E−04	1.3E−04	1.1E−04
		Ingestion dust on surface**	H	1.5E00	1.9E00	2.1E00	7.5E−01	4.2E−01	3.3E−01	3.4E−02
			M	3.5E−01	4.3E−01	4.8E−01	1.7E−01	9.5E−02	7.6E−02	4.9E−03
			L	5.0E−02	6.2E−02	7.0E−02	2.5E−02	1.4E−02	1.1E−02	1.5E−01
		Ingestion by mouthing	H	3.3E−02	2.0E−02	2.8E−02	-	-	-	-
			M	6.5E00	2.6E00	8.6E−01	-	-	-	-
			L	3.7E01	9.8E00	5.0E00	-	-	-	-
		Inhalation**	H	3.8E01	3.6E01	2.9E01	2.0E01	1.4E01	1.2E01	9.9E00
			M	8.3E00	7.8E00	6.4E00	4.4E00	3.1E00	2.7E00	2.2E00
			L	8.8E−01	8.3E−01	6.7E−01	4.7E−01	3.3E−01	2.8E−01	2.3E−01
Packaging, paper, plastic, hobby products: Toys, Playground, and Sporting Equipment	New Children's Toys	Dermal	H	2.6E−01	2.2E−01	1.9E−01	1.5E−01	1.2E−01	1.1E−01	-
			M	2.1E−01	1.8E−01	1.5E−01	1.2E−01	9.8E−02	8.9E−02	-
			L	1.1E−01	9.2E−02	8.0E−02	6.4E−02	5.1E−02	4.7E−02	-
		Ingestion suspended dust**	H	3.7E−06	3.5E−06	2.8E−06	2.0E−06	1.4E−06	1.2E−06	9.5E−07
			M	2.4E−06	2.3E−06	1.9E−06	1.3E−06	9.1E−07	7.8E−07	6.2E−07
			L	2.1E−06	1.9E−06	1.6E−06	1.1E−06	7.7E−07	6.6E−07	5.3E−07
		Ingestion dust on surface**	H	5.9E−03	7.3E−03	8.3E−03	2.9E−03	1.6E−03	1.3E−03	1.5E−04
			M	1.5E−03	1.9E−03	2.1E−03	7.4E−04	4.1E−04	3.3E−04	2.4E−05
			L	2.5E−04	3.1E−04	3.5E−04	1.2E−04	6.9E−05	5.5E−05	5.8E−04
		Ingestion by mouthing	H	3.3E−02	2.0E−02	2.8E−02	-	-	-	-
			M	6.5E00	2.6E00	8.6E−01	-	-	-	-

Consumer COU Category and Subcategory	Product / Article	Exposure Route	Scenario	Acute Dose Rate (ADR) (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1-3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6-10 years)*	Young Teen (11-15 years)	Teenagers (16-20 years)	Adult (≥21 years)
			L	3.7E01	9.8E00	5.0E00	-	-	-	-
		Inhalation**	H	1.5E−01	1.4E−01	1.1E−01	7.9E−02	5.5E−02	4.7E−02	3.8E−02
			M	3.6E−02	3.4E−02	2.8E−02	1.9E−02	1.4E−02	1.2E−02	9.4E−03
			L	4.4E−03	4.1E−03	3.4E−03	2.3E−03	1.6E−03	1.4E−03	1.1E−03
Construction, paint, electrical, and metal products: Adhesives and sealants	Construction Adhesive for Small Scale Projects	Dermal	H	-	-	-	-	8.1E00	7.5E00	8.0E00
			M	-	-	-	-	2.2E00	2.0E00	2.2E00
			L	-	-	-	-	8.5E−01	7.8E−01	8.3E−01
		Inhalation† († bystander scenario)	H	†2.2E−01	†2.0E−01	†1.7E−01	†1.2E−01	9.0E−02	7.7E−02	6.2E−02
			M	†3.0E−02	†2.9E−02	†2.3E−02	†1.6E−02	1.3E−02	1.1E−02	8.8E−03
			L	†1.3E−03	†1.2E−03	†9.7E−04	†6.8E−04	5.4E−04	4.6E−04	3.7E−04
Construction, paint, electrical, and metal products: Adhesives and sealants	Construction Sealant for Large Scale Projects	Dermal	H	-	-	-	-	1.1E01	9.9E00	1.1E01
			M	-	-	-	-	4.4E00	4.0E00	4.3E00
			L	-	-	-	-	1.7E00	1.6E00	1.7E00
		Inhalation († bystander scenario)	H	†1.2E00	†1.1E00	†9.2E−01	†6.4E−01	8.2E−01	6.4E−01	5.5E−01
			M	†2.7E−01	†2.5E−01	†2.0E−01	†1.4E−01	1.1E−01	9.6E−02	7.8E−02
			L	†5.6E−04	†5.3E−04	†4.3E−04	†3.0E−04	2.2E−04	1.9E−04	1.5E−04
Construction, paint, electrical, and metal products: Adhesives and sealants	Epoxy Floor Patch	Dermal	H	-	-	-	-	6.8E−01	6.2E−01	6.6E−01
			M	-	-	-	-	3.7E−01	3.4E−01	3.6E−01
			L	-	-	-	-	1.4E−01	1.3E−01	1.4E−01
		Inhalation († bystander scenario)	H	†6.9E−01	†6.5E−01	†5.3E−01	†3.7E−01	2.8E−01	2.4E−01	1.9E−01
			M	†1.7E−01	†1.6E−01	†1.3E−01	†9.2E−02	7.1E−02	6.0E−02	4.9E−02
			L	†7.2E−04	†6.8E−04	†5.5E−04	†3.9E−04	3.0E−04	2.5E−04	2.0E−04

Consumer COU Category and Subcategory	Product / Article	Exposure Route	Scenario	Acute Dose Rate (ADR) (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1-3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6-10 years)*	Young Teen (11-15 years)	Teenagers (16-20 years)	Adult (≥21 years)
Packaging, paper, plastic, hobby products: Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Fitness Ball	Dermal	H	-	-	-	-	8.1E−02	7.4E−02	7.9E−02
			M	-	-	-	-	5.7E−02	5.2E−02	5.6E−02
			L	-	-	-	-	4.0E−02	3.7E−02	3.9E−02
Packaging, paper, plastic, hobby products: Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Foam Flip Flops	Dermal	H	-	-	3.6E−01	2.9E−01	2.3E−01	2.1E−01	2.2E−01
			M	-	-	2.5E−01	2.0E−01	1.6E−01	1.5E−01	1.6E−01
			L	-	-	1.8E−01	1.4E−01	1.1E−01	1.0E−01	1.1E−01
Construction, paint, electrical, and metal products: Adhesives and sealants, and Paints and Coatings	Lacquer Sealer (Non-Spray)	Dermal	H	-	-	-	-	2.2E01	2.0E01	2.1E01
			M	-	-	-	-	6.6E00	6.1E00	6.5E00
			L	-	-	-	-	3.4E00	3.1E00	3.3E00
		Inhalation († bystander scenario)	H	†2.8E00	†2.7E00	†2.2E00	†1.7E00	1.3E00	1.0E00	9.0E−01
			M	†2.8E00	†2.6E00	†2.2E00	†1.6E00	1.1E00	9.3E−01	7.7E−01
			L	†2.8E00	†2.6E00	†2.1E00	†1.5E00	1.1E00	9.2E−01	7.5E−01
Construction, paint, electrical, and metal products: Adhesives and sealants, and Paints and Coatings	Lacquer Sealer (Spray)	Dermal	H	-	-	-	-	8.7E00	7.9E00	8.5E00
			M	-	-	-	-	2.6E00	2.4E00	2.6E00
			L	-	-	-	-	1.4E00	1.2E00	1.3E00
		Inhalation († bystander scenario)	H	†2.8E00	†2.7E00	†2.2E00	†1.8E00	1.4E00	1.1E00	9.2E−01
			M	†2.8E00	†2.7E00	†2.2E00	†1.6E00	1.2E00	9.6E−01	7.9E−01
			L	†2.7E00	†2.5E00	†2.1E00	†1.5E00	1.1E00	9.5E−01	7.8E−01
	Miscellaneous	Dermal	H	-	-	-	-	8.1E−02	7.4E−02	7.9E−02

Consumer COU Category and Subcategory	Product / Article	Exposure Route	Scenario	Acute Dose Rate (ADR) (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1-3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6-10 years)*	Young Teen (11-15 years)	Teenagers (16-20 years)	Adult (≥21 years)
	Coated Textiles		M	-	-	-	-	5.7E−02	5.2E−02	5.6E−02
			L	-	-	-	-	4.0E−02	3.7E−02	3.9E−02
Packaging, paper, plastic, hobby products: Arts, crafts, and hobby materials (crafting paint applied to craft)	Rubber Eraser	Dermal	H	-	-	5.1E−02	4.1E−02	3.2E−02	2.9E−02	3.1E−02
			M	-	-	3.6E−02	2.9E−02	2.3E−02	2.1E−02	2.2E−02
			L	-	-	2.5E−02	2.0E−02	1.6E−02	1.5E−02	1.6E−02
		Ingestion by mouthing	H	-	-	8.8E00	5.1E00	-	-	-
			M	-	-	1.7E00	1.0E00	-	-	-
			L	-	-	1.5E−01	8.5E−02	-	-	-
Packaging, paper, plastic, hobby products: Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Shower Curtain	Dermal	H	-	-	1.3E−01	1.0E−01	8.1E−02	7.4E−02	7.9E−02
			M	-	-	8.9E−02	7.2E−02	5.7E−02	5.2E−02	5.6E−02
			L	-	-	6.3E−02	5.1E−02	4.0E−02	3.7E−02	3.9E−02
		Ingestion suspended dust**	H	3.1E−04	2.9E−04	2.3E−04	1.6E−04	1.2E−04	9.9E−05	7.9E−05
			M	3.1E−04	2.9E−04	2.3E−04	1.6E−04	1.2E−04	9.9E−05	7.9E−05
			L	3.1E−04	2.9E−04	2.3E−04	1.6E−04	1.2E−04	9.9E−05	7.9E−05
		Ingestion dust on surface**	H	2.9E−01	3.6E−01	4.0E−01	1.4E−01	7.9E−02	6.3E−02	2.8E−02
			M	2.9E−01	3.6E−01	4.0E−01	1.4E−01	7.9E−02	6.3E−02	2.8E−02
			L	2.9E−01	3.6E−01	4.0E−01	1.4E−01	7.9E−02	6.3E−02	2.8E−02
		Inhalation**	H	9.8E00	9.3E00	7.5E00	5.2E00	3.7E00	3.2E00	2.5E00
			M	9.8E00	9.3E00	7.5E00	5.2E00	3.7E00	3.2E00	2.5E00
			L	9.8E00	9.3E00	7.5E00	5.2E00	3.7E00	3.2E00	2.5E00
Construction, paint, electrical, and metal products:	Solid Flooring	Dermal	H	2.4E−01	2.1E−01	1.8E−01	1.4E−01	1.1E−01	1.0E−01	1.1E−01
			M	1.7E−01	1.5E−01	1.3E−01	1.0E−01	8.1E−02	7.4E−02	7.9E−02

Consumer COU Category and Subcategory	Product / Article	Exposure Route	Scenario	Acute Dose Rate (ADR) (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1-3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6-10 years)*	Young Teen (11-15 years)	Teenagers (16-20 years)	Adult (≥21 years)
Building/construction materials covering large surface areas including stone, plaster, cement, glass and ceramic articles (wire or wiring systems; joint treatment			L	1.2E−01	1.0E−01	8.9E−02	7.2E−02	5.7E−02	5.2E−02	5.6E−02
		Ingestion suspended dust**	H	2.3E−04	2.2E−04	1.8E−04	1.2E−04	8.7E−05	7.5E−05	6.0E−05
			M	2.3E−04	2.2E−04	1.8E−04	1.2E−04	8.7E−05	7.5E−05	6.0E−05
			L	2.3E−04	2.2E−04	1.8E−04	1.2E−04	8.7E−05	7.5E−05	6.0E−05
		Ingestion dust on surface**	H	1.9E00	2.3E00	2.6E00	9.1E−01	5.1E−01	4.0E−01	1.8E−01
			M	1.9E00	2.3E00	2.6E00	9.1E−01	5.1E−01	4.0E−01	1.8E−01
			L	1.9E00	2.3E00	2.6E00	9.1E−01	5.1E−01	4.0E−01	1.8E−01
		Inhalation**	H	2.2E01	2.1E01	1.7E01	1.2E01	8.4E00	7.2E00	5.8E00
			M	2.2E01	2.1E01	1.7E01	1.2E01	8.4E00	7.2E00	5.8E00
			L	2.2E01	2.1E01	1.7E01	1.2E01	8.4E00	7.2E00	5.8E00
Furnishing, cleaning, treatment/care products: Fabrics, textiles, and apparel (as plasticizer)	Synthetic Leather Clothing	Dermal	H	-	-	-	-	1.0E01	9.2E00	8.8E00
			M	-	-	-	-	8.3E−01	7.6E−01	8.0E−01
			L	-	-	-	-	4.6E−02	4.2E−02	4.5E−02
Furnishing, cleaning, treatment/care products: Fabrics, textiles, and apparel (as plasticizer)	Synthetic Leather Furniture	Dermal	H	1.8E01	1.6E01	1.5E01	1.2E01	1.0E01	9.2E00	8.8E00
			M	4.2E00	1.8E00	1.4E00	1.1E00	8.3E−01	7.6E−01	8.0E−01
			L	9.7E−02	8.3E−02	7.2E−02	5.8E−02	4.6E−02	4.2E−02	4.5E−02
		Ingestion suspended dust**	H	1.9E−03	1.7E−03	1.4E−03	9.9E−04	7.0E−04	6.0E−04	4.8E−04
			M	1.3E−03	1.2E−03	9.7E−04	6.8E−04	4.8E−04	4.1E−04	3.3E−04
			L	8.4E−04	7.9E−04	6.4E−04	4.5E−04	3.2E−04	2.7E−04	2.2E−04
		Ingestion dust on surface**	H	4.6E00	5.7E00	6.5E00	2.3E00	1.3E00	1.0E00	4.5E−01
			M	2.8E00	3.5E00	3.9E00	1.4E00	7.7E−01	6.1E−01	2.7E−01
			L	1.5E00	1.9E00	2.1E00	7.5E−01	4.2E−01	3.3E−01	1.5E−01

Consumer COU Category and Subcategory	Product / Article	Exposure Route	Scenario	Acute Dose Rate (ADR) (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1-3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6-10 years)*	Young Teen (11-15 years)	Teenagers (16-20 years)	Adult (≥21 years)
		Ingestion by mouthing	H	2.3E01	1.4E01	8.8E00	-	-	-	-
			M	4.2E00	3.0E00	1.7E00	-	-	-	-
			L	1.8E−01	2.6E−01	1.5E−01	-	-	-	-
		Inhalation**	H	1.0E02	9.9E01	8.0E01	5.6E01	3.9E01	3.4E01	2.7E01
			M	6.3E01	5.9E01	4.8E01	3.4E01	2.4E01	2.0E01	1.6E01
			L	3.4E01	3.2E01	2.6E01	1.8E01	1.3E01	1.1E01	8.9E00
Packaging, paper, plastic, hobby products: Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Wallpaper	Dermal (blue highlight is for in-place and green highlight is for installation)	H	1.7E−01	1.5E−01	1.3E−01	1.0E−01	3.2E−01	2.9E−01	3.1E−01
			M	9.9E−02	8.4E−02	7.3E−02	5.9E−02	2.3E−01	2.1E−01	2.2E−01
			L	7.0E−02	6.0E−02	5.2E−02	4.2E−02	1.6E−01	1.5E−01	1.6E−01
		Ingestion suspended dust**	H	3.1E−03	3.0E−03	2.4E−03	1.7E−03	1.2E−03	1.0E−03	8.1E−04
			M	1.5E−03	1.4E−03	1.2E−03	8.1E−04	5.7E−04	4.9E−04	3.9E−04
			L	7.6E−04	7.1E−04	5.8E−04	4.0E−04	2.8E−04	2.4E−04	2.0E−04
		Ingestion dust on surface**	H	2.5E01	3.1E01	3.5E01	1.2E01	6.9E00	5.5E00	2.4E00
			M	1.2E01	1.5E01	1.7E01	5.8E00	3.2E00	2.6E00	1.2E00
			L	5.6E00	6.9E00	7.8E00	2.7E00	1.5E00	1.2E00	5.4E−01
		Inhalation**	H	3.0E02	2.9E02	2.3E02	1.6E02	1.1E02	9.8E01	7.9E01
			M	1.4E02	1.3E02	1.1E02	7.6E01	5.4E01	4.6E01	3.7E01
			L	6.7E01	6.3E01	5.1E01	3.6E01	2.5E01	2.2E01	1.7E01
Construction, paint, electrical, and metal products: Electrical and	Wire insulation	Dermal	H	1.7E−01	1.5E−01	1.3E−01	1.0E−01	8.1E−02	7.4E−02	7.9E−02
			M	1.2E−01	1.0E−01	8.9E−02	7.2E−02	5.7E−02	5.2E−02	5.6E−02

Consumer COU Category and Subcategory	Product / Article	Exposure Route	Scenario	Acute Dose Rate (ADR) (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1-3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6-10 years)*	Young Teen (11-15 years)	Teenagers (16-20 years)	Adult (≥21 years)
Electronic Products			L	8.6E−02	7.3E−02	6.3E−02	5.1E−02	4.0E−02	3.7E−02	3.9E−02
		Ingestion suspended dust**	H	1.1E−04	1.0E−04	8.3E−05	5.8E−05	4.1E−05	3.5E−05	2.8E−05
			M	4.2E−05	4.0E−05	3.3E−05	2.3E−05	1.6E−05	1.4E−05	1.1E−05
			L	2.1E−05	1.9E−05	1.6E−05	1.1E−05	7.7E−06	6.6E−06	5.3E−06
		Ingestion dust on surface**	H	8.9E−01	1.1E00	1.2E00	4.4E−01	2.4E−01	1.9E−01	8.7E−02
			M	3.5E−01	4.3E−01	4.9E−01	1.7E−01	9.6E−02	7.6E−02	3.4E−02
			L	1.7E−01	2.1E−01	2.4E−01	8.3E−02	4.6E−02	3.7E−02	1.6E−02
		Ingestion by mouthing	H	2.3E01	1.4E01	8.8E00	-	-	-	-
			M	4.2E00	3.0E00	1.7E00	-	-	-	-
			L	1.8E−01	2.6E−01	1.5E−01	-	-	-	-
		Inhalation**	H	1.1E01	1.0E01	8.3E00	5.8E00	4.1E00	3.5E00	2.8E00
			M	4.2E00	4.0E00	3.2E00	2.2E00	1.6E00	1.4E00	1.1E00
			L	2.0E00	1.9E00	1.6E00	1.1E00	7.7E−01	6.6E−01	5.3E−01

Scenarios without dose results are marked with a dash (-). Some products do not have dose results because the product examples were not targeted for that lifestage for that exposure route.
† Lifestage and exposure route are bystander scenarios, non-flagged lifestages under the same exposure route are users.
** Scenario used for indoor dust ingestion and inhalation assessment by reconstructing indoor environment with articles commonly present in indoor spaces and with large surface area in which dust can settle.

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Figure 4-1 through Figure 4-14 show acute dose rate data for all products and articles modeled in all lifestages. For each lifestage, figures are provided which show ADR estimated from exposure via inhalation, ingestion (aggregate of mouthing, suspended dust ingestion, and settled dust ingestion), and dermal contact. Among the younger lifestages, there was no clear pattern which showed a single exposure pathway most likely to drive exposure. However, for teens and adults, dermal contact was a strong driver of exposure to DIDP, with the dose received being generally higher than or similar to the dose received from exposure via inhalation or ingestion.

In addition, for each lifestage and additional set of figures is provided which shows the contribution of mouthing, suspended dust ingestion, and settled dust ingestion to the aggregated ingestion value. For all articles modeled in all lifestages, DIDP doses from ingestion of settled dust were higher than those from ingestion of suspended dust. This is likely because the overall ingestion rate of suspended dust is lower than that of settled dust. CEM models intake of small (<10 µm) particles in air as inhalation exposure, while larger airborne particles are ingested. However, this larger size fraction will settle more quickly, resulting in a higher density of ingestible dust on surfaces as compared to air. However, when mouthing exposure was included for an article, the dose received was generally higher than or similar to the dose received from ingestion of dust, indicating that mouthing may be a significant driver of exposure to DIDP when this behavior is present and therefore a particular concern for young children.

The spread of values estimated for each product or article reflects the aggregate effects of variability and uncertainty in key modeling parameters for each item; acute dose rate for some products/articles covers a larger range than others primarily due to a wider distribution of DIDP weight fraction values, chemical migration rates for mouthing exposures, and behavioral factors such as duration of use or contact time and mass of product used as described in Section 2.1. Key differences in exposures among lifestages include designation as product user or bystander; behavioral differences such as mouthing durations, hand to mouth contact times, and time spent on the floor; and dermal contact expected from touching specific articles which may not be appropriate for some lifestages. Figures and observations specific to each lifestage are below.

Figure 4-1 and Figure 4-2 show all exposure routes for infants less than a year old and toddlers 1 to 2 years old, respectively. Exposure patterns were very similar for all products or articles and routes of exposure in these lifestages. Ingestion route acute dose results in Figure 4-1 and Figure 4-2 show the sum of all ingestion scenarios, mouthing, suspended dust and surface dust. Inhalation exposure from toys, flooring, synthetic leather furniture, wallpaper, and wire insulation include a consideration of dust collected on the surface of a relatively large area, like flooring and wallpaper, but also multiple toys and wires collecting dust with DIDP and subsequent inhalation and ingestion. This is further explored in the indoor dust exposure assessment: Section 3, 4.1.2, and 4.3.

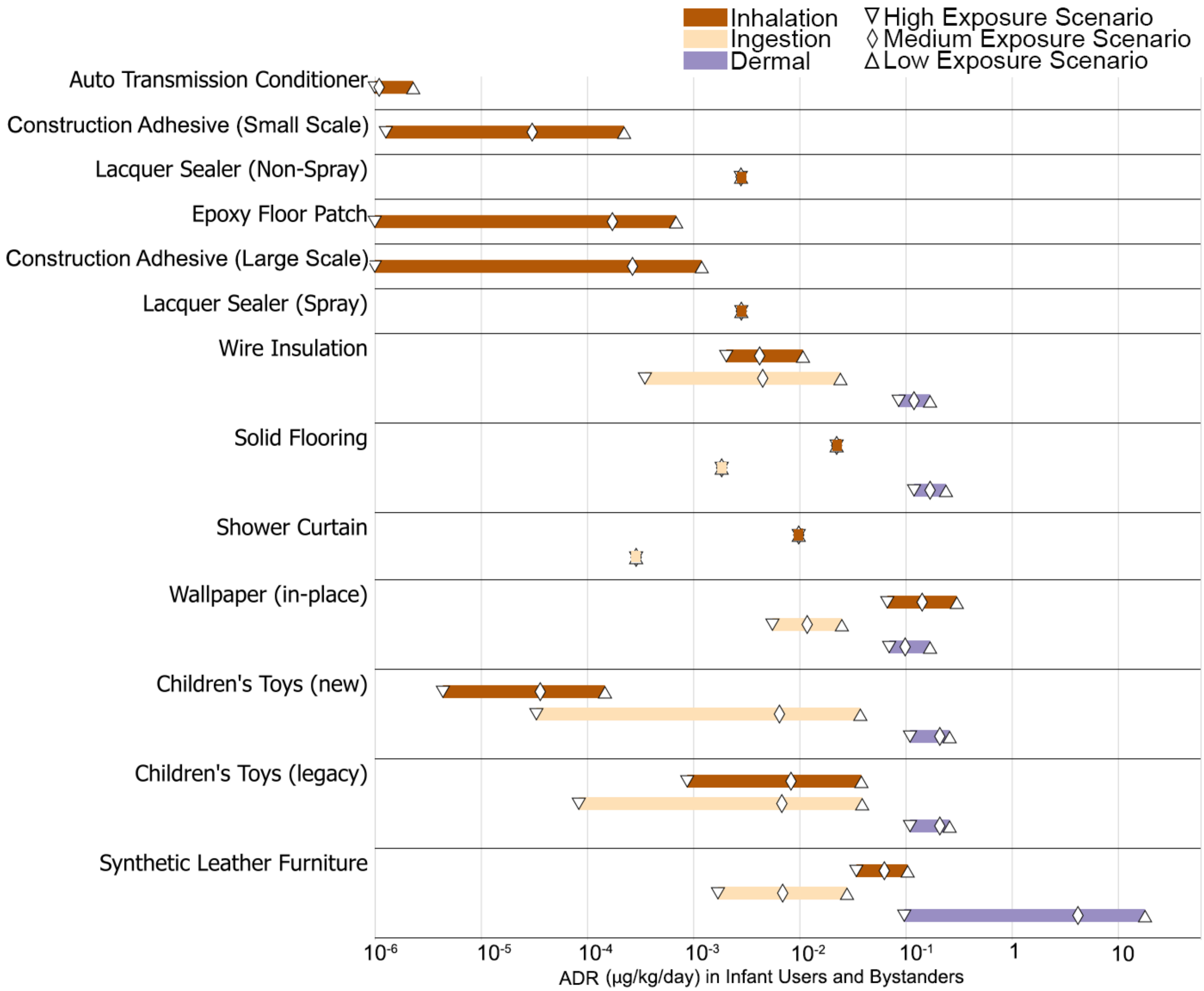


Figure 4-1. Acute Dose Rate for DIDP from Ingestion, Inhalation, Dermal Exposure Routes in Infants <1 Year Old

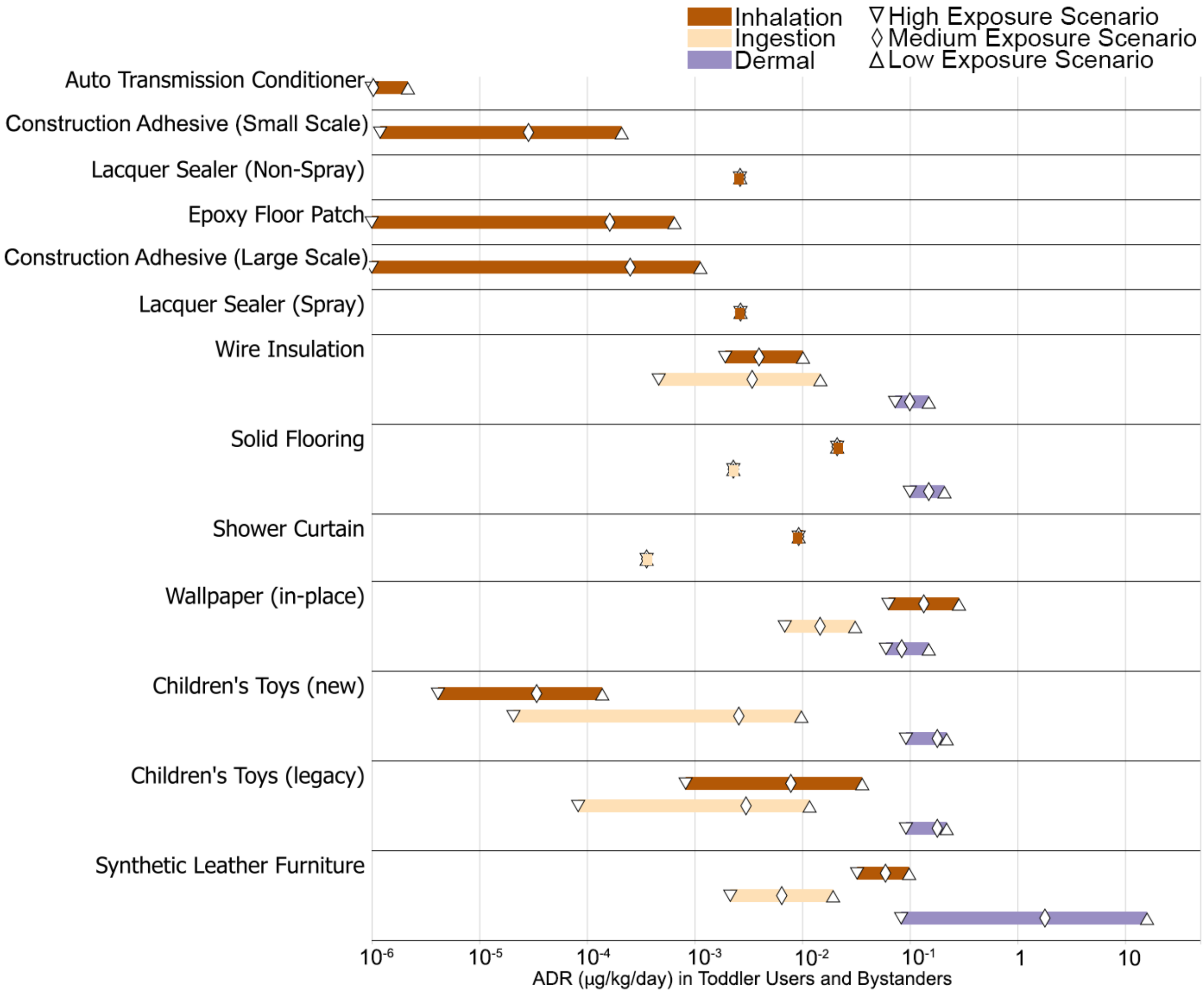


Figure 4-2. Acute Dose Rate for DIDP from Ingestion, Inhalation, Dermal Exposure Routes for Toddlers 1 to 2 Years Old

Figure 4-3 and Figure 4-4 show only the ingestion exposure route for infants less than a year and toddlers 1 to 2 years old, respectively. The acute dose of DIDP from ingestion of suspended dust is significantly lower than the dose from ingestion of settled dust. Ingestion via mouthing had the highest doses for toys, synthetic leather furniture, and wires.

Mouthing of legacy and new toys, as well as dermal contact, have similar high-end doses because the same chemical migration rates and dermal flux rates were used for all scenarios. However, we note that the concentration of DIDP in new toys is below the range of values used to derive the chemical migration rates and it is likely that the high-end mouthing exposure estimates are not representative of actual doses which would be received from these items. Inhalation doses from legacy toys is within the same range as dermal and ingestion doses, while inhalation doses from new toys are lower by two orders of magnitude. The differences in inhalation doses for new and legacy toys is likely due to the content of DIDP used in the scenarios.

For wallpaper, dust inhalation and ingestion contribute more to exposure than dermal contact. This is likely because the wallpaper scenario only considers in-place exposure rather than the installation process. Ingestion of dust on flooring is lower than inhalation likely due to particles in the inhalable size fraction can remain suspended for long periods of time and inhalation exposure is continuous while ingestion of dust from surfaces is not. Dermal contact with furniture is larger than any other dose, followed by wallpaper and furniture inhalation.

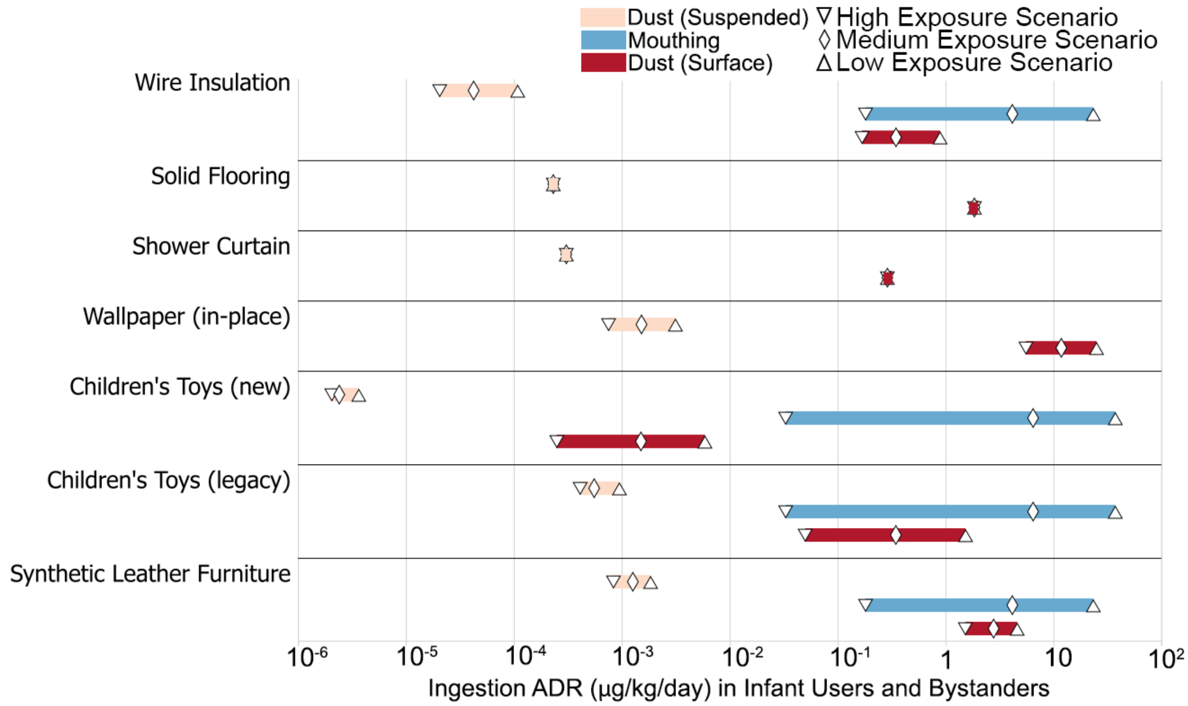


Figure 4-3. Acute Dose Rate of DIDP from Ingestion of Airborne Dust, Surface Dust, and Mouthing for Infants Less than a Year Old

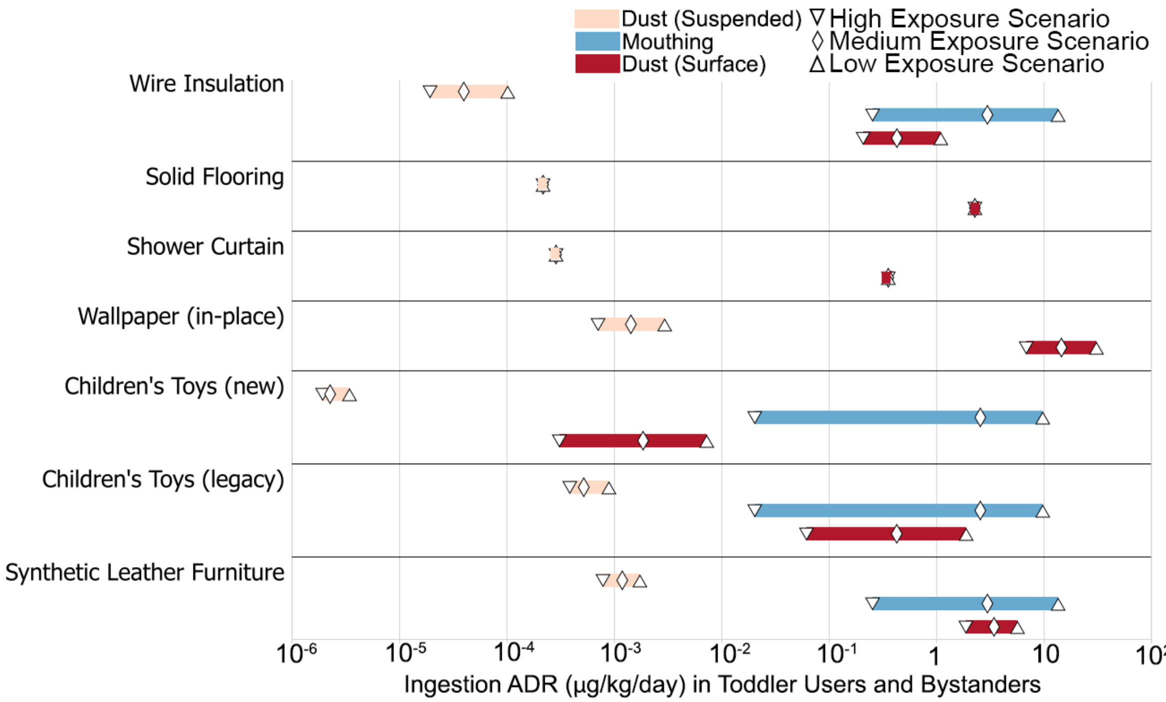
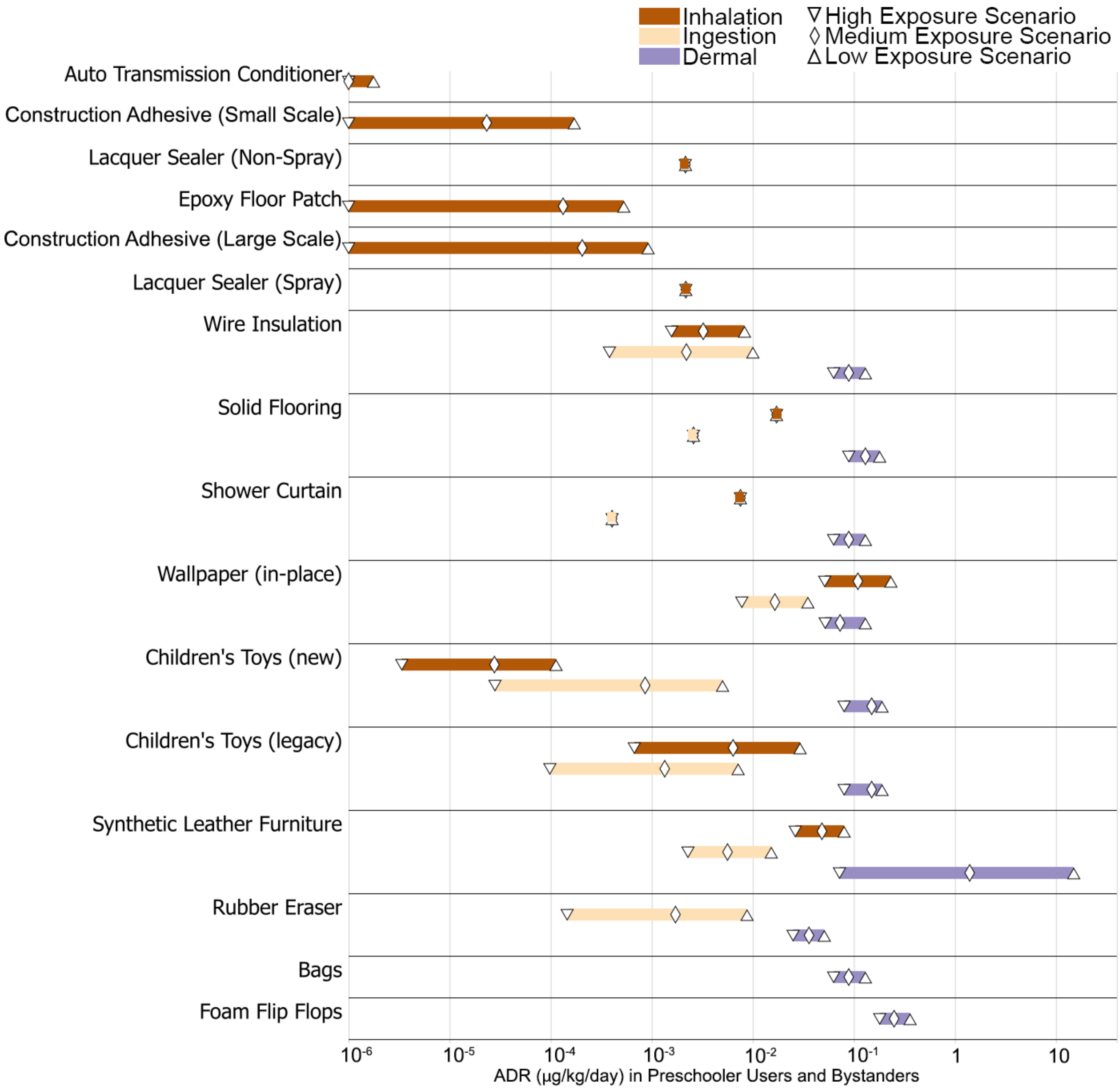


Figure 4-4. Acute Dose Rate of DIDP from Ingestion of Airborne Dust, Surface Dust, and Mouthing for Toddlers 1 to 2 Years Old

Figure 4-5 and Figure 4-6 show all exposure routes for preschoolers ages 3-5 and middle childhood children ages 6-10 years, respectively. Exposure patterns were very similar for all products or articles and routes of exposure in these lifestages. The acute dose rate for some products/articles covers a larger range than others primarily due to a wider distribution of weight fraction values for those examples, as described in Section 2.1.2.1 and 2.1.2.2. These lifestages have exposures from handling rubber erasers that younger lifestages did not have. The highest ADR estimated for these lifestages was for dermal exposure to synthetic leather furniture. The lower bound is similar in dermal exposure to toys, erasers, shower curtains, flooring, furniture, wallpaper, and wire insulation. However, the upper bound is approximately three magnitudes higher due to significantly longer potential contact time.



1613
1614 **Figure 4-5. Acute Dose Rate of DIDP from Ingestion, Inhalation, and Dermal Exposure Routes for**
1615 **Preschoolers 3 to 5 Years Old**
1616

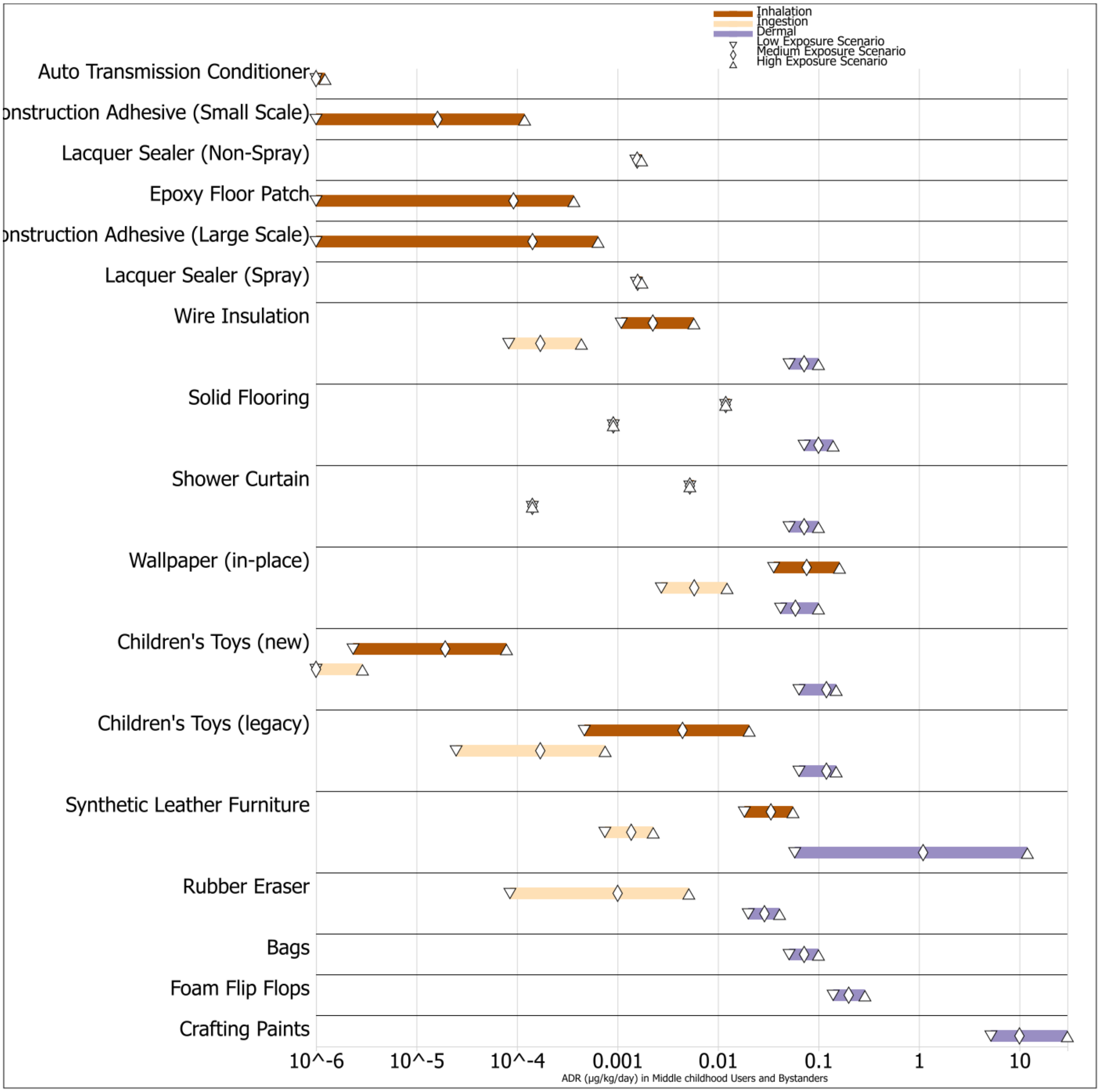


Figure 4-6. Acute Dose Rate of DIDP from Ingestion, Inhalation, and Dermal Exposure Routes for Middle Childhood 6 to 10 Years Old

Figure 4-7 and Figure 4-8 show only the ingestion route for preschoolers (3–5 years old) and children (6–10 years old), respectively. Ingestion of suspended dust has the lowest acute doses while ingestion of surface dust had the highest doses for dust collected on wallpaper. Mouthing exposures can be higher or slightly lower than surface dust ingestion for some products. Mouthing tendencies decrease for children 6 to 10 years old and hence most of the products/articles do not have a mouthing estimate. Inhalation of DIDP-contaminated dust is also an important contributor to indoor exposure when considering dust ingestion and inhalation for toys, synthetic leather furniture, flooring, wallpaper, and wire insulation. This is further explored in the indoor dust exposure assessment: Section 3, 4.1.2, and 4.3.

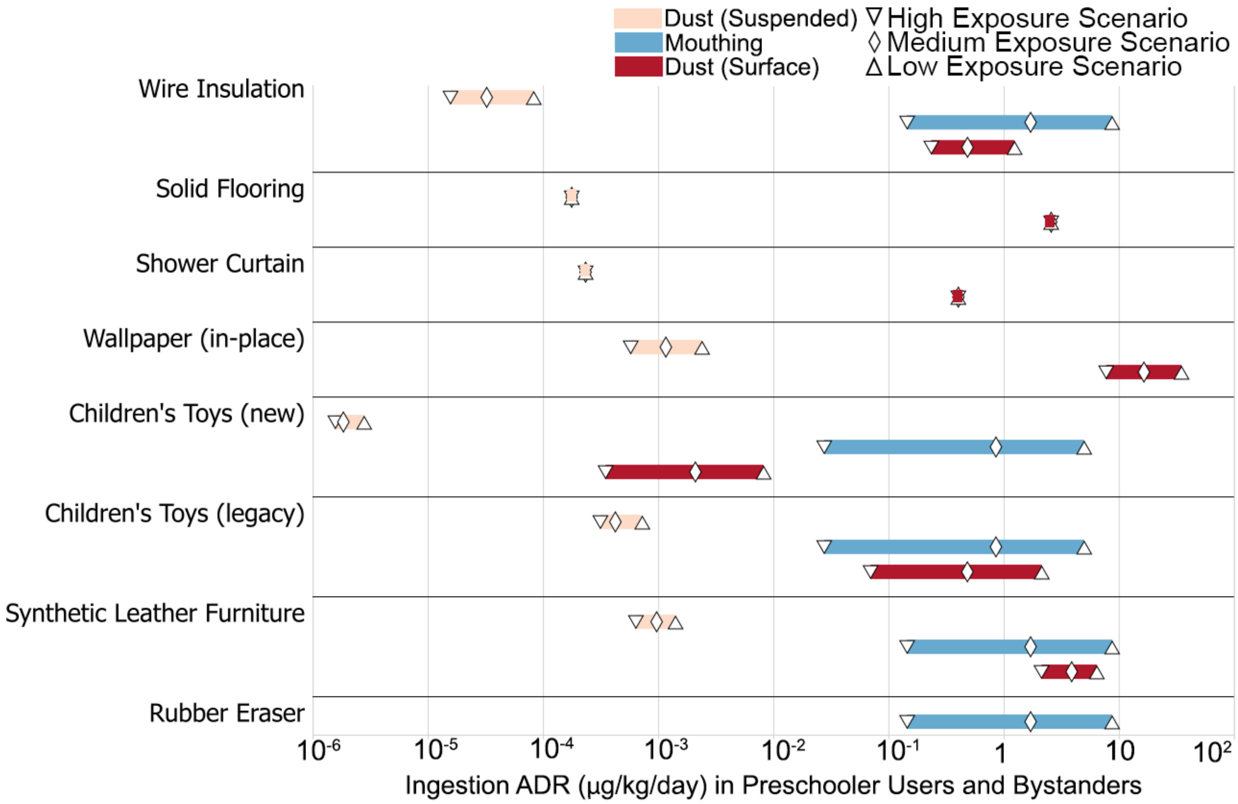


Figure 4-7. Acute Dose Rate of DIDP from Ingestion of Airborne Dust, Surface Dust, and Mouthing for Preschoolers 3 to 5 Years Old

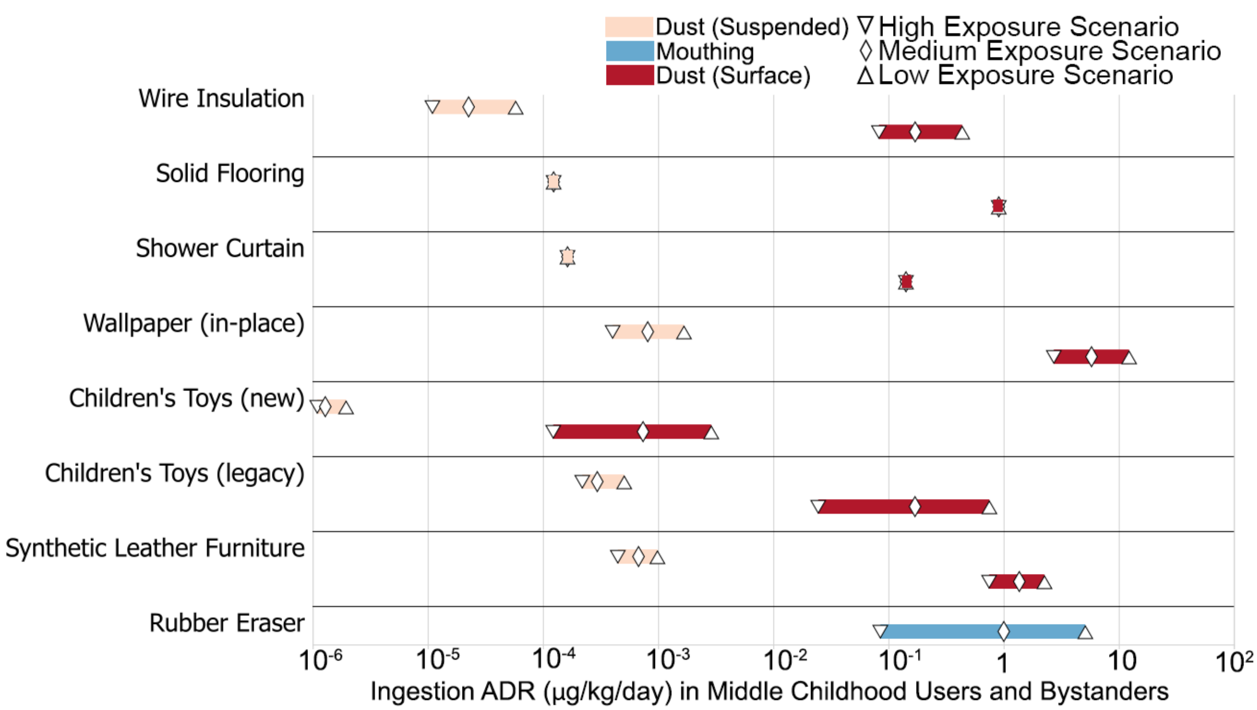
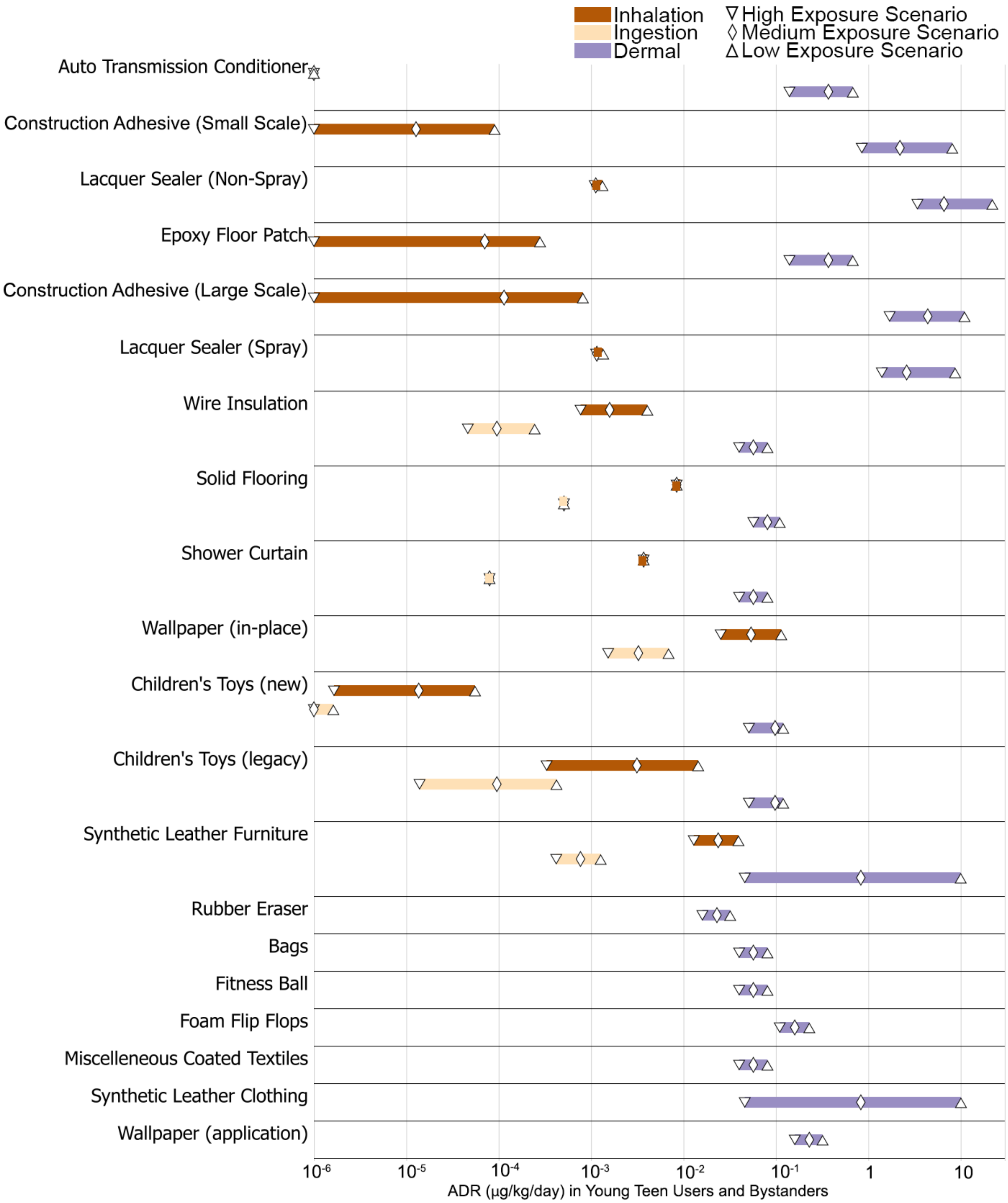


Figure 4-8. Acute Dose Rate of DIDP from Ingestion of Airborne Dust, Surface Dust, and Mouthing for Middle Childhood 6 to 10 Years Old

Figure 4-7 and Figure 4-8 show all exposure routes for preschoolers ages 3 to 5 and middle childhood children ages 6 to 10 years, respectively. These two figures are essentially the same for all products or articles and routes of exposures. The acute dose rate for some products/articles covers a larger range than others primarily due to a wider distribution of weight fraction values for those examples, as described in Section 2.1.2.1 and 2.1.2.2. The largest ingestion dose was observed from surface dust from dust collected on wallpaper followed by mouthing of rubber erasers and synthetic leather furniture. The lowest ingestion dose is from suspended dust for all items.

Figure 4-9 and Figure 4-10 show all exposure routes for young teens (11 to 15 years) and teenagers and young adults (16 to 20 years), respectively. Exposure patterns were very similar for all products or articles and routes of exposure in these lifestages., except teenagers and young adults 16 to 20 have added exposures to adult toys. The acute dose rate for some products/articles covers a larger range than others primarily due to a wider distribution of weight fraction values for those examples, as described in Section 2.1.2.1 and 2.1.2.2. Inhalation exposure as a bystander for these lifestages were not targeted for auto transmission, adhesives, epoxy floor patch, and lacquers. Young adults (16 to 20 year-olds) can use these products in similar capacity as adults during do-it-yourself projects and as bystanders; hence this lifestage was modeled as a user of the product rather than a bystander. Dermal exposure resulted in the highest doses overall, especially for synthetic leather clothing and furniture. Ingestion exposure decreases significantly compared to children, which is expected due to a decrease in mouthing behavior. Mouthing is still an important exposure route for adult toys.



1659

1660 **Figure 4-9. Acute Dose Rate of DIDP from Ingestion, Inhalation, and Dermal Exposure Routes for**
1661 **Young Teen 11 to 15 Years Old**
1662

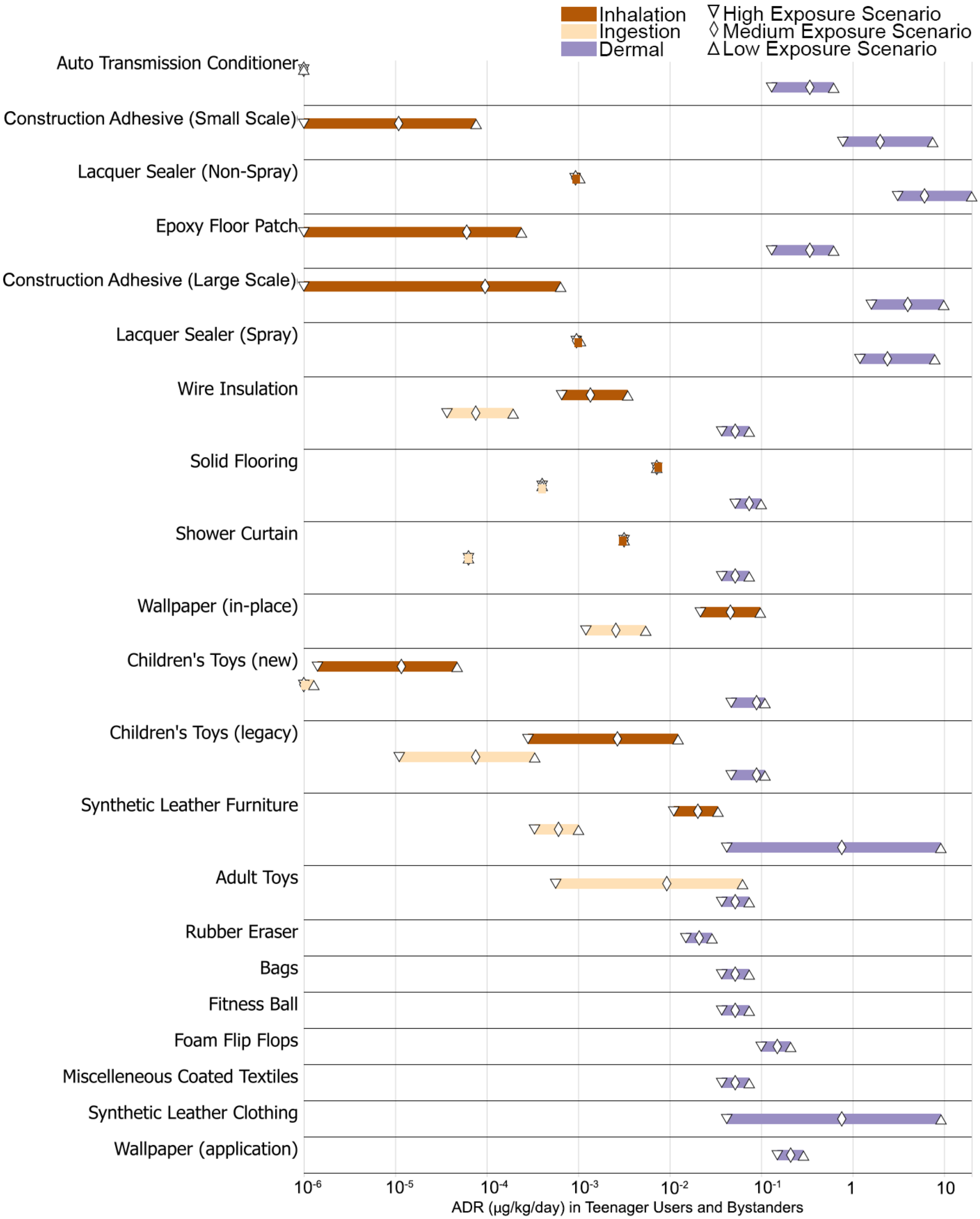


Figure 4-10. Acute Dose Rate of DIDP from Ingestion, Inhalation, and Dermal Exposure Routes for Teenagers and Young Adults 16 to 20 Years Old

Figure 4-11 and Figure 4-12 show only the ingestion exposure routes for young teens (11 to 15 years old) and teenagers and young adults (16 to 20 years old), respectively. Ingestion of suspended dust has the lowest acute doses while the largest dose is observed for ingestion of surface dust on wallpaper and mouthing of adult toys for the young adults lifestage (16 to 20 years). The only article considered for ingestion via mouthing is for adult toys. Mouthing tendencies decrease significantly for this lifestage; thus, most scenarios do not estimate exposure via mouthing.

Ingestion and inhalation of surface dust is an exposure route with similar dose estimates as dermal for most of the articles used in the indoor dust assessment. This is further explored in the indoor dust exposure assessment, Section 3, 4.1.2, and 4.3.

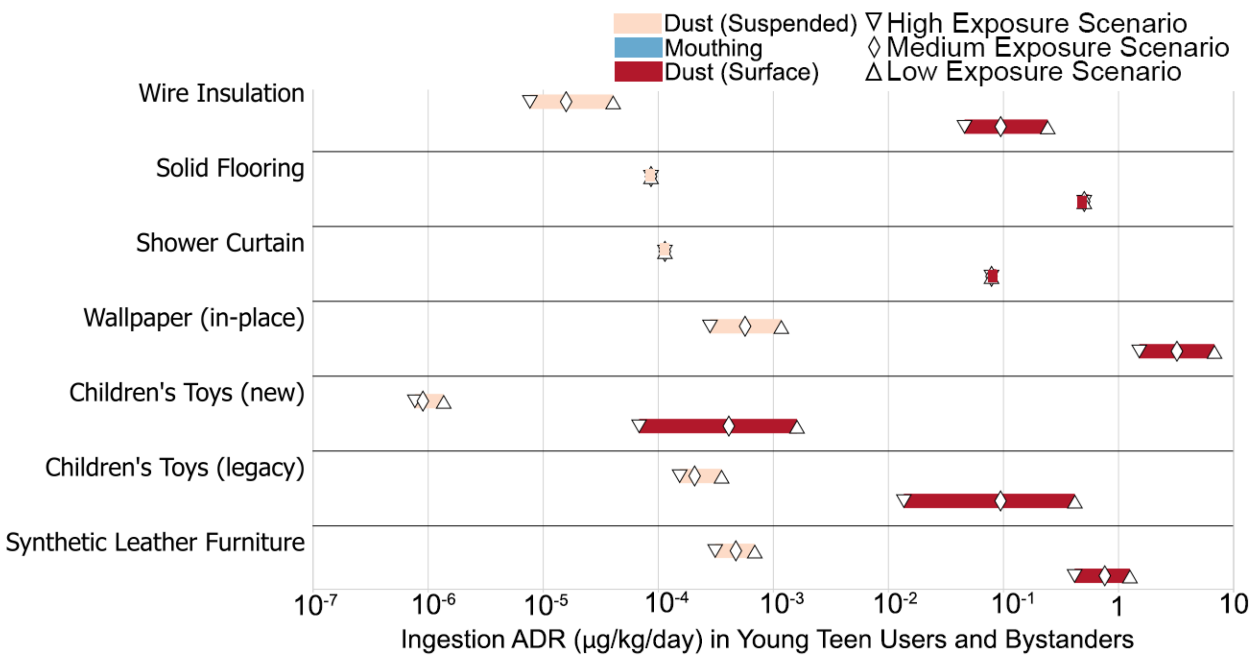


Figure 4-11. Acute Dose Rate of DIDP from Ingestion of Airborne Dust, Surface Dust, and Mouthing for Young Teens 11 to 15 Years Old

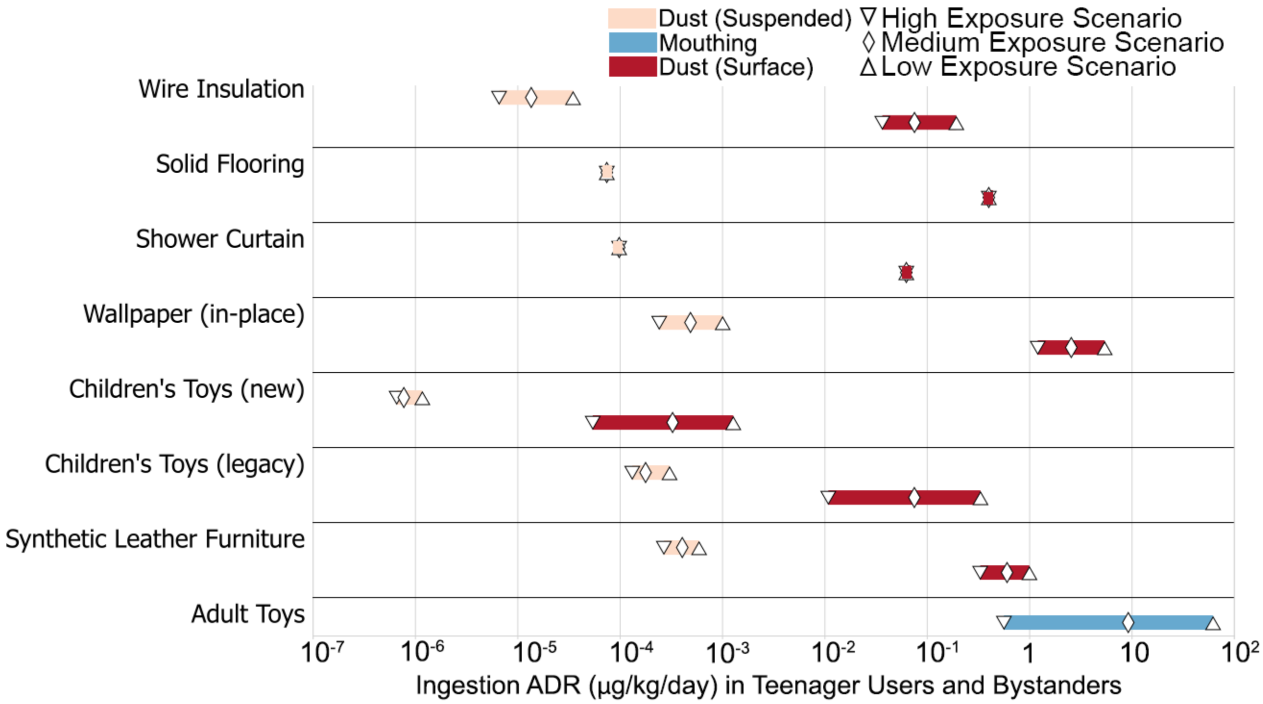


Figure 4-12. Acute Dose Rate of DIDP from Ingestion of Airborne Dust, Surface Dust, and Mouthing for Teenagers and Young Adults 16 to 20 Years Old

Figure 4-13 show all exposure routes for adults above 21 years old. This figure and Figure 4-10 (acute doses for 16- to 20-year-old teenagers and young adults) are essentially the same for all products or articles and routes of exposures. The acute dose rate for some products or articles covers a larger range than others primarily due to a wider distribution of weight fraction values for those examples, as described in Section 2.1.2.1 and 2.1.2.2. The largest dose is from dermal exposures from synthetic leather furniture and clothing, followed by ingestion via mouthing from adult toys and inhalation of surface just from wallpaper.

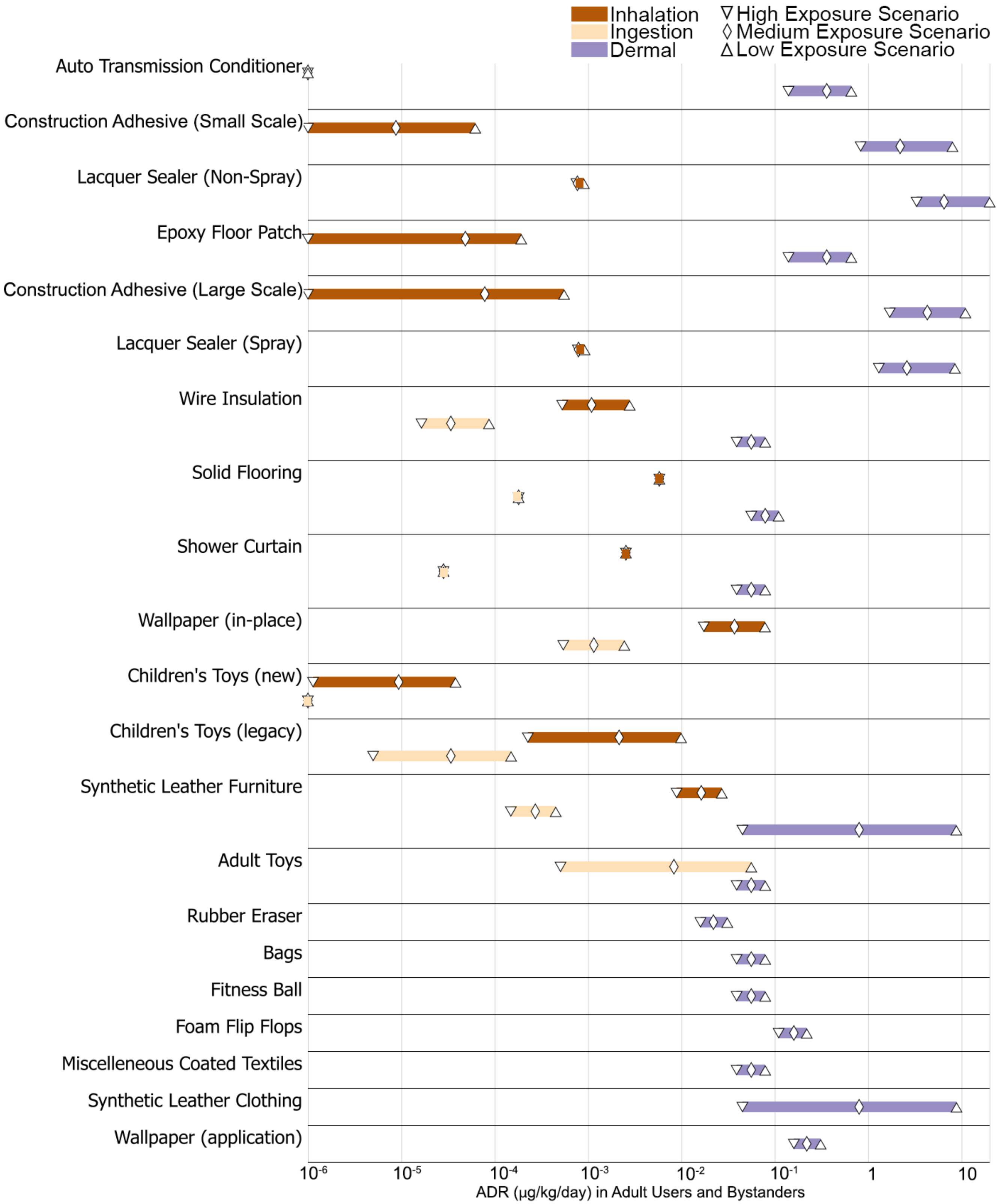


Figure 4-13. Acute Dose Rate of DIDP from Ingestion, Inhalation, and Dermal Exposure Routes in Adults Older Than 21 Years Old

Figure 4-14 show only the ingestion exposure routes for adults. Ingestion of suspended dust has the lowest acute doses. This is expected as DIDP tends to partition to dust which can settle rather quickly, as shown exposure to settled dust being higher than to suspended solids. Ingestion via mouthing is the largest dose for adults from adult toys, and that is the only article considered for mouthing for this lifestage. Ingestion and inhalation of surface dust has similar exposure estimates as dermal exposure for most of the articles used in the indoor dust assessment: toys, flooring, wallpaper, furniture, and wire insulation. These articles have a significant surface area either on their own or in combination with other articles present in indoor environments. This is further explored in the indoor dust exposure assessment, Section 3, 4.1.2, and 4.3.

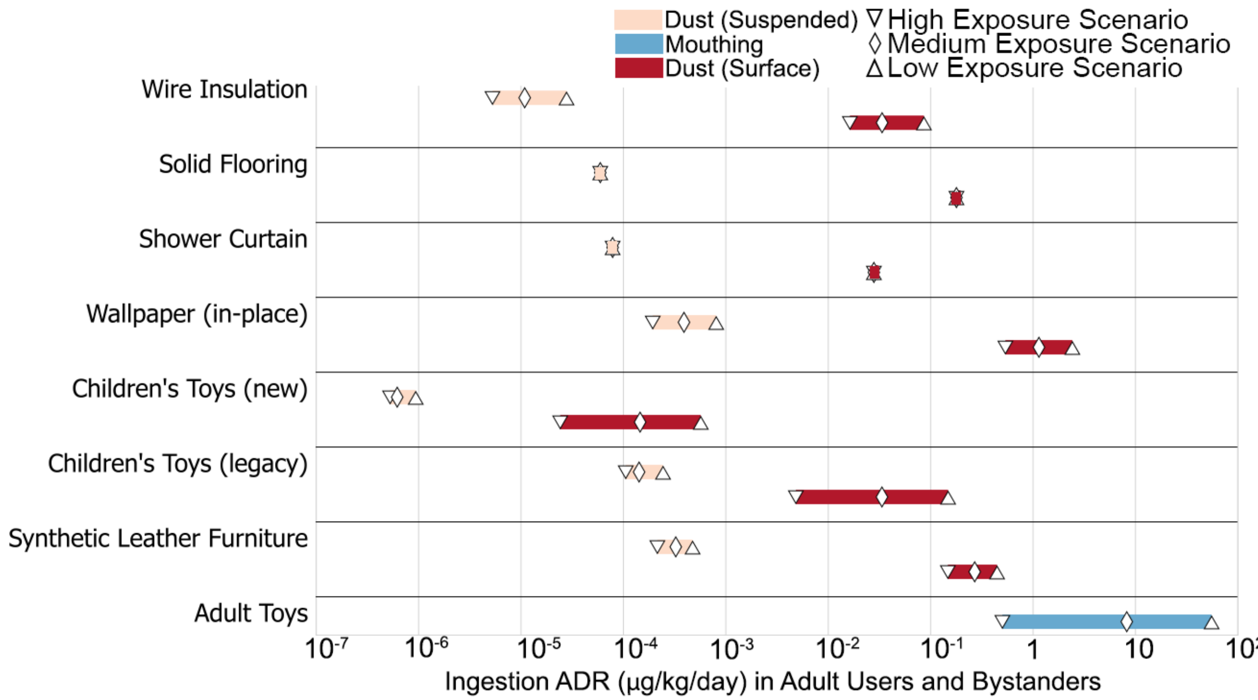


Figure 4-14. Acute Dose Rate of DIDP from Ingestion of Airborne Dust, Surface Dust, and Mouthing in Adults Older Than 21 Years Old

4.1.2 Non-cancer Chronic Dose Results, Conclusions and Data Patterns

Table 4-2 summarizes all the high (H), medium (M), and low (L) chronic daily dose results from modeling in CEM and outside of CEM (dermal only) for all exposure routes and all lifestages. Some products and articles did not have dose results because the product or article was not targeted for that lifestage or exposure route. Scenarios without dose results are marked with a dash (-). Dose results applicable to bystanders are highlighted in yellow. Bystanders are people that are not in direct use or application of the product/article but can be exposed to DIDP by proximity to the use of the product/article via inhalation of gas-phase emissions or suspended dust. Some product/article scenarios were assessed for bystanders for children under 10 years and as users for older than 11 years because the products were not targeted for very young children (<10 years). People older than 11 years can also be bystanders, however the user scenarios utilize inputs that would result in larger exposure doses. The main purpose of Table 4-2 is to summarize chronic daily dose results, show which products or articles did not have a quantitative result, and which results are used for bystanders. Data patterns are illustrated in figures after the table and includes summary descriptions of the patterns by exposure route and population or lifestage.

1727 **Table 4-2. Chronic Average Dose Results for All Exposure Routes for All Lifestages**

COU	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Chronic Daily Dose (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1–3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6–10 years)*	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
Other: Novelty Products	Adult Toys	Dermal	H	-	-	-	-	-	7.4E−02	7.9E−02
			M	-	-	-	-	-	5.2E−02	5.6E−02
			L	-	-	-	-	-	3.7E−02	3.9E−02
		Ingestion by mouthing	H	-	-	-	-	-	2.8E−01	2.5E−01
			M	-	-	-	-	-	4.6E00	4.2E00
			L	-	-	-	-	-	3.1E01	2.8E01
Automotive, fuel, agriculture, outdoor use products: Lubricants	Auto Transmission Conditioner	Dermal	H	-	-	-	-	1.9E−03	1.7E−03	1.8E−03
			M	-	-	-	-	1.0E−03	9.2E−04	9.8E−04
			L	-	-	-	-	3.9E−04	3.5E−04	3.8E−04
		Inhalation († bystander scenario)	H	†7.30E−04	†6.9E−04	†5.6E−04	†3.9E−04	3.2E−04	2.7E−04	2.2E−04
			M	†3.48E−04	†3.3E−04	†2.7E−04	†1.9E−04	1.5E−04	1.3E−04	1.0E−04
			L	†1.04E−04	†9.8E−05	†8.0E−05	†5.6E−05	4.5E−05	3.8E−05	3.1E−05
Packaging, paper, plastic, hobby products: Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Bags	Dermal	H	-	-	1.3E−01	1.0E−01	8.1E−02	7.4E−02	7.9E−02
			M	-	-	8.9E−02	7.2E−02	5.7E−02	5.2E−02	5.6E−02
			L	-	-	6.3E−02	5.1E−02	4.0E−02	3.7E−02	3.9E−02
Packaging, paper, plastic, hobby products: Toys, Playground, and Sporting Equipment	Legacy Children's Toys	Dermal	H	2.6E−01	2.2E−01	1.9E−01	1.5E−01	1.2E−01	1.1E−01	-
			M	2.1E−01	1.8E−01	1.5E−01	1.2E−01	9.8E−02	8.9E−02	-
			L	1.1E−01	9.2E−02	8.0E−02	6.4E−02	5.1E−02	4.7E−02	-

COU	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Chronic Daily Dose (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1–3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6–10 years)*	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
		Ingestion suspended dust**	H	8.1E−04	7.6E−04	6.2E−04	4.3E−04	3.0E−04	2.6E−04	2.1E−04
			M	4.9E−04	4.6E−04	3.7E−04	2.6E−04	1.8E−04	1.6E−04	1.3E−04
			L	3.7E−04	3.5E−04	2.8E−04	2.0E−04	1.4E−04	1.2E−04	9.5E−05
		Ingestion dust on surface**	H	1.4E00	1.7E00	1.9E00	6.6E−01	3.7E−01	2.9E−01	1.3E−01
			M	3.1E−01	3.8E−01	4.3E−01	1.5E−01	8.4E−02	6.7E−02	3.0E−02
			L	4.5E−02	5.6E−02	6.3E−02	2.2E−02	1.2E−02	9.8E−03	4.4E−03
		Ingestion by mouthing	H	3.3E−02	2.0E−02	2.8E−02	-	-	-	-
			M	6.5E00	2.6E00	8.6E−01	-	-	-	-
			L	3.7E01	9.8E00	5.0E00	-	-	-	-
		Inhalation**	H	3.4E01	3.2E01	2.6E01	1.8E01	1.3E01	1.1E01	8.9E00
			M	7.4E00	7.0E00	5.7E00	4.0E00	2.8E00	2.4E00	1.9E00
			L	7.8E−01	7.4E−01	6.0E−01	4.2E−01	2.9E−01	2.5E−01	2.0E−01
Packaging, paper, plastic, hobby products: Toys, Playground, and Sporting Equipment	New Children's Toys	Dermal	H	2.6E−01	2.2E−01	1.9E−01	1.5E−01	1.2E−01	1.1E−01	-
			M	2.1E−01	1.8E−01	1.5E−01	1.2E−01	9.8E−02	8.9E−02	-
			L	1.1E−01	9.2E−02	8.0E−02	6.4E−02	5.1E−02	4.7E−02	-
		Ingestion suspended dust**	H	3.1E−06	2.9E−06	2.4E−06	1.7E−06	1.2E−06	1.0E−06	8.0E−07
			M	2.1E−06	2.0E−06	1.6E−06	1.1E−06	8.0E−07	6.8E−07	5.5E−07
			L	1.8E−06	1.7E−06	1.4E−06	9.8E−07	6.9E−07	5.9E−07	4.7E−07
		Ingestion dust on surface**	H	5.2E−03	6.4E−03	7.3E−03	2.5E−03	1.4E−03	1.1E−03	5.1E−04
			M	1.3E−03	1.6E−03	1.9E−03	6.5E−04	3.7E−04	2.9E−04	1.3E−04

COU	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Chronic Daily Dose (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1–3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6–10 years)*	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
			L	2.3E−04	2.8E−04	3.2E−04	1.1E−04	6.2E−05	4.9E−05	2.2E−05
		Ingestion by mouthing	H	3.3E−02	2.0E−02	2.8E−02	-	-	-	-
			M	6.5E00	2.6E00	8.6E−01	-	-	-	-
			L	3.7E01	9.8E00	5.0E00	-	-	-	-
		Inhalation**	H	1.3E−01	1.2E−01	1.0E−01	7.0E−02	5.0E−02	4.2E−02	3.4E−02
			M	3.2E−02	3.0E−02	2.5E−02	1.7E−02	1.2E−02	1.0E−02	8.4E−03
			L	3.9E−03	3.7E−03	3.0E−03	2.1E−03	1.5E−03	1.3E−03	1.0E−03
Construction, paint, electrical, and metal products: Adhesives and sealants	Construction Adhesive for Small Scale Projects	Dermal	H	-	-	-	-	3.9E−01	3.5E−01	3.8E−01
			M	-	-	-	-	1.0E−01	9.6E−02	1.0E−01
			L	-	-	-	-	4.0E−02	3.7E−02	3.9E−02
		Inhalation († bystander scenario)	H	†1.1E00	†1.1E00	†8.6E−01	†6.0E−01	5.1E−01	4.3E−01	3.5E−01
			M	†1.5E−01	†1.4E−01	†1.2E−01	†8.0E−02	6.5E−02	5.6E−02	4.5E−02
			L	†6.3E−03	†5.9E−03	†4.8E−03	†3.3E−03	2.7E−03	2.3E−03	1.9E−03
Construction, paint, electrical, and metal products: Adhesives and sealants	Construction Sealant for Large Scale Projects	Dermal	H	-	-	-	-	8.9E−02	8.2E−02	8.7E−02
			M	-	-	-	-	3.6E−02	3.3E−02	3.5E−02
			L	-	-	-	-	1.4E−02	1.3E−02	1.4E−02
		Inhalation († bystander scenario)	H	†1.1E00	†1.0E00	†8.3E−01	†5.8E−01	6.9E−01	5.5E−01	4.7E−01
			M	†2.7E−01	†2.6E−01	†2.1E−01	†1.5E−01	1.4E−01	1.1E−01	9.6E−02
			L	†5.4E−04	†5.1E−04	†4.2E−04	†2.9E−04	2.5E−04	2.1E−04	1.7E−04
Construction, paint,	Epoxy Floor	Dermal	H	-	-	-	-	1.9E−03	1.7E−03	1.8E−03

COU	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Chronic Daily Dose (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1–3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6–10 years)*	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
electrical, and metal products: Adhesives and sealants	Patch		M	-	-	-	-	1.0E−03	9.2E−04	9.8E−04
			L	-	-	-	-	3.9E−04	3.5E−04	3.8E−04
		Inhalation († bystander scenario)	H	†2.2E−01	†2.1E−01	†1.7E−01	†1.2E−01	9.4E−02	8.0E−02	6.5E−02
			M	†5.4E−02	†5.1E−02	†4.2E−02	†2.9E−02	2.3E−02	2.0E−02	1.6E−02
			L	†2.3E−04	†2.1E−04	†1.7E−04	†1.2E−04	9.7E−05	8.3E−05	6.7E−05
Packaging, paper, plastic, hobby products: Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Fitness Ball	Dermal	H	-	-	-	-	8.1E−02	7.4E−02	7.9E−02
			M	-	-	-	-	5.7E−02	5.2E−02	5.6E−02
			L	-	-	-	-	4.0E−02	3.7E−02	3.9E−02
Packaging, paper, plastic, hobby products: Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Foam Flip Flops	Dermal	H	-	-	3.6E−01	2.9E−01	2.3E−01	2.1E−01	2.2E−01
			M	-	-	2.5E−01	2.0E−01	1.6E−01	1.5E−01	1.6E−01
			L	-	-	1.8E−01	1.4E−01	1.1E−01	1.0E−01	1.1E−01
Construction, paint, electrical, and metal products: Adhesives and sealants, and Paints and Coatings	Lacquer Sealer (Non-Spray)	Dermal	H	-	-	-	-	1.2E−01	1.1E−01	1.2E−01
			M	-	-	-	-	3.6E−02	3.3E−02	3.5E−02
			L	-	-	-	-	1.9E−02	1.7E−02	1.8E−02
		Inhalation († bystander scenario)	H	†1.6E00	†1.5E00	†1.2E00	†9.2E−01	8.7E−01	6.9E−01	5.9E−01
			M	†1.6E00	†1.5E00	†1.2E00	†8.7E−01	7.0E−01	5.8E−01	4.8E−01
			L	†1.6E00	†1.5E00	†1.2E00	†8.5E−01	6.8E−01	5.6E−01	4.6E−01

COU	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Chronic Daily Dose (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1–3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6–10 years)*	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
Construction, paint, electrical, and metal products: Adhesives and sealants, and Paints and Coatings	Lacquer Sealer (Spray)	Dermal	H	-	-	-	-	4.8E−02	4.4E−02	4.7E−02
			M	-	-	-	-	1.5E−02	1.3E−02	1.4E−02
			L	-	-	-	-	7.4E−03	6.8E−03	7.3E−03
		Inhalation († bystander scenario)	H	†1.6E00	†1.5E00	†1.2E00	9.2E−01	8.7E−01	6.9E−01	5.9E−01
			M	†1.6E00	†1.5E00	†1.2E00	8.7E−01	7.0E−01	5.8E−01	4.8E−01
			L	†1.6E00	†1.5E00	†1.2E00	8.6E−01	6.8E−01	5.6E−01	4.6E−01
	Miscellaneous Coated Textiles	Dermal	H	-	-	-	-	8.1E−02	7.4E−02	7.9E−02
			M	-	-	-	-	5.7E−02	5.2E−02	5.6E−02
			L	-	-	-	-	4.0E−02	3.7E−02	3.9E−02
Packaging, paper, plastic, hobby products: Arts, crafts, and hobby materials (crafting paint applied to craft)	Rubber Eraser	Dermal	H	-	-	5.1E−02	4.1E−02	3.2E−02	2.9E−02	3.1E−02
			M	-	-	3.6E−02	2.9E−02	2.3E−02	2.1E−02	2.2E−02
			L	-	-	2.5E−02	2.0E−02	1.6E−02	1.5E−02	1.6E−02
		Ingestion by mouthing	H	-	-	8.8E00	5.1E00	-	-	-
			M	-	-	1.7E00	1.0E00	-	-	-
			L	-	-	1.5E−01	8.5E−02	-	-	-
Packaging, paper, plastic, hobby products: Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Shower Curtain	Dermal	H	-	-	1.3E−01	1.0E−01	8.1E−02	7.4E−02	7.9E−02
			M	-	-	8.9E−02	7.2E−02	5.7E−02	5.2E−02	5.6E−02
			L	-	-	6.3E−02	5.1E−02	4.0E−02	3.7E−02	3.9E−02
		Ingestion suspended dust**	H	2.7E−04	2.5E−04	2.0E−04	1.4E−04	1.0E−04	8.6E−05	6.9E−05
			M	2.7E−04	2.5E−04	2.0E−04	1.4E−04	1.0E−04	8.6E−05	6.9E−05

COU	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Chronic Daily Dose (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1–3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6–10 years)*	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
			L	2.7E−04	2.5E−04	2.0E−04	1.4E−04	1.0E−04	8.6E−05	6.9E−05
		Ingestion dust on surface**	H	2.5E−01	3.2E−01	3.6E−01	1.2E−01	7.0E−02	5.5E−02	2.5E−02
			M	2.5E−01	3.2E−01	3.6E−01	1.2E−01	7.0E−02	5.5E−02	2.5E−02
			L	2.5E−01	3.2E−01	3.6E−01	1.2E−01	7.0E−02	5.5E−02	2.5E−02
		Inhalation**	H	8.8E00	8.3E00	6.8E00	4.7E00	3.3E00	2.8E00	2.3E00
			M	8.8E00	8.3E00	6.8E00	4.7E00	3.3E00	2.8E00	2.3E00
			L	8.8E00	8.3E00	6.8E00	4.7E00	3.3E00	2.8E00	2.3E00
Construction, paint, electrical, and metal products: Building/construction materials covering large surface areas including stone, plaster, cement, glass and ceramic articles (wire or wiring systems; joint treatment	Solid Flooring	Dermal	H	2.4E−01	2.1E−01	1.8E−01	1.4E−01	1.1E−01	1.0E−01	1.1E−01
			M	1.7E−01	1.5E−01	1.3E−01	1.0E−01	8.1E−02	7.4E−02	7.9E−02
			L	1.2E−01	1.0E−01	8.9E−02	7.2E−02	5.7E−02	5.2E−02	5.6E−02
		Ingestion suspended dust**	H	1.9E−04	1.8E−04	1.4E−04	1.0E−04	7.0E−05	6.0E−05	4.8E−05
			M	1.9E−04	1.8E−04	1.4E−04	1.0E−04	7.0E−05	6.0E−05	4.8E−05
			L	1.9E−04	1.8E−04	1.4E−04	1.0E−04	7.0E−05	6.0E−05	4.8E−05
		Ingestion dust on surface**	H	1.6E00	2.0E00	2.3E00	8.0E−01	4.5E−01	3.5E−01	1.6E−01
			M	1.6E00	2.0E00	2.3E00	8.0E−01	4.5E−01	3.5E−01	1.6E−01
			L	1.6E00	2.0E00	2.3E00	8.0E−01	4.5E−01	3.5E−01	1.6E−01
		Inhalation**	H	2.0E01	1.9E01	1.5E01	1.1E01	7.5E00	6.4E00	5.2E00
			M	2.0E01	1.9E01	1.5E01	1.1E01	7.5E00	6.4E00	5.2E00
			L	2.0E01	1.9E01	1.5E01	1.1E01	7.5E00	6.4E00	5.2E00
Furnishing, cleaning,	Synthetic	Dermal	H	-	-	-	-	1.0E01	9.2E00	8.8E00

COU	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Chronic Daily Dose (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1–3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6–10 years)*	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
treatment/care products: Fabrics, textiles, and apparel (as plasticizer)	Leather Clothing		M	-	-	-	-	8.3E−01	7.6E−01	8.0E−01
			L	-	-	-	-	4.6E−02	4.2E−02	4.5E−02
Furnishing, cleaning, treatment/care products: Fabrics, textiles, and apparel (as plasticizer)	Synthetic Leather Furniture	Dermal	H	1.8E01	1.6E01	1.5E01	1.2E01	1.0E01	9.2E00	8.8E00
			M	4.2E00	1.8E00	1.4E00	1.1E00	8.3E−01	7.6E−01	8.0E−01
			L	9.7E−02	8.3E−02	7.2E−02	5.8E−02	4.6E−02	4.2E−02	4.5E−02
		Ingestion suspended dust**	H	1.5E−03	1.4E−03	1.2E−03	8.1E−04	5.7E−04	4.9E−04	3.9E−04
			M	1.1E−03	9.9E−04	8.1E−04	5.6E−04	4.0E−04	3.4E−04	2.7E−04
			L	7.1E−04	6.7E−04	5.4E−04	3.8E−04	2.7E−04	2.3E−04	1.8E−04
		Ingestion dust on surface**	H	4.1E00	5.0E00	5.7E00	2.0E00	1.1E00	8.8E−01	4.0E−01
			M	2.5E00	3.0E00	3.4E00	1.2E00	6.7E−01	5.3E−01	2.4E−01
			L	1.3E00	1.7E00	1.9E00	6.6E−01	3.7E−01	2.9E−01	1.3E−01
		Ingestion by mouthing	H	2.3E01	1.4E01	8.8E00	-	-	-	-
			M	4.2E00	3.0E00	1.7E00	-	-	-	-
			L	1.8E−01	2.6E−01	1.5E−01	-	-	-	-
		Inhalation**	H	9.3E01	8.8E01	7.2E01	5.0E01	3.5E01	3.0E01	2.4E01
			M	5.6E01	5.3E01	4.3E01	3.0E01	2.1E01	1.8E01	1.5E01
			L	3.1E01	2.9E01	2.3E01	1.6E01	1.2E01	9.9E00	7.9E00
Packaging, paper, plastic, hobby products: Plastic and rubber products (textiles, apparel, and leather; vinyl tape;	Wallpaper	Dermal (blue highlight is for in-place and green highlight is for application)	H	1.7E−01	1.5E−01	1.3E−01	1.0E−01	8.8E−04	8.1E−04	8.6E−04
			M	9.9E−02	8.4E−02	7.3E−02	5.9E−02	6.2E−04	5.7E−04	6.1E−04
			L	7.0E−02	6.0E−02	5.2E−02	4.2E−02	4.4E−04	4.0E−04	4.3E−04

COU	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Chronic Daily Dose (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1–3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6–10 years)*	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
flexible tubes; profiles; hoses		Ingestion suspended dust**	H	2.5E−03	2.4E−03	1.9E−03	1.4E−03	9.5E−04	8.2E−04	6.6E−04
			M	1.2E−03	1.2E−03	9.4E−04	6.6E−04	4.6E−04	4.0E−04	3.2E−04
			L	6.1E−04	5.8E−04	4.7E−04	3.3E−04	2.3E−04	2.0E−04	1.6E−04
		Ingestion dust on surface**	H	2.2E01	2.7E01	3.1E01	1.1E01	6.1E00	4.8E00	2.2E00
			M	1.0E01	1.3E01	1.5E01	5.1E00	2.9E00	2.3E00	1.0E00
			L	4.9E00	6.1E00	6.8E00	2.4E00	1.3E00	1.1E00	4.8E−01
		Inhalation**	H	2.7E02	2.6E02	2.1E02	1.4E02	1.0E02	8.7E01	7.0E01
			M	1.3E02	1.2E02	9.8E01	6.8E01	4.8E01	4.1E01	3.3E01
			L	6.0E01	5.6E01	4.6E01	3.2E01	2.3E01	1.9E01	1.6E01
Construction, paint, electrical, and metal products: Electrical and Electronic Products	Wire insulation	Dermal	H	1.7E−01	1.5E−01	1.3E−01	1.0E−01	8.1E−02	7.4E−02	7.9E−02
			M	1.2E−01	1.0E−01	8.9E−02	7.2E−02	5.7E−02	5.2E−02	5.6E−02
			L	8.6E−02	7.3E−02	6.3E−02	5.1E−02	4.0E−02	3.7E−02	3.9E−02
		Ingestion suspended dust**	H	8.7E−05	8.2E−05	6.7E−05	4.7E−05	3.3E−05	2.8E−05	2.3E−05
			M	3.4E−05	3.2E−05	2.6E−05	1.8E−05	1.3E−05	1.1E−05	8.8E−06
			L	1.7E−05	1.6E−05	1.3E−05	8.8E−06	6.2E−06	5.3E−06	4.3E−06
		Ingestion dust on surface**	H	7.8E−01	9.7E−01	1.1E00	3.8E−01	2.2E−01	1.7E−01	7.6E−02
			M	3.1E−01	3.8E−01	4.3E−01	1.5E−01	8.4E−02	6.7E−02	3.0E−02
			L	1.5E−01	1.8E−01	2.1E−01	7.3E−02	4.1E−02	3.2E−02	1.4E−02
		Ingestion by mouthing	H	2.3E01	1.4E01	8.8E00	-	-	-	-
			M	4.2E00	3.0E00	1.7E00	-	-	-	-

COU	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Chronic Daily Dose (µg/kg-day)						
				Infant (<1 Year)*	Toddler (1–3 Years)*	Preschooler (3-5 years)*	Middle Childhood (6–10 years)*	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
			L	1.8E−01	2.6E−01	1.5E−01	-	-	-	-
		Inhalation**	H	9.6E00	9.1E00	7.4E00	5.1E00	3.6E00	3.1E00	2.5E00
			M	3.8E00	3.5E00	2.9E00	2.0E00	1.4E00	1.2E00	9.7E−01
			L	1.8E00	1.7E00	1.4E00	9.7E−01	6.9E−01	5.9E−01	4.7E−01

Scenarios without dose results are marked with a dash (-). Some products do not have dose results because the product examples were not targeted for that lifestage for that exposure route.
† Lifestage and exposure route are bystander scenarios, non-flagged lifestages under the same exposure route are users.
** Scenario used for indoor dust ingestion and inhalation assessment by reconstructing indoor environment with articles commonly present in indoor spaces and with large surface area in which dust can settle.

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The following set of figures (Figure 4-15 to Figure 4-28) show chronic average daily dose data for all products and articles modeled in all lifestages. For each lifestage, figures are provided which show CADD estimated from exposure via inhalation, ingestion (aggregate of mouthing, suspended dust ingestion, and settled dust ingestion), and dermal contact. The chronic average daily dose figures resulted in the same data patterns as the acute doses, see Section 2.1.1.1 figure narrative under each lifestage for data patterns and discussion.

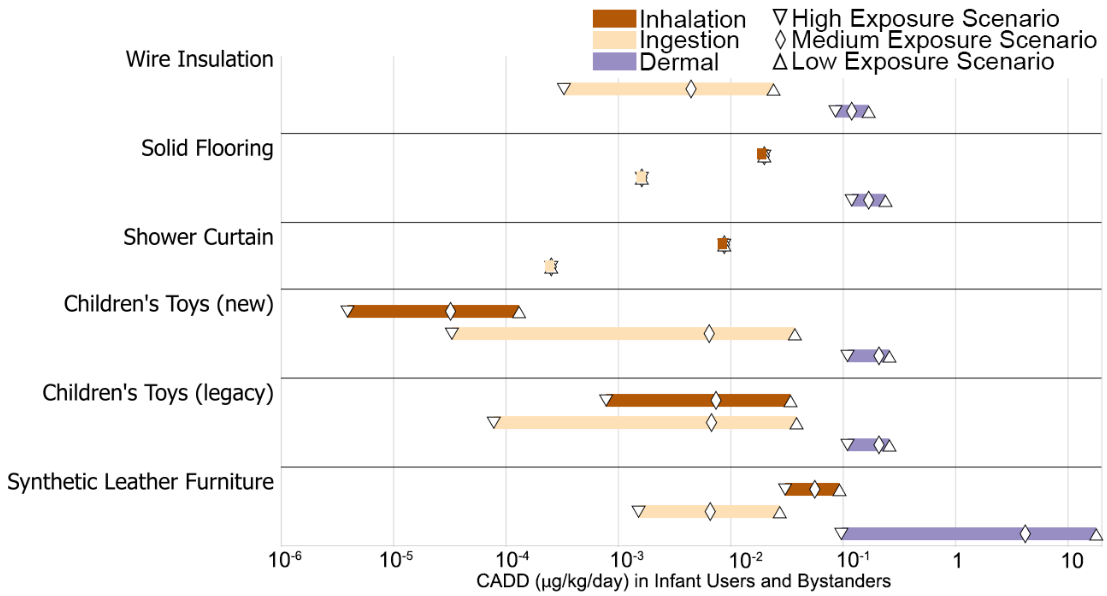


Figure 4-15. Chronic Average Daily Dose of DIDP from Ingestion, Inhalation, and Dermal Exposure Routes for Infants <1 Year Old

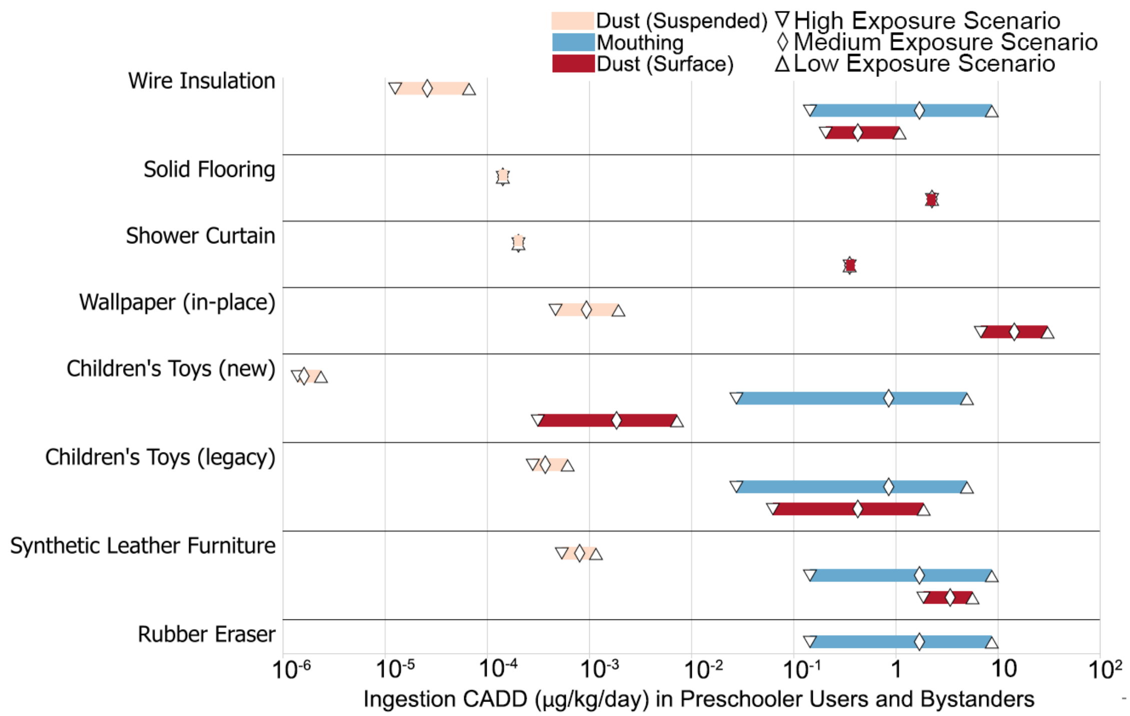


Figure 4-16. Chronic Daily Dose of DIDP from Ingestion of Airborne Dust, Surface Dust, and Mouthing for Infants Less Than a Year Old

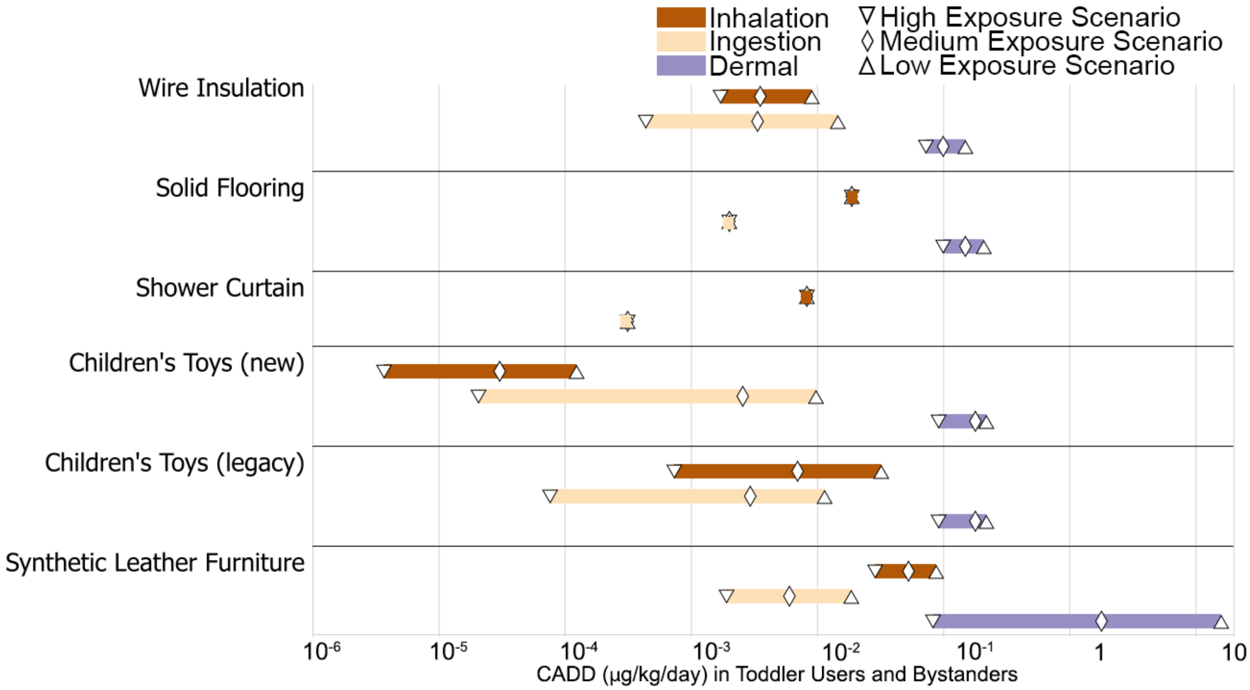


Figure 4-17. Chronic Average Daily Dose for DIDP from Ingestion, Inhalation, Dermal Exposure Routes for Toddlers 1 to 2 Years Old

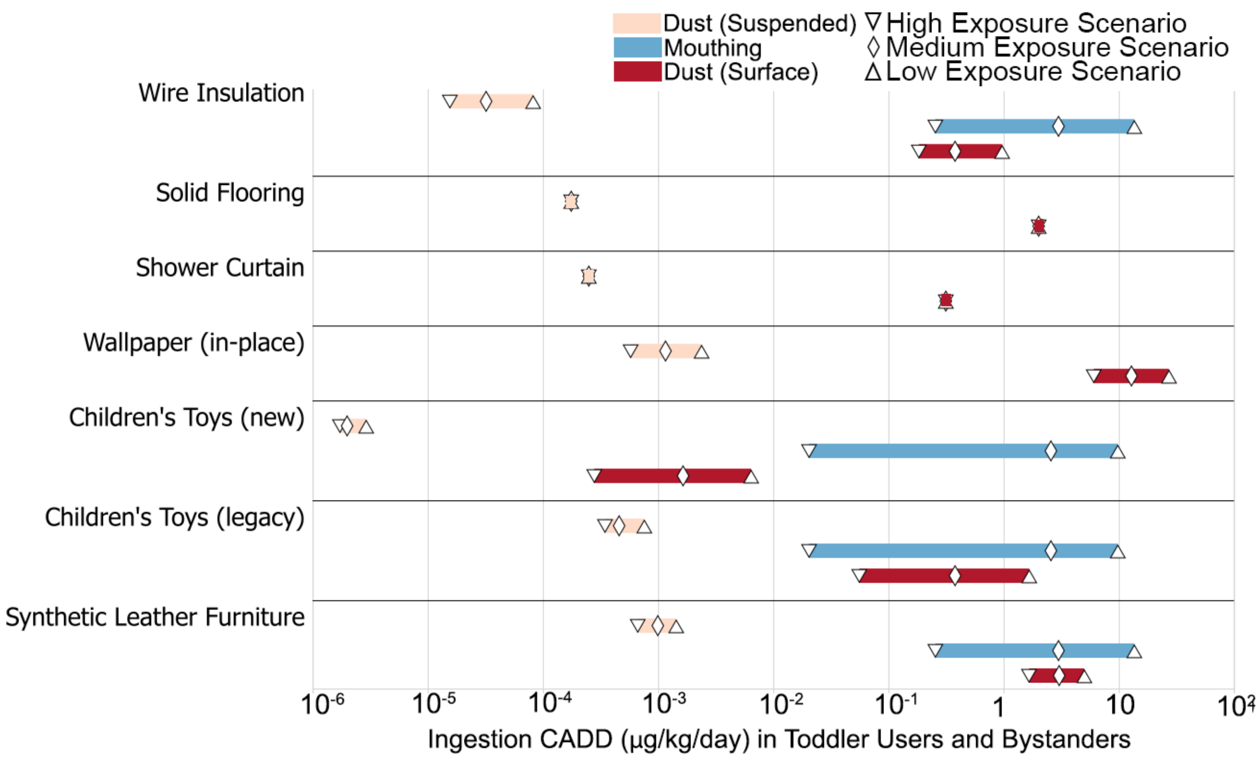


Figure 4-18. Chronic Daily Dose of DIDP from Ingestion of Airborne Dust, Surface Dust, and Mouthing for Toddlers 1 to 2 Years Old

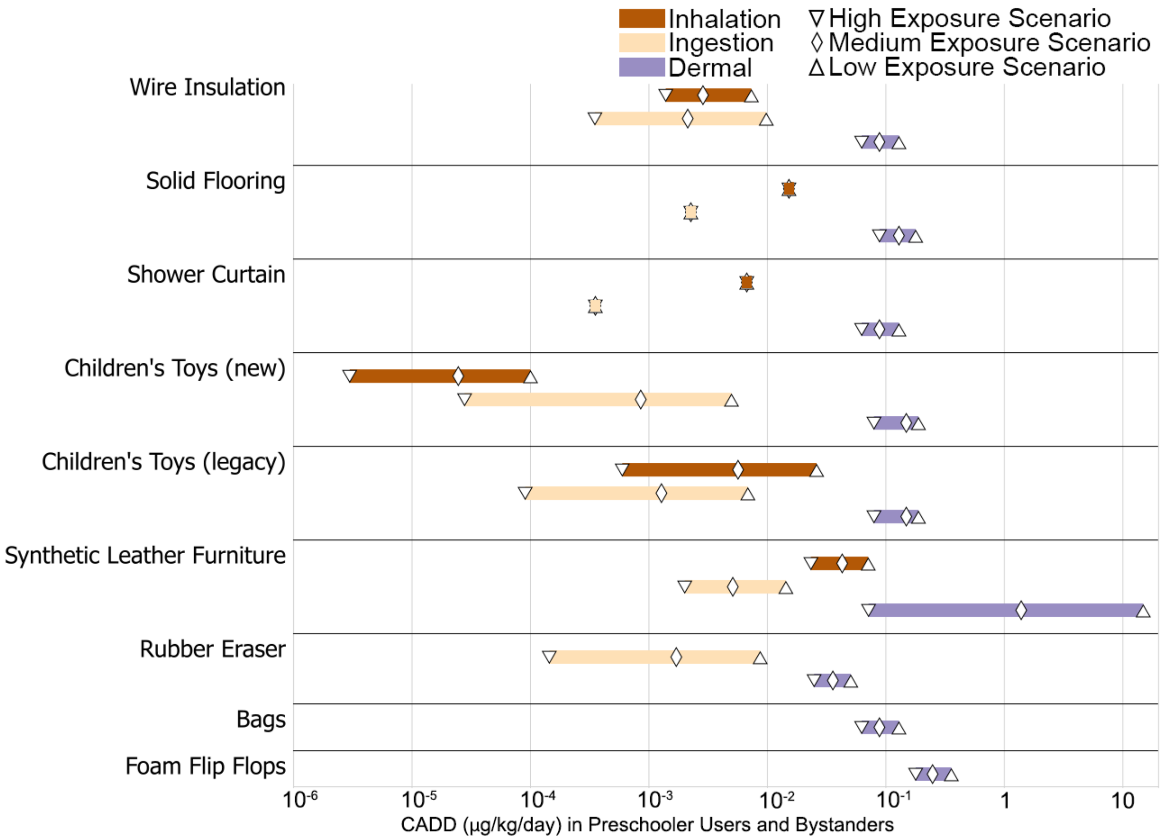


Figure 4-19. Chronic Average Daily Dose for DIDP from Ingestion, Inhalation, Dermal Exposure Routes for Preschooler 3 to 5 Years Old

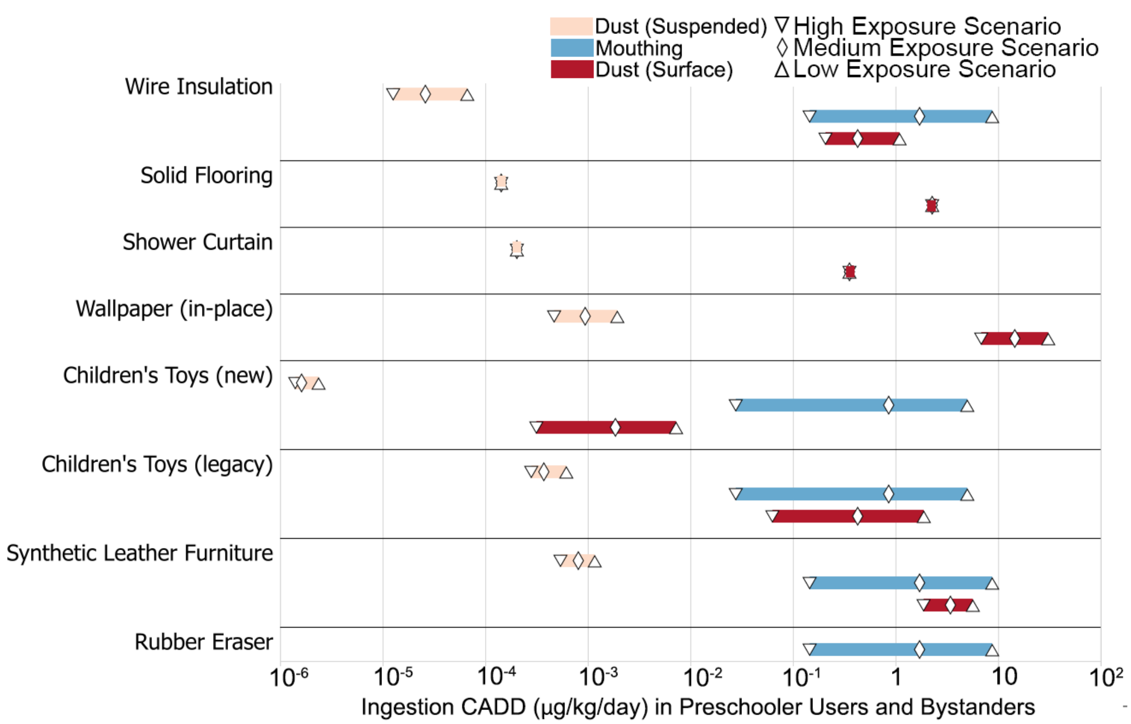


Figure 4-20. Chronic Daily Dose of DIDP from Ingestion of Airborne Dust, Surface Dust, and Mouthing for Preschooler 3 to 5 Years Old

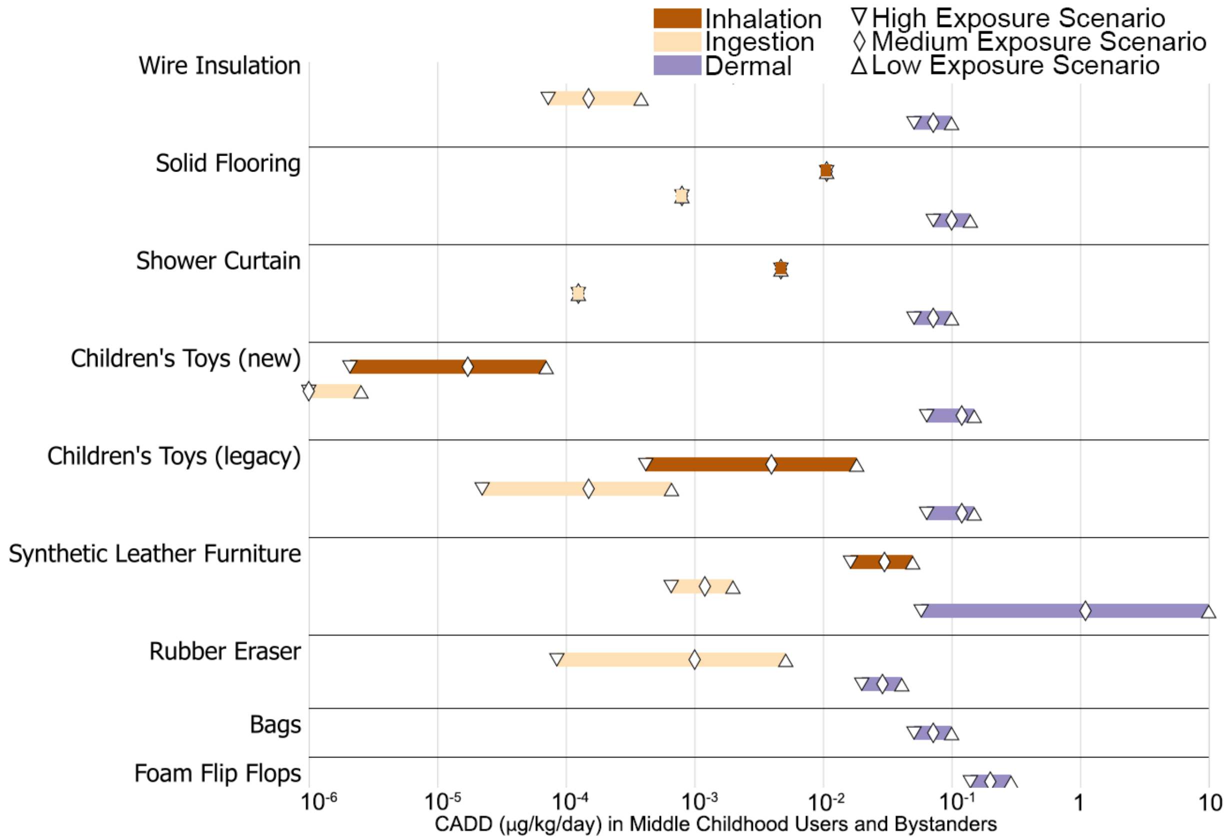


Figure 4-21. Chronic Average Daily Dose for DIDP from Ingestion, Inhalation, Dermal Exposure Routes for Middle Childhood 6 to 10 Years Old

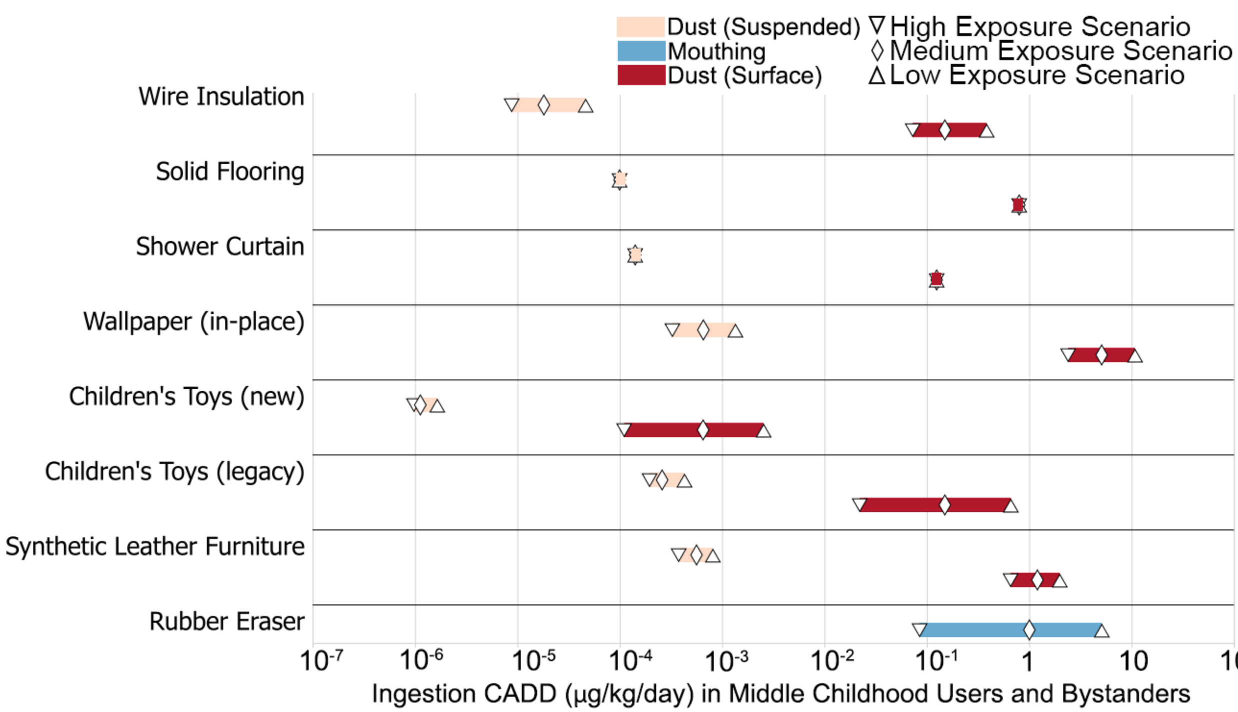


Figure 4-22. Chronic Daily Dose of DIDP from Ingestion of Airborne Dust, Surface Dust, and Mouthing for Middle Childhood 6 to 10 Years Old

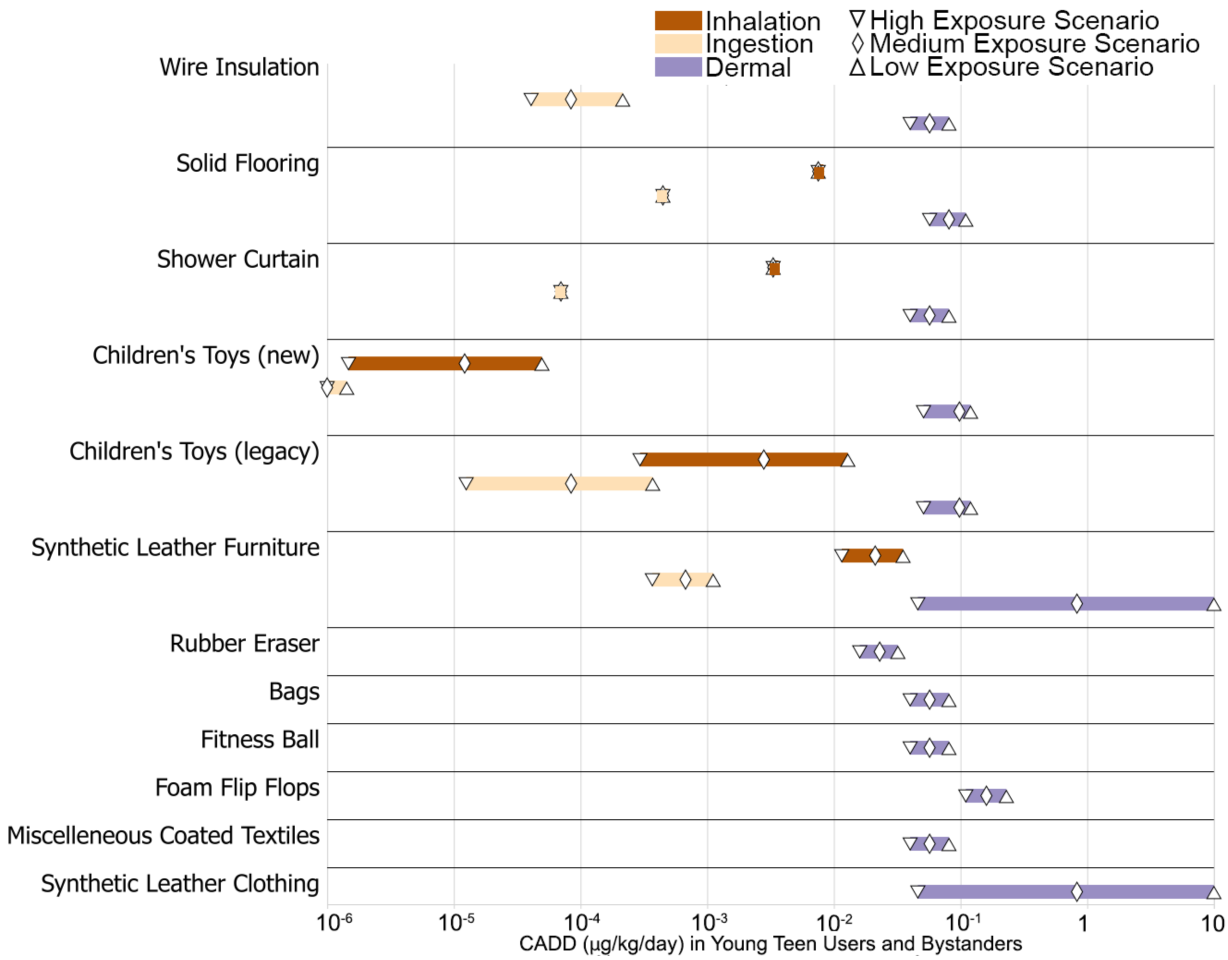


Figure 4-23. Chronic Average Daily Dose for DIDP from Ingestion, Inhalation, Dermal Exposure Routes for Young Teens 11 to 15 Years Old

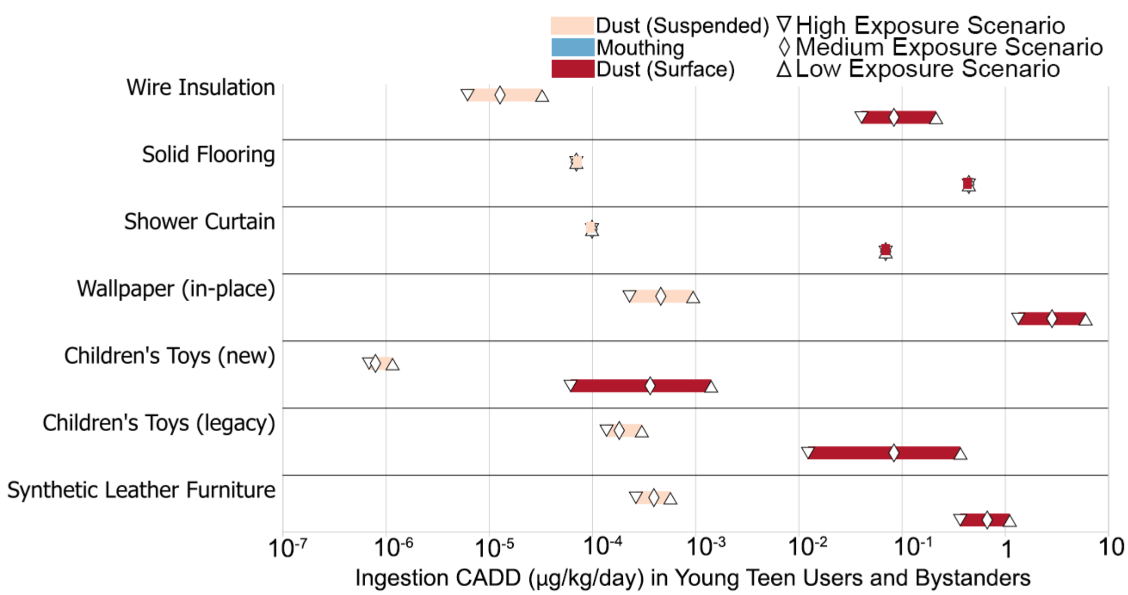


Figure 4-24. Chronic Daily Dose of DIDP from Ingestion of Airborne Dust, Surface Dust, and Mouthing for Young Teens 11 to 15 Years Old

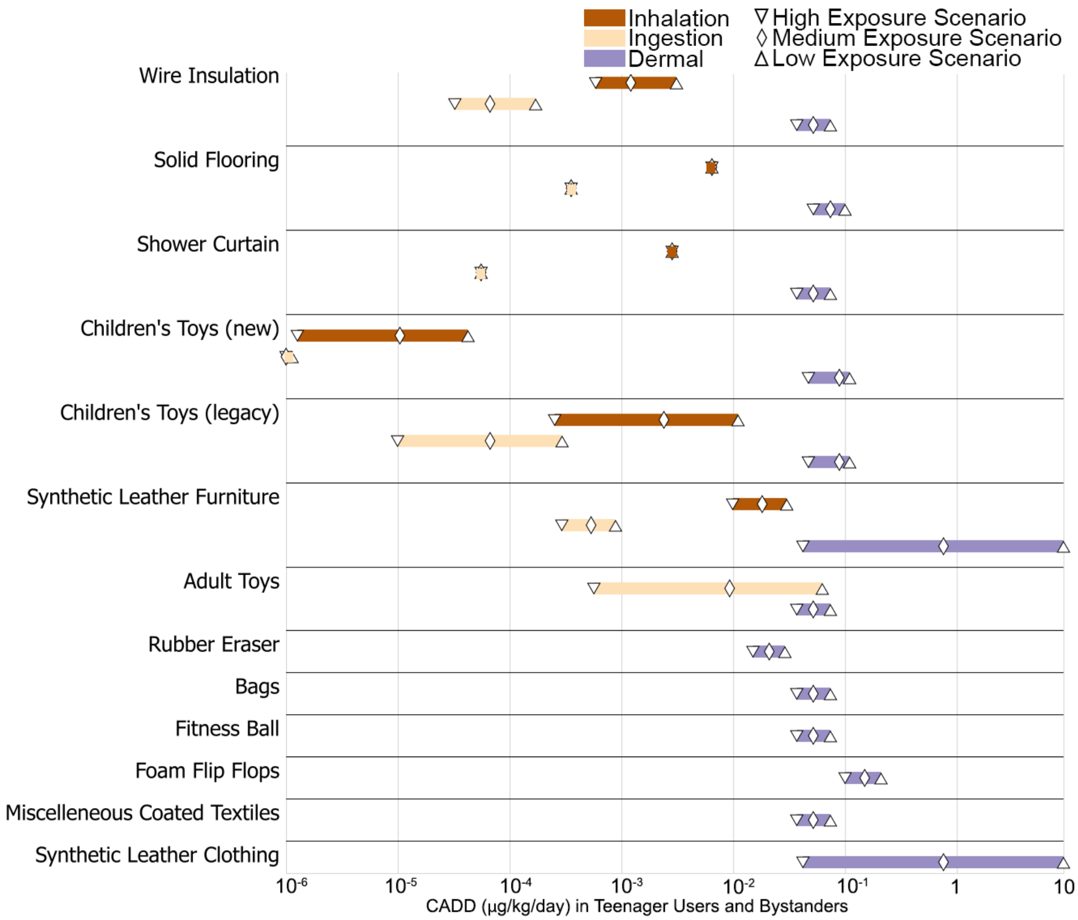


Figure 4-25. Chronic Average Daily Dose for DIDP from Ingestion, Inhalation, Dermal Exposure Routes for Teenagers and Young Adults, 16 to 20 Years Old

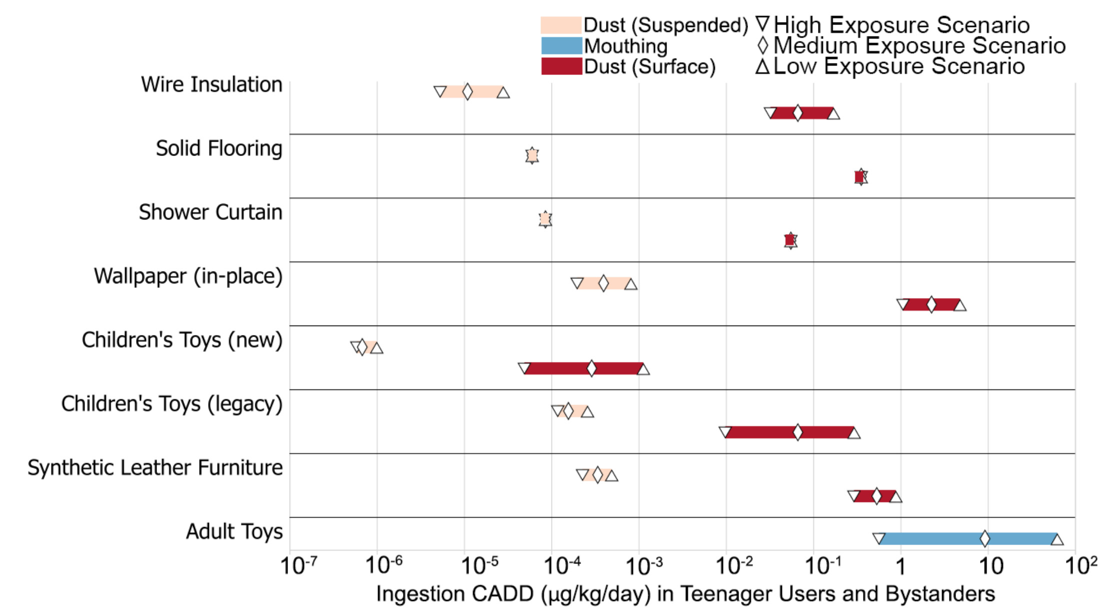
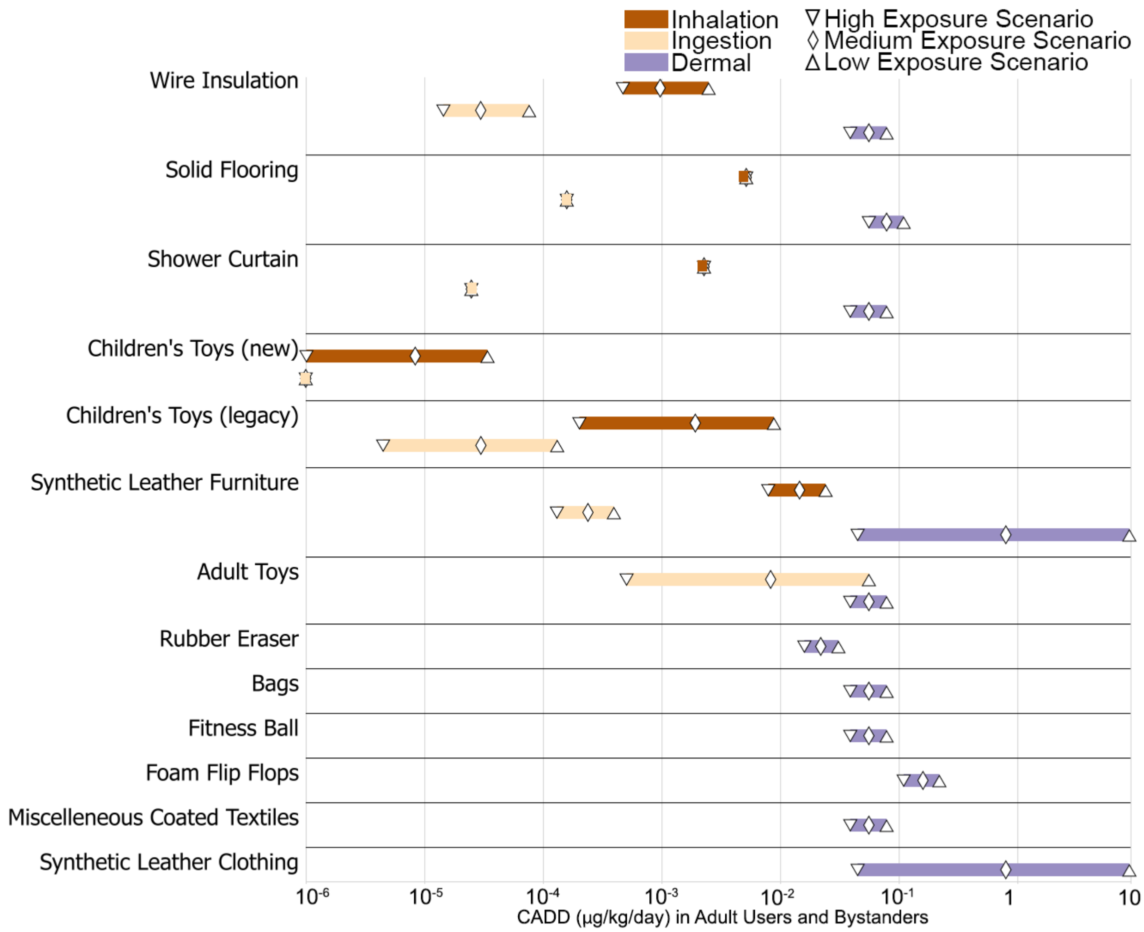


Figure 4-26. Chronic Daily Dose of DIDP from Ingestion of Airborne Dust, Surface Dust, and Mouthing for Teenagers and Young Adults, 16 to 20 Years Old



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1786 **Figure 4-27. Chronic Average Daily Dose for DIDP from Ingestion, Inhalation, Dermal Exposure**
1787 **Routes for Adults above 21 Years Old**
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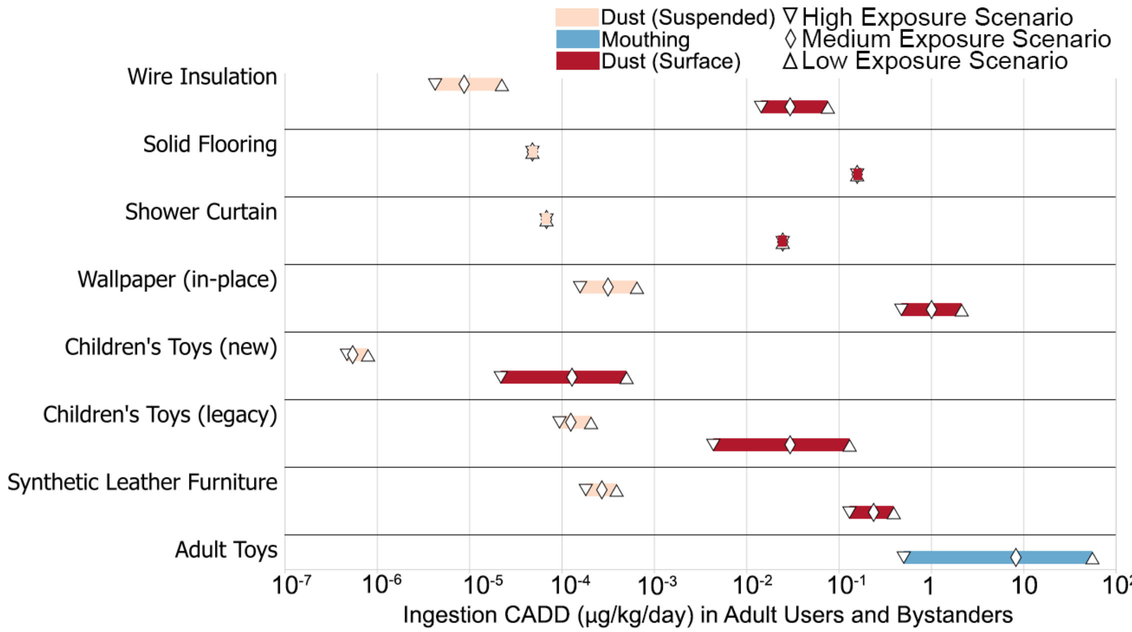

Figure 4-28. Chronic Daily Dose of DIDP from Ingestion of Airborne Dust, Surface Dust, and Mouthing for Adults above 21 Years Old

Intermediate Average Daily Dose Conclusions and Data Patterns

Table 4-3 summarizes all the high-end tendency (HE), central tendency (CT), and low-end tendency (LE) intermediate dose results from modeling in CEM and outside of CEM (dermal only) for all exposure routes and all lifestages. Only four product examples under the *Construction, paint, electrical, and metal products Adhesives and Sealants and Paints and Coatings* COUs were candidates for intermediate exposure scenarios. Intermediate exposure scenarios were built for products used between 30 and 60 days, and EPA used 30 days or ~1 month for product use. Some products did not have dose results because the product examples were not targeted for that lifestage for that exposure route. Scenarios without dose results are marked with a dash (-).

Table 4-3. Intermediate Dose Results for All Exposure Routes for All Lifestages

COU and Subcategories	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Intermediate Dose (µg/kg-month)						
				Infant (<1 Year)	Toddler (1–3 Years)	Preschooler (3–5 years)	Middle Childhood (6–10 years)	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
Construction, paint, electrical, and metal products: Adhesives and sealants	Construction Adhesive for Small Scale Projects	Dermal	H	-	-	-	-	1.09E01	9.94E00	1.06E01
			M	-	-	-	-	3.90E00	3.57E00	3.81E00
			L	-	-	-	-	2.54E00	2.32E00	2.48E00
		Inhalation	H	2.89E−01	2.72E−01	2.21E−01	1.54E−01	1.20E−01	1.02E−01	8.27E−02
			M	4.05E−02	3.82E−02	3.10E−02	2.16E−02	1.70E−02	1.45E−02	1.17E−02
			L	1.70E−03	1.60E−03	1.30E−03	9.04E−04	7.19E−04	6.15E−04	4.94E−04
Construction, paint, electrical, and metal products: Adhesives and sealants	Construction Sealant for Large Scale Projects	Dermal	H	-	-	-	-	3.26E01	2.98E01	3.19E01
			M	-	-	-	-	1.76E01	1.61E01	1.72E01
			L	-	-	-	-	1.14E01	1.04E01	1.11E01
		Inhalation	H	3.61E00	3.40E00	2.760711537	1.922328	2.45E00	1.93E00	1.66E00
			M	8.03E−01	7.56E−01	0.614931387	0.428187	3.43E−01	2.88E−01	2.35E−01
			L	1.68E−03	1.58E−03	0.001283181	0.000893	6.59E−04	5.61E−04	4.53E−04
Construction, paint, electrical, and metal products: Adhesives and sealants, and Paints and Coatings	Lacquer Sealer (Non-Spray)	Dermal	H	-	-	-	-	4.35E01	3.97E01	4.25E01
			M	-	-	-	-	1.76E01	1.61E01	1.72E01
			L	-	-	-	-	1.52E01	1.39E01	1.49E01
		Inhalation	H	5.64E00	5.31E00	4.32E00	3.48E00	2.66E00	2.08E00	1.80E00
			M	5.63E00	5.30E00	4.31E00	3.14E00	2.25E00	1.87E00	1.54E00
			L	5.61E00	5.28E00	4.29E00	3.05E00	2.19E00	1.85E00	1.50E00

COU and Subcategories	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Intermediate Dose (µg/kg-month)						
				Infant (<1 Year)	Toddler (1–3 Years)	Preschooler (3–5 years)	Middle Childhood (6–10 years)	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
Construction, paint, electrical, and metal products: Adhesives and sealants, and Paints and Coatings	Lacquer Sealer (Spray)	Dermal	H	-	-	-	-	1.74E01	1.59E01	1.70E01
			M	-	-	-	-	7.02E00	6.42E00	6.86E00
			L	-	-	-	-	6.08E00	5.56E00	5.95E00
		Inhalation	H	5.67E00	5.34E00	4.34E00	3.50E00	2.70E00	2.11E00	1.84E00
			M	5.67E00	5.34E00	4.34E00	3.17E00	2.31E00	1.91E00	1.58E00
			L	5.40E00	5.08E00	4.13E00	2.98E00	2.27E00	1.91E00	1.55E00
Scenarios without dose results are marked with a dash (-). Some products do not have dose results because the product examples were not targeted for that lifestage for that exposure route.										

The following set of figures (Figure 4-29 to Figure 4-35) are similar images of the figures built for the acute daily dose results in Section 2.1.1.1 for the products used in the intermediate assessment. Only construction adhesives and lacquers qualified to be used in intermediate scenarios. Based on manufacturer use description and professional judgement/assumption, these products may be used repeatedly within a 30-day period depending on projects. Infants to childhood lifestages do not have dermal doses as these products are not targeted for their use and application. However, starting from young teens through adults, it is possible that these lifestages can use construction adhesives and lacquers in home renovation projects or other hobbies. Infants to middle childhood lifestages are considered bystanders when these products are in use and are exposed via inhalation. Use of lacquers results in the highest doses for all lifestages. Direct dermal contact has a larger dose than inhalation for the uses during application.

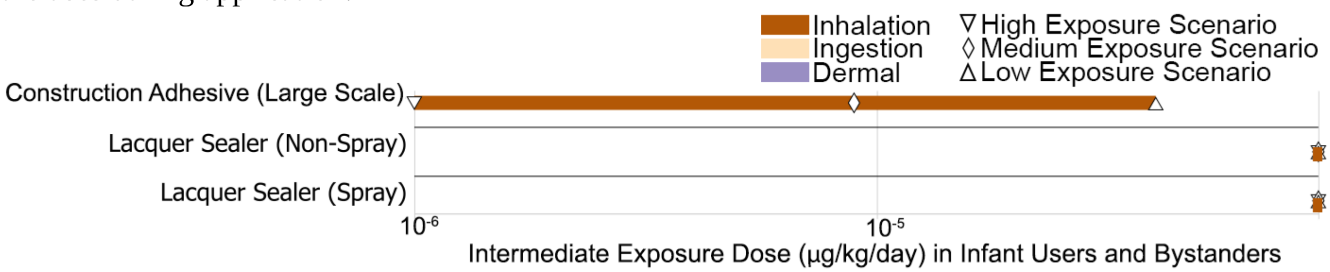

Figure 4-29. Intermediate Average Daily Dose of DIDP from Inhalation for Infants <1 Year Old

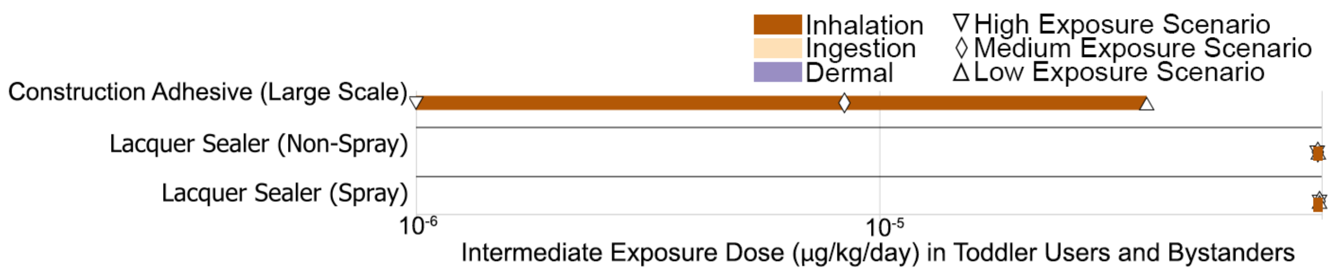

Figure 4-30. Intermediate Average Daily Dose of DIDP from Inhalation for Toddlers 1 to 2 Years Old

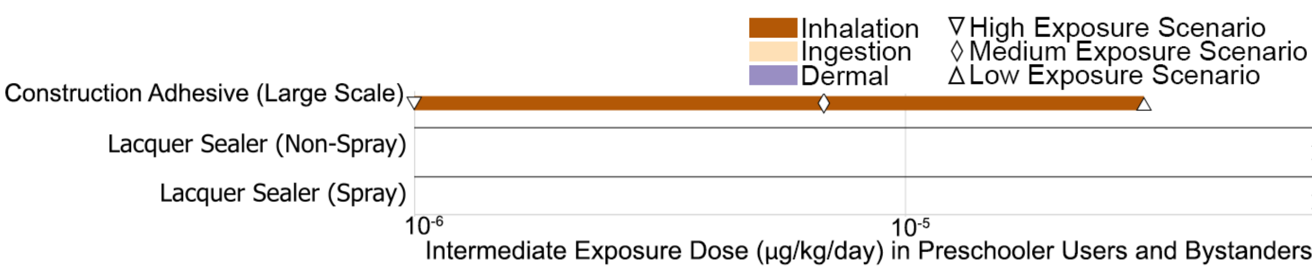

Figure 4-31. Intermediate Average Daily Dose of DIDP from Inhalation for Preschoolers 3 to 5 Years Old

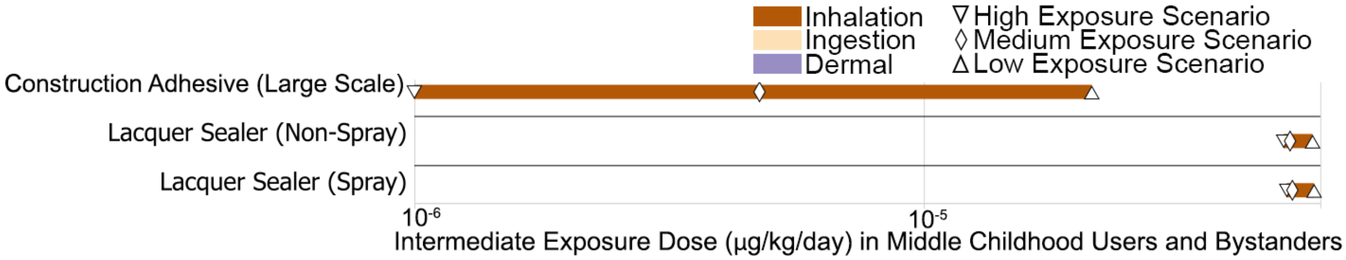

Figure 4-32. Intermediate Average Daily Dose of DIDP from Inhalation for Middle Childhood 6 to 10 Years Old

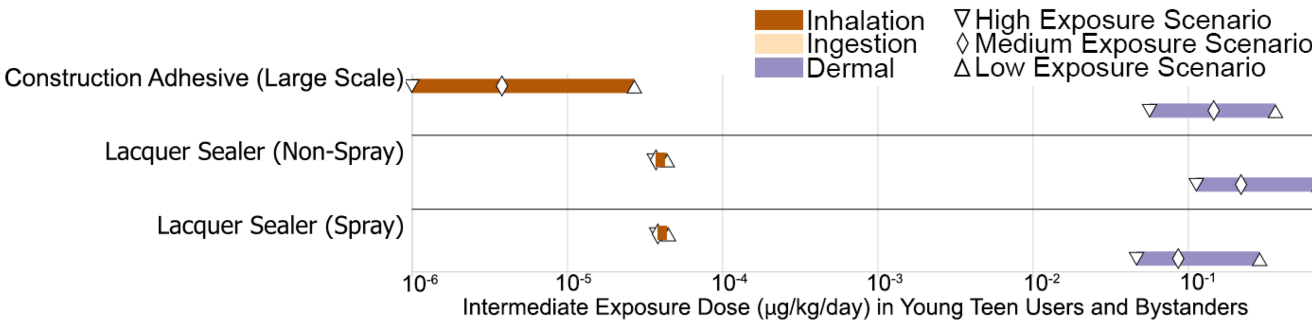

Figure 4-33. Intermediate Average Daily Dose of DIDP from Inhalation and Dermal Exposure for Young Teens 11 to 15 Years Old

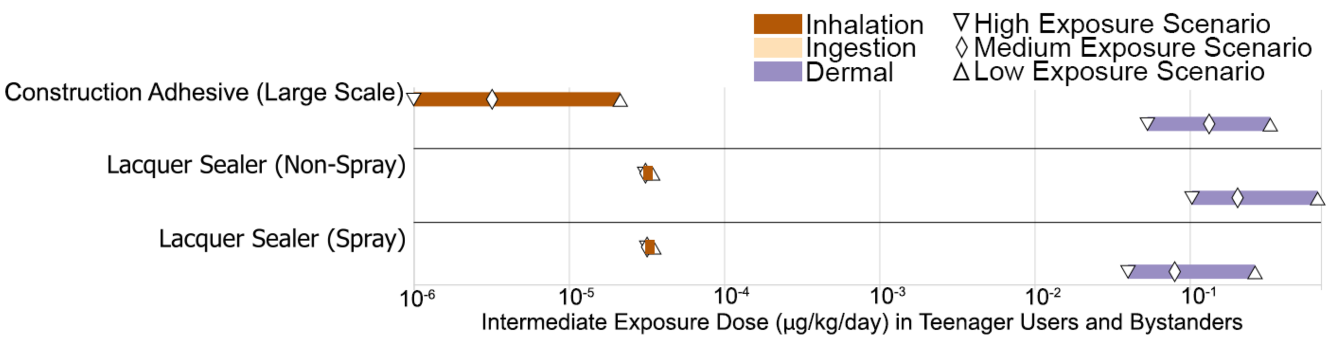

Figure 4-34. Intermediate Average Daily Dose of DIDP from Inhalation and Dermal Exposure for Teenagers and Young Adults 16 to 20 Years Old

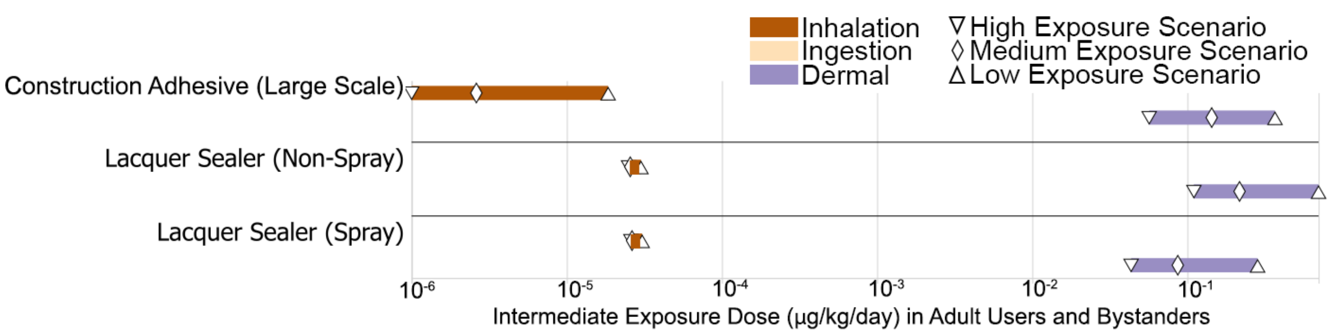

Figure 4-35. Intermediate Average Daily Dose of DIDP from Inhalation and Dermal Exposure for Adults >21 Years Old

4.2 Indoor Dust Monitoring Results

Estimates of DIDP ingestion in indoor dust per day based on monitoring data are presented in Table 4-4 and Table 4-5.

Table 4-4. Estimates of DIDP Dust Ingestion Per Day from Monitoring, Age 0 to 21 Years

Age Range		0-<1m	1-<3m	3-<6m	6m-<1y	1-<2y	2-<3y	3-<6y	6-<11y	11-<16y	16-<21y
Dust ingestion (mg/day) [a]	GM	19	21	23	26	23	14	15	13	8.8	3.5
	95th Percentile	103	116	112	133	119	83	94	87	78	46
Body weight (kg) [b]		4.8	5.9	7.4	9.2	11.4	13.8	18.6	31.8	56.8	71.6
DIDP Ingestion (µg/kg-day)	Central tendency (111 µg DIDP/g dust)	0.44	0.40	0.35	0.31	0.22	0.11	0.090	0.045	0.017	0.0054
	High end (433.9 µg DIDP/g dust)	1.72	1.54	1.35	1.23	0.88	0.44	0.35	0.18	0.067	0.021

[a] From Özkaynak et al. (2022)
[b] From U.S. EPA (2011b)

Table 4-5. Estimates of DIDP Dust Ingestion Per Day from Monitoring, Age 21 to 80+ Years

Age Range		21-<30y	30-<40y	40-<50y	50-<60y	60-<70y	70-<80y	>80y
Dust ingestion (mg/day) [a]	GM	3.5	3.5	3.5	3.5	3.5	3.5	3.5
	95th Percentile	46	46	46	46	46	46	46
DIDP Ingestion (µg/kg-day)	Central tendency (111 µg DIDP/g dust)	0.0050	0.0048	0.0046	0.0047	0.0047	0.0051	0.0057
	High end (433.9 µg DIDP/g dust)	0.019	0.019	0.018	0.018	0.018	0.020	0.022
Body weight (kg)[b]		78.4	80.8	83.6	83.4	82.6	76.4	68.5

[a] From Özkaynak et al. (2022) (rates for 16-21y)
[b] From U.S. EPA (2011b)

4.3 Indoor Dust Modeling Results

All indoor dust exposure scenarios were modeled in CEM for inhalation, ingestion of suspended dust, and ingestion of surface dust. The indoor assessment used CEM outputs for articles from the consumer analysis that have large surface area and hence potential to collect surface dust. See Section 2.1.2.1 for CEM parameterization, input values, and article specific scenario assumptions and sources. DIDP has a very low volatility and partitions to particulate quickly, and suspended particulate tends to settle and accumulate on surfaces. Exposure to DIDP via ingestion of suspended dust is expected to be lower than surface dust, as seen in Figure 4-3, Figure 4-4, Figure 4-7, Figure 4-8, Figure 4-11, Figure 4-12, Figure 4-14, Figure 4-16, Figure 4-18, Figure 4-20, Figure 4-22, Figure 4-24, Figure 4-26, Figure 4-28. Because monitoring intake rates were only assessed for ingestion the comparison between monitoring and modeling only includes ingestion estimates, see Section 4.4. Section 4.3.1 summarizes CEM outputs for the ingestion scenarios used in the monitoring and modeling comparison.

DIDP intake for inhalation of indoor dust by COU and by article was estimated by applying the Consumer Exposure Model (CEM). DIDP exposure via inhalation of indoor dust by COU and by article was estimated with CEM. See Section 2.1 for a detailed description of how CEM was applied to estimate DIDP inhalation intake for indoor dust. Estimates of the acute and chronic daily dose of DIDP per type of consumer article for inhalation and ingestion of airborne dust are provided in Table 4-1 and Table 4-2. To facilitate finding the ingestion intakes for the set of articles used in indoor environment reconstruction scenarios and perform a monitoring and modeling comparison, the estimates of the acute and chronic dose rate of DIDP are taken from Table 4-1 and Table 4-2 and provided in Section 4.3.1 below in Table 4-6 and Table 4-7.

4.3.1 Modeling Results for Ingestion of Indoor Dust

See Section 2.1 for a detailed description of how CEM was applied to estimate DIDP intake for indoor dust. To facilitate finding the ingestion intakes for the set of articles used in indoor environment reconstruction scenarios, the estimates of the acute dose rate of DIDP by the type of consumer article, both for ingestion of airborne dust and incidental ingestion of dust on surfaces, are taken from Table 4-1 and provided in Table 4-6.

For all lifestages, exposure from ingestion of surface dust on wallpaper was the largest source of acute DIDP exposure by a significant margin. The highest exposures were for children aged 3 to 5 years and ranged from 7.80 to 35.06 µg/kg-day. Slightly lower ranges were estimated for infants less than 1 year old (5.60 to 25.08 µg/kg-day) and toddlers 1 to 2 years old (6.89 to 31.06 µg/kg-day). After age 5, exposure began to decline, with a range of 2.73 to 12.31 µg/kg-day in children aged 6 to 10, a range of 1.53 to 6.89 µg/kg-day in young teens aged 11 to 15, a range of 1.21 to 5.47 µg/kg-day in teenagers aged 16 to 20, and a range of 0.54 to 2.45 µg/kg-day in adults 21 years or older. The next largest source of exposure, synthetic leather furniture, was between 4 and 5 times lower in magnitude for all lifestages studied. Other sources of DIDP ingestion in dust, in descending order of magnitude, included solid flooring and legacy children's toys (for all lifestages below 21 years old), followed by wire insulation.

The highest estimated acute DIDP exposure from ingestion of airborne dust was for wallpaper in infants less than 1 year old and ranged from 0.001 to 0.003 µg/kg-day. All other articles and lifestages had lower estimated DIDP exposures. Compared to exposure from ingestion of surface dust, estimated airborne dust exposures were lower.

Table 4-6. Acute Daily Dose Results for Indoor Dust for All Lifestages

COU	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Acute Daily Dose (µg/kg-day)						
				Infant (<1 Year)	Toddler (1–3 Years)	Preschooler (3–5 years)	Middle Childhood (6–10 years)	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
Packaging, paper, plastic, hobby products: Toys, Playground, and Sporting Equipment	Legacy Children's Toys	Ingestion suspended dust	H	9.5E−04	9.0E−04	7.3E−04	5.1E−04	3.6E−04	3.1E−04	2.5E−04
			M	5.6E−04	5.2E−04	4.3E−04	3.0E−04	2.1E−04	1.8E−04	1.4E−04
			L	4.1E−04	3.9E−04	3.2E−04	2.2E−04	1.5E−04	1.3E−04	1.1E−04
		Ingestion dust on surface	H	1.5E00	1.9E00	2.1E00	7.5E−01	4.2E−01	3.3E−01	3.4E−02
			M	3.5E−01	4.3E−01	4.8E−01	1.7E−01	9.5E−02	7.6E−02	4.9E−03
			L	5.0E−02	6.2E−02	7.0E−02	2.5E−02	1.4E−02	1.1E−02	1.5E−01
Packaging, paper, plastic, hobby products: Toys, Playground, and Sporting Equipment	New Children's Toys	Ingestion suspended dust	H	3.7E−06	3.5E−06	2.8E−06	2.0E−06	1.4E−06	1.2E−06	9.5E−07
			M	2.4E−06	2.3E−06	1.9E−06	1.3E−06	9.1E−07	7.8E−07	6.2E−07
			L	2.1E−06	1.9E−06	1.6E−06	1.1E−06	7.7E−07	6.6E−07	5.3E−07
		Ingestion dust on surface	H	5.9E−03	7.3E−03	8.3E−03	2.9E−03	1.6E−03	1.3E−03	1.5E−04
			M	1.5E−03	1.9E−03	2.1E−03	7.4E−04	4.1E−04	3.3E−04	2.4E−05
			L	2.5E−04	3.1E−04	3.5E−04	1.2E−04	6.9E−05	5.5E−05	5.8E−04
Packaging, paper, plastic, hobby products: Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Shower Curtain	Ingestion suspended dust	H	3.1E−04	2.9E−04	2.3E−04	1.6E−04	1.2E−04	9.9E−05	7.9E−05
			M	3.1E−04	2.9E−04	2.3E−04	1.6E−04	1.2E−04	9.9E−05	7.9E−05
			L	3.1E−04	2.9E−04	2.3E−04	1.6E−04	1.2E−04	9.9E−05	7.9E−05
		Ingestion dust on surface	H	2.9E−01	3.6E−01	4.0E−01	1.4E−01	7.9E−02	6.3E−02	2.8E−02
			M	2.9E−01	3.6E−01	4.0E−01	1.4E−01	7.9E−02	6.3E−02	2.8E−02
			L	2.9E−01	3.6E−01	4.0E−01	1.4E−01	7.9E−02	6.3E−02	2.8E−02
Construction, paint, electrical, and metal products:	Solid Flooring	Ingestion suspended dust	H	2.3E−04	2.2E−04	1.8E−04	1.2E−04	8.7E−05	7.5E−05	6.0E−05
			M	2.3E−04	2.2E−04	1.8E−04	1.2E−04	8.7E−05	7.5E−05	6.0E−05

COU	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Acute Daily Dose (µg/kg-day)						
				Infant (<1 Year)	Toddler (1–3 Years)	Preschooler (3–5 years)	Middle Childhood (6–10 years)	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
Building/construction materials covering large surface areas including stone, plaster, cement, glass and ceramic articles (wire or wiring systems; joint treatment			L	2.3E−04	2.2E−04	1.8E−04	1.2E−04	8.7E−05	7.5E−05	6.0E−05
		Ingestion dust on surface	H	1.9E00	2.3E00	2.6E00	9.1E−01	5.1E−01	4.0E−01	1.8E−01
			M	1.9E00	2.3E00	2.6E00	9.1E−01	5.1E−01	4.0E−01	1.8E−01
			L	1.9E00	2.3E00	2.6E00	9.1E−01	5.1E−01	4.0E−01	1.8E−01
Furnishing, cleaning, treatment/care products: Fabrics, textiles, and apparel (as plasticizer)	Synthetic Leather Furniture	Ingestion suspended dust	H	1.9E−03	1.7E−03	1.4E−03	9.9E−04	7.0E−04	6.0E−04	4.8E−04
			M	1.3E−03	1.2E−03	9.7E−04	6.8E−04	4.8E−04	4.1E−04	3.3E−04
			L	8.4E−04	7.9E−04	6.4E−04	4.5E−04	3.2E−04	2.7E−04	2.2E−04
		Ingestion dust on surface	H	4.6E00	5.7E00	6.5E00	2.3E00	1.3E00	1.0E00	4.5E−01
			M	2.8E00	3.5E00	3.9E00	1.4E00	7.7E−01	6.1E−01	2.7E−01
			L	1.5E00	1.9E00	2.1E00	7.5E−01	4.2E−01	3.3E−01	1.5E−01
Packaging, paper, plastic, hobby products: Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Wallpaper	Ingestion suspended dust	H	3.1E−03	3.0E−03	2.4E−03	1.7E−03	1.2E−03	1.0E−03	8.1E−04
			M	1.5E−03	1.4E−03	1.2E−03	8.1E−04	5.7E−04	4.9E−04	3.9E−04
			L	7.6E−04	7.1E−04	5.8E−04	4.0E−04	2.8E−04	2.4E−04	2.0E−04
		Ingestion dust on surface	H	2.5E01	3.1E01	3.5E01	1.2E01	6.9E00	5.5E00	2.4E00
			M	1.2E01	1.5E01	1.7E01	5.8E00	3.2E00	2.6E00	1.2E00
			L	5.6E00	6.9E00	7.8E00	2.7E00	1.5E00	1.2E00	5.4E−01
Construction, paint, electrical, and metal products: Electrical and Electronic Products	Wire insulation	Ingestion suspended dust	H	1.1E−04	1.0E−04	8.3E−05	5.8E−05	4.1E−05	3.5E−05	2.8E−05
			M	4.2E−05	4.0E−05	3.3E−05	2.3E−05	1.6E−05	1.4E−05	1.1E−05
			L	2.1E−05	1.9E−05	1.6E−05	1.1E−05	7.7E−06	6.6E−06	5.3E−06

COU	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Acute Daily Dose (µg/kg-day)						
				Infant (<1 Year)	Toddler (1–3 Years)	Preschooler (3–5 years)	Middle Childhood (6–10 years)	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
		Ingestion dust on surface	H	8.9E−01	1.1E00	1.2E00	4.4E−01	2.4E−01	1.9E−01	8.7E−02
			M	3.5E−01	4.3E−01	4.9E−01	1.7E−01	9.6E−02	7.6E−02	3.4E−02
			L	1.7E−01	2.1E−01	2.4E−01	8.3E−02	4.6E−02	3.7E−02	1.6E−02

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To estimate ingestion intakes for the set of articles used in indoor environment reconstruction scenarios, the medium exposure scenario estimates of chronic daily dose of DIDP for each consumer article were summed. This was done for both ingestion of airborne dust and incidental ingestion of dust on surfaces, and the values are provided in Table 4-7**.**

The patterns of chronic exposure to DIDP from indoor dust were similar to acute exposure. For all lifestages, exposure from ingestion of surface dust on wallpaper was the largest source of chronic DIDP exposure by a significant margin. The highest exposures were for children aged 3-5 years and ranged from 6.85 to 30.85 µg/kg-day. Slightly lower exposure ranges were estimated for infants less than 1 year old (4.90 to 22.07 µg/kg-day) and toddlers 1 to 2 years old (6.06 to 27.32 µg/kg-day). Exposures begins to decline with older lifestages: range of 2.40 to10.83 µg/kg-day in children aged 6 to 10; 1.35 to 6.06 µg/kg-day in young teens aged 11 to 15; 1.07 to 4.81 µg/kg-day in teenagers aged 16 to 20; and 0.48 to 2.15 µg/kg-day in adults 21 years and older. The next largest source of exposure, synthetic leather furniture, was between 4 and 5 times lower in magnitude for all lifestages studied. Other sources of DIDP ingestion in dust, in descending order of magnitude, included solid flooring and legacy children's toys (for all lifestages below 21 years old), followed by wire insulation.

The highest estimated chronic DIDP exposure from ingestion of airborne dust was for wallpaper in infants less than 1 year old and ranged from 0.001 to 0.003 µg/kg-day. All other articles and lifestages had lower estimated DIDP exposures. Compared to exposure from ingestion of surface dust, estimated airborne dust exposures were extremely low.

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COU	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Chronic Daily Dose (µg/kg-day)						
				Infant (<1 Year)	Toddler (1–3 Years)	Preschooler (3–5 years)	Middle Childhood (6–10 years)	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
Packaging, paper, plastic, hobby products: Toys, Playground, and Sporting Equipment	Legacy Children's Toys	Ingestion suspended dust	H	8.1E−04	7.6E−04	6.2E−04	4.3E−04	3.0E−04	2.6E−04	2.1E−04
			M	4.9E−04	4.6E−04	3.7E−04	2.6E−04	1.8E−04	1.6E−04	1.3E−04
			L	3.7E−04	3.5E−04	2.8E−04	2.0E−04	1.4E−04	1.2E−04	9.5E−05
		Ingestion dust on surface	H	1.4E00	1.7E00	1.9E00	6.6E−01	3.7E−01	2.9E−01	1.3E−01
			M	3.1E−01	3.8E−01	4.3E−01	1.5E−01	8.4E−02	6.7E−02	3.0E−02
			L	4.5E−02	5.6E−02	6.3E−02	2.2E−02	1.2E−02	9.8E−03	4.4E−03
Packaging, paper, plastic, hobby products: Toys, Playground, and Sporting Equipment	New Children's Toys	Ingestion suspended dust	H	3.1E−06	2.9E−06	2.4E−06	1.7E−06	1.2E−06	1.0E−06	8.0E−07
			M	2.1E−06	2.0E−06	1.6E−06	1.1E−06	8.0E−07	6.8E−07	5.5E−07
			L	1.8E−06	1.7E−06	1.4E−06	9.8E−07	6.9E−07	5.9E−07	4.7E−07
		Ingestion dust on surface	H	5.2E−03	6.4E−03	7.3E−03	2.5E−03	1.4E−03	1.1E−03	5.1E−04
			M	1.3E−03	1.6E−03	1.9E−03	6.5E−04	3.7E−04	2.9E−04	1.3E−04
			L	2.3E−04	2.8E−04	3.2E−04	1.1E−04	6.2E−05	4.9E−05	2.2E−05
Packaging, paper, plastic, hobby products: Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Shower Curtain	Ingestion suspended dust	H	2.7E−04	2.5E−04	2.0E−04	1.4E−04	1.0E−04	8.6E−05	6.9E−05
			M	2.7E−04	2.5E−04	2.0E−04	1.4E−04	1.0E−04	8.6E−05	6.9E−05
			L	2.7E−04	2.5E−04	2.0E−04	1.4E−04	1.0E−04	8.6E−05	6.9E−05
		Ingestion dust on surface	H	2.5E−01	3.2E−01	3.6E−01	1.2E−01	7.0E−02	5.5E−02	2.5E−02
			M	2.5E−01	3.2E−01	3.6E−01	1.2E−01	7.0E−02	5.5E−02	2.5E−02
			L	2.5E−01	3.2E−01	3.6E−01	1.2E−01	7.0E−02	5.5E−02	2.5E−02
Construction, paint,	Solid	Ingestion	H	1.9E−04	1.8E−04	1.4E−04	1.0E−04	7.0E−05	6.0E−05	4.8E−05

COU	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Chronic Daily Dose (µg/kg-day)						
				Infant (<1 Year)	Toddler (1–3 Years)	Preschooler (3–5 years)	Middle Childhood (6–10 years)	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
electrical, and metal products: Building/construction materials covering large surface areas including stone, plaster, cement, glass and ceramic articles (wire or wiring systems; joint treatment	Flooring	suspended dust	M	1.9E−04	1.8E−04	1.4E−04	1.0E−04	7.0E−05	6.0E−05	4.8E−05
			L	1.9E−04	1.8E−04	1.4E−04	1.0E−04	7.0E−05	6.0E−05	4.8E−05
		Ingestion dust on surface	H	1.6E00	2.0E00	2.3E00	8.0E−01	4.5E−01	3.5E−01	1.6E−01
			M	1.6E00	2.0E00	2.3E00	8.0E−01	4.5E−01	3.5E−01	1.6E−01
			L	1.6E00	2.0E00	2.3E00	8.0E−01	4.5E−01	3.5E−01	1.6E−01
Furnishing, cleaning, treatment/care products: Fabrics, textiles, and apparel (as plasticizer)	Synthetic Leather Furniture	Ingestion suspended dust	H	1.5E−03	1.4E−03	1.2E−03	8.1E−04	5.7E−04	4.9E−04	3.9E−04
			M	1.1E−03	9.9E−04	8.1E−04	5.6E−04	4.0E−04	3.4E−04	2.7E−04
			L	7.1E−04	6.7E−04	5.4E−04	3.8E−04	2.7E−04	2.3E−04	1.8E−04
		Ingestion dust on surface	H	4.1E00	5.0E00	5.7E00	2.0E00	1.1E00	8.8E−01	4.0E−01
			M	2.5E00	3.0E00	3.4E00	1.2E00	6.7E−01	5.3E−01	2.4E−01
			L	1.3E00	1.7E00	1.9E00	6.6E−01	3.7E−01	2.9E−01	1.3E−01
Packaging, paper, plastic, hobby products: Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Wallpaper	Ingestion suspended dust	H	2.5E−03	2.4E−03	1.9E−03	1.4E−03	9.5E−04	8.2E−04	6.6E−04
			M	1.2E−03	1.2E−03	9.4E−04	6.6E−04	4.6E−04	4.0E−04	3.2E−04
			L	6.1E−04	5.8E−04	4.7E−04	3.3E−04	2.3E−04	2.0E−04	1.6E−04
		Ingestion dust on surface	H	2.2E01	2.7E01	3.1E01	1.1E01	6.1E00	4.8E00	2.2E00
			M	1.0E01	1.3E01	1.5E01	5.1E00	2.9E00	2.3E00	1.0E00
			L	4.9E00	6.1E00	6.8E00	2.4E00	1.3E00	1.1E00	4.8E−01
Construction, paint, electrical, and metal products: Electrical	Wire insulation	Ingestion suspended dust	H	8.7E−05	8.2E−05	6.7E−05	4.7E−05	3.3E−05	2.8E−05	2.3E−05
			M	3.4E−05	3.2E−05	2.6E−05	1.8E−05	1.3E−05	1.1E−05	8.8E−06

COU	Product / Article	Exposure Route	High (H) Medium (M) Low (L)	Chronic Daily Dose (µg/kg-day)						
				Infant (<1 Year)	Toddler (1–3 Years)	Preschooler (3–5 years)	Middle Childhood (6–10 years)	Young Teen (11–15 years)	Teenagers (16–20 years)	Adult (≥21 years)
and Electronic Products			L	1.7E−05	1.6E−05	1.3E−05	8.8E−06	6.2E−06	5.3E−06	4.3E−06
		Ingestion dust on surface	H	7.8E−01	9.7E−01	1.1E00	3.8E−01	2.2E−01	1.7E−01	7.6E−02
			M	3.1E−01	3.8E−01	4.3E−01	1.5E−01	8.4E−02	6.7E−02	3.0E−02
			L	1.5E−01	1.8E−01	2.1E−01	7.3E−02	4.1E−02	3.2E−02	1.4E−02

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4.4 Indoor Dust Comparison Between Monitoring and Modeling Ingestion Exposure Estimates

The exposure estimates for indoor dust from the CEM model are larger than those indicated by the monitoring approach. Table 4-8 compares the sum of the chronic daily dose central tendency for indoor dust ingestion from CEM outputs for all COUs to the central tendency predicted daily dose from the monitoring approach.

Table 4-8 Comparison Between Modeled and Monitored Daily Dust Intake Estimates for DIDP

Lifestage	Daily DIDP Intake Estimate from Dust, μg/kg-day, Modeled Exposure [a]	Daily DIDP Intake Estimate from Dust, μg/kg-day, Monitoring Exposure [b]
Infant (<1 Year)	17.46	0.35 [c]
Toddler (1–2 Years)	21.62	0.22
Preschooler (3–5 Years)	24.41	0.09
Middle Childhood (6–10 Years)	8.56	0.045
Young Teen (11–15 Years)	4.79	0.017
Teenager (16–20 Years)	3.80	0.0054
Adult (21+ Years)	1.67	0.0048 [d]

[a] Sum of chronic daily doses for indoor dust ingestion for the "medium" intake scenario for all COUs modeled in CEM
[b] Central tendency estimate of daily dose for indoor dust ingestion from monitoring data
[c] Weighted average by month of monitored lifestages from birth to 12 months
[d] Weighted average by year of monitored lifestages from 21 to 80 years

The sum of DIDP intakes from dust in CEM modeled scenarios were, in all cases, considerably higher than those predicted by the monitoring approach. The difference between the two approaches ranged from 50 times in infants less than 1 year old, to a high of 704 times in teenagers 16 to 20 years old. These discrepancies partially stem from differences in the exposure assumptions of the CEM model versus the assumptions made when estimating daily dust intakes in Özkaynak et al. (2022). Dust intakes in Özkaynak et al. (2022) decline rapidly as a person ages due to behavioral factors including walking upright instead of crawling, cessation of exploratory mouthing behavior, and a decline in hand-to-mouth events. This agE−mediated decline in dust intake, which is more rapid for the Özkaynak et al. (2022) study than in CEM, partially explains why the margin of error between the modeled and monitoring results grows larger with age.

In the indoor dust modeling assessment, EPA reconstructed the scenario using consumer articles as the source of DIDP in dust. CEM modeling parameters and inputs for dust ingestion can partially explain the differences between modeling and monitoring estimates. For example, surface area, indoor environment volume, and ingestion rates by lifestage were selected to represent common use patterns. CEM calculates DIDP concentration in small particles (respirable particles) and large particles (dust) that are settled on the floor or surfaces. The model assumes these particles bound to DIDP are available via incidental dust ingestion and estimates exposure based on a daily dust ingestion rate and a fraction of the day that is spent in the zone with the DIDP-containing dust. The use of a weighted dust concentration can also introduce discrepancies between monitoring and modeling results.

5 WEIGHT OF SCIENTIFIC EVIDENCE

Variability refers to the inherent heterogeneity or diversity of data in an assessment. It is a description of the range or spread of a set of values. Uncertainty refers to a lack of data or an incomplete understanding of the context of the risk evaluation decision. Variability cannot be reduced, but it can be better characterized while uncertainty can be reduced by collecting more or better data. Uncertainty is addressed qualitatively by including a discussion of factors such as data gaps and subjective decisions or instances where professional judgment was used. Uncertainties associated with approaches and data used in the evaluation of consumer exposures are described below.

5.1 Consumer Exposure Analysis Weight of Scientific Evidence

The exposure assessment of chemicals from consumer products and articles has inherent challenges due to many sources of uncertainty in the analysis, including variations in product formulation, patterns of consumer use, frequency, duration, and application methods. Variability in environmental conditions may also alter physical and/or chemical behavior of the product or article. Key sources of uncertainty for evaluating exposure to DIDP in consumer goods and strategies to address those uncertainties are described in this section.

Generally, designation of robust confidence suggests thorough understanding of the scientific evidence and uncertainties. The supporting weight of scientific evidence outweighs the uncertainties to the point where it is unlikely that the uncertainties could have a significant effect on the exposure estimate. The designation of moderate confidence suggests some understanding of the scientific evidence and uncertainties. More specifically, the supporting scientific evidence weighed against the uncertainties is reasonably adequate to characterize exposure estimates. The designation of slight confidence is assigned when the weight of scientific evidence may not be adequate to characterize the scenario, and when the assessor is making the best scientific assessment possible in the absence of complete information and there are additional uncertainties that may need to be considered. While the uncertainty for some of the scenarios and parameters ranges from slight to robust the confidence to use the results for risk characterization ranges from moderate to robust, see Table 5-1, Table 5-2, and Table 5-3. The basis for the moderate to robust confidence in the overall exposure estimates is a balance between using parameters that will represent various populations use patterns and lean on protective assumptions that are not excessive or unreasonable.

Product Formulation and Composition

Variability in the formulation of consumer products, including changes in ingredients, concentrations, and chemical forms, can introduce uncertainty in exposure assessments. In addition, data were often limited for weight fractions of DIDP in consumer goods. EPA obtained DIDP weight fractions in various products and articles from material safety sheets, data bases, and existing literature (Section 2.1.2.1). Where possible, EPA obtained multiple values for weight fractions for similar products or articles. The lowest value was used in the low exposure scenario, the highest value in the high exposure scenario, and the average of all values in the medium exposure scenario. Weight fraction of DIDP in articles was sourced from the available literature and database values. Robust was selected for products with multiple sources, moderate was selected for products with limited sources but more current, and slight was selected for products with limited and older sources. The uncertainty was improved by using ranges that included either a wide range or higher values that are considered health protective, but not excessive. The low, medium, and high estimates capture a range of concentrations that is representative of past, present, and future practices, encompassing lots of possible exposures.

Product Use Patterns

Consumer use patterns like frequency of use, duration of use, and methods of application are expected to differ. Where possible, high, medium, and low default values from CEM 3.2's prepopulated scenarios were selected for mass of product used, duration of use, and frequency of use. In instances where no prepopulated scenario was appropriate for a specific product, low, medium, and high values for each of these parameters were estimated based on the manufacturers' product descriptions. Use duration and frequency were primarily sourced from manufacturer use instructions, the EPA's *Exposure Factors Handbook*, and by the judgment of the exposure assessor. Robust was selected when the used values are well understood and represent a wide range of the population. Moderate was selected for durations of use sourced from manufacturer use instructions that had multiple types of products with different use instructions and variability is expected to increase with numerous products available. The main limitation in this analysis and source of uncertainty in the selected inputs is in the accuracy of the selected use pattern inputs, however EPA is confident that the selected inputs include health protective inputs in the low, medium, and high exposure scenarios. The high duration scenarios may represent high intensity users, while the average expected use patterns are captured in the medium scenarios, and low use patterns for occasional and incidental exposures.

Article Surface Area

The surface area of an article directly affects the potential for DIDP emissions to the indoor environment. For each article modeled for inhalation exposure, low, medium, and high estimates for surface area were calculated (Section 2.1.2.1)2.1.2.2. This approach relied on manufacturer-provided dimensions where possible, or values from the EPA Exposure Factors Handbook for floor and wall coverings. For small items which might be expected to be present in a home in significant quantities, such as insulated wires and children's toys, aggregate values were calculated for the cumulative surface area for each type of article in the indoor environment. Surface area inputs are based on manufacturer use instructions, the EPA's *Exposure Factors Handbook*, and by the judgment of the exposure assessor. Robust confidence rating was selected for commonly known product dimensions and moderate for when the assessor made assumptions about the number of products present in a room.

Human Behavior

CEM 3.2 has three different activity patterns: stay-at-home, part-time out-of-the home (daycare, school, or work), and full-time out-of-thE‑home. The activity patterns were developed based on the Consolidated Human Activity Database (CHAD). For all products and articles modeled, the stay-at-home activity pattern was chosen as it is the most protective assumption.

Mouthing durations are a source of uncertainty in human behavior. The data used in this assessment are based on a study in which parents observed children (n=236) ages 1 month to 5 years of age for 15 minutes each session and 20 sessions in total ((Smith and Norris, 2003)). There was considerable variability in the data due to behavioral differences among children of the same lifestage. For instance, while children aged 6-9 months had the highest average mouthing duration for toys at 39 minutes per day, the minimum duration was 0 minutes and the maximum was 227 minutes per day. The observers noted that the items mouthed were made of plastic roughly 50 percent of the mouthing time, but this not limited to soft plastic items likely to contain significant plasticizer content. In another study, 169 children aged 3 months to 3 years were monitored by trained observers for 12 sessions at 12 minutes each (Greene, 2002). They reported mean mouthing durations ranging from 0.8 to 1.3 minutes per day for soft plastic toys and 3.8-4.4 minutes per day for other soft plastic objects (except pacifiers). Thus, it is likely that the mouthing durations used in this assessment provide a health protective estimate for mouthing of soft plastic items likely to contain DIDP and the low, medium, and high scenarios encompass a wide number of behaviors at various ages.

Mouthing duration confidence designation of robust is given to scenarios about children toys because the information used to derive these values is more comprehensive and specific about children toys and children behaviors while other non-toy scenarios are less specific about mouthing durations and more generalized, those were given a moderate confidence rating. In addition, mouthing area robust rating was selected for scenarios in which the mouthing area is well defined by object boundaries, moderate when object dimensions were based on generalizations and assumptions by the assessor from manufacturer descriptions.

Modeling Parameters for DIDP Flux, Dermal Absorption, and Chemical Migration

DIDP is considered a data poor chemical with respect to dermal absorption, meaning specific empirical information is scarce. Data were lacking for key parameters to describe the dynamic physical behavior of DIDP that will influence exposure, particularly the skin permeability coefficient and chemical migration rate from articles mouthed. To address this data gap, a scientifically informed approach was adopted, wherein values from analogous chemicals sharing comparable physical and chemical properties were leveraged as surrogates. These surrogate data, drawn from substances with established empirical evidence and recognized similarity in relevant characteristics, facilitated the estimation of needed parameters.

EPA identified only one set of experimental data related to the dermal absorption of neat DIDP (Elsisi et al., 1989). This dermal absorption study was conducted *in vivo* using male F344 rats. There have been additional studies conducted to determine the difference in dermal absorption between rat skin and human skin. Specifically, Scott (1987) examined the difference in dermal absorption between rat skin and human skin for four different phthalates (*i.e.*, DMP, DEP, DBP, and DEHP) using *in vitro* dermal absorption testing. Results from the *in vitro* dermal absorption experiments showed that rat skin was more permeable than human skin for all four phthalates examined. Though there is uncertainty regarding the magnitude of difference between dermal absorption through rat skin versus human skin for DIDP, based on DIDP physical and chemical properties (size, solubility), EPA is confident that the *in vivo* dermal absorption data using male F344 rats (Elsisi et al., 1989) provides an upper bound of dermal absorption of DIDP based on the findings of (Scott et al., 1987).

Differences in skin structure and metabolism between rats and humans may limit the direct applicability of rat data to human scenarios. The flux of other phthalates across rat skin has been shown to be about 2-10 times higher than the flux across human skin for the same chemical. Additionally, the permeation characteristics of neat chemicals may differ from those of saturated solutions of phthalates. Because DIDP is strongly hydrophobic, dermal flux of neat chemical is expected to be lower than that of saturated solutions, introducing a potential underestimation of dermal flux when extrapolating from neat DIDP to aqueous solutions. However, the range of dermal flux values used in this assessment (0.05 to 0.09 µg/cm^2/hr) were consistent with the value of 0.061 µg/cm^2/hr recommended in the ECHA report on new evidence of human exposure to DIDP and DINP (ECHA, 2013b). The ECHA recommended value was based on an internal dose of DEHP in rats received from dermal exposure to PVC film. The internal dose of DIDP was extrapolated from the DEHP data by assuming that absorption of DEHP is ten times that of DIDP, and an absorption factor of 0.04 was applied to arrive at the recommended flux rate. While this parameter is still considered uncertain, the convergence of estimated dermal flux values derived from diverse methods and data lends considerable support to the reliability of the estimated range.

Another source of uncertainty regarding the dermal absorption of DIDP from products or formulations stems from the varying concentrations and co-formulants that exist in products or formulations containing DIDP. For purposes of this risk evaluation, EPA assumes that the absorptive flux of neat DIDP measured from *in vivo* rat experiments serves as an upper bound of potential absorptive flux of chemical into and through the skin for dermal contact with all liquid products or formulations, and that the modeled absorptive flux of aqueous DIDP serves as an upper bound of potential absorptive flux of chemical into and through the skin for dermal contact with all solid products. However, dermal contact with products or formulations that have concentrations of DIDP lesser than that assumed may exhibit lower rates of flux since there is less material available for absorption. Conversely, co-formulants or materials within the products or formulations may lead to enhanced dermal absorption, even at lower concentrations. Therefore, it is uncertain whether the products or formulations containing DIDP would result in decreased or increased dermal absorption. Based on the available dermal absorption data for DIDP, EPA has made assumptions that result in exposure assessments that are conservative human health protective in nature.

Lastly, EPA notes that there is uncertainty with respect to the modeling of dermal absorption of DIDP from solid matrices or articles. Because there were no available data related to the dermal absorption of DIDP from solid matrices or articles, EPA has assumed that dermal absorption of DIDP from solid objects would be limited by aqueous solubility of DIDP. Therefore, to determine the maximum steady-state aqueous flux of DIDP, EPA utilized the Consumer Exposure Model (CEM) (U.S. EPA, 2022) to first estimate the steady-state aqueous permeability coefficient of DIDP. The estimation of the steady-state aqueous permeability coefficient within CEM (U.S. EPA, 2022) is based on quantitative structurE–activity relationship (QSAR) model presented by ten Berge (2009), which considers chemicals with log(K_{ow}) ranging from -3.70 to 5.49 and molecular weights ranging from 18 to 584.6. The molecular weight of DIDP falls within the range suggested by ten Berge (2009), but the log(K_{ow}) of DIDP exceeds the range suggested by ten Berge (2009). Therefore, there is uncertainty regarding the accuracy of the QSAR model used to predict the steady-state aqueous permeability coefficient for DIDP. However, EPA is confident that the selected approach represents an upper bound of dermal absorption of DIDP from solid articles.

For chemical migration rates to saliva, existing data were highly variable both within and between studies. This indicates the significant level of uncertainty for the chemical migration rate, as uncertainty from differences among similar items due to variations in chemical makeup and polymer structure adds on. As such, an effort was made to choose DIDP migration rates likely to be representative of broad classes of items that make up consumer COUs produced with different manufacturing processes and material formulations. There is no consensus on the correct value to use for this parameter in past assessments of DIDP. The 2003 EU Risk Assessment for DINP (used as a surrogate) used a migration rate of 53.4 $\mu g/cm^2/h$ selected from the highest individual estimate from a 1998 study by the Netherlands National Institute for Public Health and the Environment (RIVM) (ECJRC, 2003b; RIVM, 1998). The RIVM study measured DINP in saliva of 20 adult volunteers biting and sucking four PVC disks with a surface of 10 cm^2. Average migration to saliva from the samples tested were 8.4, 14,4, and 9.6 $\mu g/cm^2/hr$, and there was considerable variability in the results. In a more recent report, the European Chemicals Agency (ECHA) compiled and evaluated new evidence on human exposure to DIDP and DINP, including chemical migration rates (ECHA, 2013b). They concluded that chemical migration rate of 14 $\mu g/cm^2/hr$ was likely to be representative of a "typical mouthing scenario" and a migration rate of 45 $\mu g/cm^2/hr$ was a reasonable worst-case estimate of this parameter. The "typical" value was determined by compiling in vivo migration rate data from existing studies (Chen, 1998); (Fiala et al., 2000); (Meuling et al., 2000); (Niino et al., 2003); (RIVM, 1998); (Sugita et al., 2003). The "worst case" value was midway between the two highest individual measurements among all the studies (the higher of which was used in the 2003 EU risk assessment.

However, a major limitation of all existing data is that DIDP weight fractions for products tested skew heavily towards relatively high weight fractions (30-60%) and measurements for weight fractions <15 percent are very rarely represented in the data set. Many of the products and articles in this assessment were in the <15 percent weight fraction range. Thus, it is unclear whether these migration rate values are applicable to consumer goods with low (<15%) weight fractions of DIDP, where rates might be lower than represented by "typical" or worst-case values determined by existing data sets. As such, based on available data for chemical migration rates of DIDP to saliva, the range of values used in this assessment (1.6, 13.3, and 44.8 $\mu g/cm^2/hr$) are considered likely to capture the true value of the parameter.

Table 5-1. Weight of Scientific Evidence Confidence for Inhalation Consumer Exposure Modeling Scenarios

COU / Subcategory / Article or Product Example			Confidence in Model[a]	Confidence in User-Selected Inputs[b]						Overall Exposure Confidence
Category	Subcategory	Example		Frequency of Use[c]	Density[d]	Surface Area[e]	Weight Fraction[f]	Duration of Use[g]	Mass Used[h]	
Automotive, fuel, agriculture, outdoor use products	Lubricants	Auto Transmission Conditioner	+++	+++	NA	NA	++	+++	+++	+++
Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Construction Adhesive for Small Scale Projects	+++	++	NA	NA	+++	++	++	+++
Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Construction Sealant for Large Scale Projects	+++	++	NA	NA	+++	++	++	+++
Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Epoxy Floor Patch	+++	++	++	NA	++	+++	++	++
Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Lacquer Sealer (Non-Spray)	+++	++	++	NA	+	+++	++	++
Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Lacquer Sealer (Spray)	+++	++	++	NA	+	+++	++	++
Construction, paint, electrical, and metal products	Building/construction materials covering large surface areas including stone, plaster, cement, glass and ceramic articles (wire or wiring systems; joint treatment	Solid flooring	+++	+++	++	+++	+	+++	NA	+++
Construction, paint, electrical, and metal products	Electrical and Electronic Products	Wire Insulation	++	++	++	++	+	++	NA	++

COU / Subcategory / Article or Product Example			Confidence in Model[a]	Confidence in User-Selected Inputs[b]						Overall Exposure Confidence
Category	Subcategory	Example		Frequency of Use[c]	Density[d]	Surface Area[e]	Weight Fraction[f]	Duration of Use[g]	Mass Used[h]	
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Shower Curtain	+++	+++	++	+++	+	+++	NA	+++
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Wallpaper	+++	++	++	++	+	+++	NA	++
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Synthetic Leather Furniture	+++	+++	++	++	+	+++	NA	+++
Packaging, paper, plastic, hobby products	Toys, Playground, and Sporting Equipment	Children's Toys (new)	+++	+++	++	++	+++	+++	NA	+++
Packaging, paper, plastic, hobby products	Toys, Playground, and Sporting Equipment	Children's Toys (legacy)	+++	+++	++	++	+++	+++	NA	+++

[a] Confidence in Model Used considers whether model has been peer reviewed, as well as whether it is being applied in a manner appropriate to its design and objective. The model used (CEM 3.2) has been peer reviewed, is publicly available, and has been applied in a manner intended by estimating exposures associated with uses of household products and/or articles. Moderate was selected for the wire insulation scenario because of uncertainties surrounding the barrier layers. This also considers the default values data source(s) such as building and room volumes, interzonal ventilation rates, and air exchange rates.
[b] Confidence in User-Selected Varied Inputs considers the quality of their data sources, as well as relevance of the inputs for the selected consumer condition of use.
[c] Frequency of Use was primarily based on manufacturer use instructions and professional judgment
[d] Density Used was primarily based on gray literature values available for product descriptions.
[e] Surface Area is based on manufacturer use instructions, the EPA's *Exposure Factors Handbook* and by the judgment of the exposure assessor. Robust was selected for commonly known product dimensions, and moderate for when assumptions about number of products present in a room by assessor. NA designation under mass used column is for articles. This input is not used by CEM inhalation estimates for articles, rather surface area is used.
[f] Weight fraction of DIDP in articles was sourced from the available literature and database values.
[g] Use Duration is primarily sourced from manufacturer use instructions, the EPA's *Exposure Factors Handbook,* and by the judgment of the exposure assessor. Moderate was selected for durations of use sourced from manufacturer use instructions that had multiple types of products with different use instructions and variability is expected to increase with numerous products available.
[h] Mass Used is primarily sourced from manufacturer use instructions and CEM defaults for saved analysis. NA designation under surface area column is for products. This input is not used by CEM inhalation estimates for products, rather mass of product is used.
+ + + Robust confidence suggests thorough understanding of the scientific evidence and uncertainties. The supporting weight of scientific evidence outweighs the

COU / Subcategory / Article or Product Example			Confidence in Model[a]	Confidence in User-Selected Inputs[b]						Overall Exposure Confidence
Category	Subcategory	Example		Frequency of Use[c]	Density[d]	Surface Area[e]	Weight Fraction[f]	Duration of Use[g]	Mass Used[h]	
uncertainties to the point where it is unlikely that the uncertainties could have a significant effect on the exposure estimate. + + Moderate confidence suggests some understanding of the scientific evidence and uncertainties. The supporting scientific evidence weighed against the uncertainties is reasonably adequate to characterize exposure estimates. + Slight confidence is assigned when the weight of scientific evidence may not be adequate to characterize the scenario, and when the assessor is making the best scientific assessment possible in the absence of complete information. There are additional uncertainties that may need to be considered.										

Table 5-2. Weight of Scientific Evidence Confidence for Ingestion Consumer Exposure Modeling Scenarios

COU / Subcategory / Article or Product Example			Confidence in User-Selected Inputs[a]							Confidence in Model[i]	Overall Exposure Confidence
Category	Subcategory	Example Exposure Route	Chemical Migration Rate[b]	Density[c]	Surface Area[d]	Weight Fraction[e]	Duration of Use[f]	Mouthing Area[g]	Mouthing Duration[h]		
Construction, paint, electrical, and metal products	Building/construction materials covering large surface areas including stone, plaster, cement, glass and ceramic articles (wire or wiring systems; joint treatment	Solid Flooring: Ingestion suspended / ingestion settled dust	++	++	+++	+	+++	NA	NA	+++	+++
Construction, paint, electrical, and metal products	Electrical and Electronic Products	Wire Insulation: Ingestion suspended / ingestion settled dust / mouthing	++	++	++	+	++	+++	++	++	++
Packaging, paper, plastic, hobby products	Arts, crafts, and hobby materials (crafting paint applied to craft)	Rubber Eraser: Mouthing	++	++	+++	+	+++	+++	++	+++	+++
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Shower Curtain: Ingestion suspended / ingestion settled dust	++	++	+++	+	++	NA	NA	+++	++
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible	Wallpaper: Ingestion suspended /	++	++	++	+	+++	NA	NA	+++	++

COU / Subcategory / Article or Product Example			Confidence in User-Selected Inputs[a]							Confidence in Model[i]	Overall Exposure Confidence
Category	Subcategory	Example Exposure Route	Chemical Migration Rate[b]	Density[c]	Surface Area[d]	Weight Fraction[e]	Duration of Use[f]	Mouthing Area[g]	Mouthing Duration[h]		
	tubes; profiles; hoses	ingestion settled dust									
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Synthetic Leather Furniture: Ingestion suspended / ingestion settled dust / mouthing	++	++	++	+	+++	+++	++	+++	++
Packaging, paper, plastic, hobby products	Toys, Playground, and Sporting Equipment	Children's Toys (new): Ingestion suspended / ingestion settled dust / mouthing	++	++	++	+++	+++	+++	+++	+++	+++
Packaging, paper, plastic, hobby products	Toys, Playground, and Sporting Equipment	Children's Toys (legacy): Ingestion suspended / ingestion settled dust / mouthing	++	++	++	+++	+++	+++	+++	+++	+++
Other	Novelty Products	Adult toys: Mouthing	++	+	++	++	++	+++	++	++	++

[a] Confidence in User-Selected Varied Inputs considers the quality of their data sources, as well as relevance of the inputs for the selected consumer condition of use.
[b] Chemical Migration Rate of DIDP was estimated based on data compiled in a review (Danish EPA, 2016) for in vitro migration rates for the phthalates in soft PVC to artificial sweat and artificial saliva and in vivo tests when such studies were available, which use DINP as a DIDP surrogate. Moderate was selected because DINP is expected to have similar rate to DIDP based on physical-chemical properties.
[c] Density Used was primarily based on gray literature values available for product descriptions.
[d] Surface Area is based on manufacturer use instructions, the EPA's *Exposure Factors Handbook*, and by the judgment of the exposure assessor. Robust was selected for commonly known product dimensions and moderate for when the assessor made assumptions about the number of products present in a room.
[e] Weight fraction of DIDP in articles was sourced from the available literature and database values. Robust was selected for products with multiple sources, moderate was selected for products with limited sources but more current, and slight was selected for products with limited and older sources.
[f] Use Duration is primarily sourced from manufacturer use instructions, the EPA's *Exposure Factors Handbook*, and by the judgment of the exposure assessor. Robust was selected when the used values are well understood and represent a wide range of the population. Moderate was selected for durations of use sourced from manufacturer use instructions that had multiple types of products with different use instructions and variability is expected to increase with numerous products available.
[g] Mouthing Area NA status for articles that were not considered for ingestion via mouthing. Robust was selected for scenarios in which the mouthing area is well defined by object boundaries.

COU / Subcategory / Article or Product Example			Confidence in User-Selected Inputs[a]							Confidence in Model[i]	Overall Exposure Confidence
Category	Subcategory	Example Exposure Route	Chemical Migration Rate[b]	Density[c]	Surface Area[d]	Weight Fraction[e]	Duration of Use[f]	Mouthing Area[g]	Mouthing Duration[h]		

[h] Mouthing Duration NA status for articles that were not considered for ingestion via mouthing. Robust is given to scenarios about children toys because the information used to derive these values is more comprehensive and specific about children toys and children behaviors while other non-toy scenarios are less specific about mouthing durations and more generalized.

[i] Confidence in Model Used considers whether model has been peer reviewed, as well as whether it is being applied in a manner appropriate to its design and objective. The model used (CEM 3.2) has been peer reviewed, is publicly available, and has been applied in a manner intended to estimate exposures associated with uses of household products and/or articles. Moderate was selected for the wire insulation scenario because of uncertainties surrounding the barrier layers, and for adult toys because uncertainties about mouthing default values. This also considers the default values data source(s) such as events per day and year.

+ + + Robust confidence suggests thorough understanding of the scientific evidence and uncertainties. The supporting weight of scientific evidence outweighs the uncertainties to the point where it is unlikely that the uncertainties could have a significant effect on the exposure estimate.

+ + Moderate confidence suggests some understanding of the scientific evidence and uncertainties. The supporting scientific evidence weighed against the uncertainties is reasonably adequate to characterize exposure estimates.

+ Slight confidence is assigned when the weight of scientific evidence may not be adequate to characterize the scenario, and when the assessor is making the best scientific assessment possible in the absence of complete information. There are additional uncertainties that may need to be considered.

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COU / Subcategory / Article or Product Example			Confidence in User-Selected Inputs[a]				Confidence in Model[g]	Overall Exposure Confidence
Category	**Subcategory**	**Example**	**Flux[b] or Dermal Absorption[c]**	**Contact Area[d]**	**Event Time[e]**	**Frequency of Use[f]**		
Automotive, fuel, agriculture, outdoor use products	Lubricants	Auto Transmission Conditioner	++	+++	++	+++	++	++
Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Construction Adhesive for Small Scale Projects	++	+++	++	++	++	++
Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Construction Sealant for Large Scale Projects	++	+++	++	++	++	++
Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Epoxy Floor Patch	++	+++	+++	+++	++	+++
Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Lacquer Sealer (Non-Spray)	++	+++	+++	++	++	++
Construction, paint, electrical, and metal products	Adhesives and sealants (including plasticizers in adhesives and sealants)	Lacquer Sealer (Spray)	++	+++	+++	++	++	++
Construction, paint, electrical, and metal products	Building/construction materials covering large surface areas including stone, plaster, cement, glass and ceramic articles (wire or wiring systems; joint treatment	Solid Flooring	+	++	++	+++	++	++
Construction, paint, electrical, and metal products	Electrical and Electronic Products	Wire Insulation	+	+++	++	+++	++	++
Packaging, paper, plastic, hobby products	Arts, crafts, and hobby materials (crafting paint applied to craft)	Rubber Eraser	+	+++	+++	+++	++	+++
Packaging, paper, plastic, hobby products	PVC film and sheet	Miscellaneous coated textiles: truck awnings	+	+++	++	++	++	++

COU / Subcategory / Article or Product Example			Confidence in User-Selected Inputs[a]				Confidence in Model[g]	Overall Exposure Confidence
Category	Subcategory	Example	Flux[b] or Dermal Absorption[c]	Contact Area[d]	Event Time[e]	Frequency of Use[f]		
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Shower Curtain	+	+++	+++	+++	++	+++
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Wallpaper	+	+++	++	+++	++	++
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Foam Flip Flops	+	++	+++	++	++	++
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Synthetic Leather Furniture	+	+++	+++	+++	++	+++
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Synthetic Leather Clothing	+	+++	+++	++	++	++
Packaging, paper, plastic, hobby products	Plastic and rubber products (textiles, apparel, and leather; vinyl tape; flexible tubes; profiles; hoses	Bags	+	+++	++	+++	++	++
Packaging, paper, plastic, hobby products	Toys, playgrounds, and sporting equipment	Fitness Ball	+	++	++	++	++	++
Packaging, paper, plastic, hobby products	Toys, Playground, and Sporting Equipment	Children's Toys (new)	+	+++	+++	+++	++	+++

COU / Subcategory / Article or Product Example			**Confidence in User-Selected Inputs[a]**				**Confidence in Model[g]**	**Overall Exposure Confidence**
Category	**Subcategory**	**Example**	**Flux[b] or Dermal Absorption[c]**	**Contact Area[d]**	**Event Time[e]**	**Frequency of Use[f]**		
Packaging, paper, plastic, hobby products	Toys, Playground, and Sporting Equipment	Children's Toys (legacy)	+	+++	+++	+++	++	+++
Other	Novelty Products	Adult toys	+	++	+++	++	++	++

[a] Confidence in User-Selected Varied Inputs considers the quality of their data sources, as well as relevance of the inputs for the selected consumer condition of use.
[b] Used for liquid products. Flux was estimated based on DIDP in vivo dermal absorption in rats. Moderated was selected for liquid or paste form products that match the studies setup. However, uncertainties about the difference between human and rat skin absorption are considered.
[c] Used for solid articles. Dermal absorption estimate based on the assumption that dermal absorption of DIDP from solid objects would be limited by aqueous solubility of DIDP. Slight was selected for solid objects because the high uncertainty in the assumption of partitioning form solid to liquid and subsequent dermal absorption is not well characterized.
[d] Contact Area was determined based on product use instructions and CEM suggested area for body parts selected to be in contact with object. Robust was assigned when the body part in contact and area suggested by CEM defaults matched expected contact with object. Moderate was selected when the body part selected is a proxy, such as hands for feet in the case of flip flops, and hands in the case of adult toys which is missing other body part considerations unavailable to CEM modeling.
[e] Event Time was determine based on manufacturer use instructions, the EPA's *Exposure Factors Handbook* and by the judgment of the exposure assessor. Robust was selected when the patterns of use are well characterized and described by source of information. Moderate was selected when there are multiple product examples and use instructions vary from product to product or when the use patterns are less understood by the various group ages under consideration.
[f] Frequency of Use was determine based on manufacturer use instructions, the EPA's *Exposure Factors Handbook* and by the judgment of the exposure assessor. Robust was selected for scenarios that use patterns are well defined by sources of information, while moderate was selected when use frequency may not consider seasonal or intermittent use patterns.
[g] Confidence in Model Used considers whether model has been peer reviewed, as well as whether it is being applied in a manner appropriate to its design and objective. This model has not been peer reviewed, but the sources of information used to build it are all peer reviewed, hence the moderate rating.
+ + + Robust confidence suggests thorough understanding of the scientific evidence and uncertainties. The supporting weight of scientific evidence outweighs the uncertainties to the point where it is unlikely that the uncertainties could have a significant effect on the exposure estimate.
+ + Moderate confidence suggests some understanding of the scientific evidence and uncertainties. The supporting scientific evidence weighed against the uncertainties is reasonably adequate to characterize exposure estimates.
+ Slight confidence is assigned when the weight of scientific evidence may not be adequate to characterize the scenario, and when the assessor is making the best scientific assessment possible in the absence of complete information. There are additional uncertainties that may need to be considered.

5.2 Indoor Dust Monitoring Weight of Scientific Evidence

The weight of scientific evidence for the indoor dust exposure assessment of DIDP (Table 5-4**)** is dependent on studies that include indoor residential dust monitoring data (Table 3-1, Table 3-2). Based on the systematic review SOP, only studies that included indoor dust samples taken from residences were included for data extraction. In the case of DIDP, three studies were identified. They are summarized in Table 3-1 and Table 3-2. All studies that were included for data extraction were rated "High" quality per the exposure systematic review criteria.

Table 5-4. Weight of Scientific Evidence Conclusions for Indoor Dust Ingestion Exposure

Scenario	Confidence in Data Used [a]	Confidence in Model Inputs		Weight of Scientific Evidence Conclusion
		Body Weight [b]	Dust Ingestion Rate [c]	
Indoor exposure to residential dust via ingestion	++	+++	++	++

+ = Slight; ++ = Moderate; +++ = Robust

Kubwabo et al. (2013); with Giovanoulis et al. (2017) and Christia et al. (2019) as comparators

[b] U.S. EPA (2011b)

[c] Özkaynak et al. (2022)

Table 5-4 presents the assessor's level of confidence in the data quality of the input data sets for estimating dust ingestion from monitoring data, including the DIDP dust monitoring data themselves, the estimates of US body weights, and the estimates of dust ingestion rates, according to the following rubric:

- Robust confidence (+++) means the supporting weight of scientific evidence outweighs the uncertainties to the point that the assessor has decided that it is unlikely that the uncertainties could have a significant effect on the exposure estimate.
- Moderate confidence (++) means the supporting scientific evidence weighed against the uncertainties is reasonably adequate to characterize exposure estimates, but uncertainties could have an effect on the exposure estimate.
- Slight confidence (+) means the assessor is making the best scientific assessment possible in the absence of complete information. There may be significant uncertainty in the underlying data that need to be considered.

These confidence conclusions were derived from a combination of systematic review (*i.e.*, the quality determinations for individual studies) and the assessor's professional judgment. Table 5-4. Weight of Scientific Evidence Conclusions for Indoor Dust Ingestion Exposure

EPA did not identify U.S. monitoring data available for DIDP concentrations in residential indoor dust. Therefore, Canadian data from Kubwabo et al. (2013) was used as a surrogate. These data were drawn from a large randomly selected sample that was designed to be nationally representative for Canada, and the results are reasonably close to residential dust concentration data from other countries with comparable consumer practices and standards of living (Christia et al., 2019; Giovanoulis et al., 2017). Some uncertainties include the applicability of Canadian data to the US population, the time difference since the Canadian measurements were taken, the representativeness of the sampled population, and regulations on DIDP content in certain baby and child related consumer goods in the US and Canada. Based on these strengths and uncertainties, EPA has assigned moderate confidence to the Kubwabo et al. (2013) residential dust DIDP concentration data set.

Body weight data was obtained from the Exposure Factors Handbook (U.S. EPA, 2011b). This source is considered the default for exposure related inputs for EPA risk assessments and is typically used unless there is a particular reason to seek alternative data. Because the Exposure Factors Handbook is generally considered the gold standard input for body weight, and because the underlying body weight data were derived from the U.S. nationally representative NHANES data set, EPA has assigned robust confidence to our use of this model input.

Total daily dust intake was obtained from Özkaynak et al. (2022). This study used a mechanistic modeling approach to aggregate data from a wide variety of input variables (Table 5-5). These input variables were derived from several scientific sources as well as from the professional judgment of the study authors. The dust ingestion rates are similar to those found in the Exposure Factors Handbook for children under 1 year old but diverge above this age (Table 5-6). The Özkaynak et al. (2022) dust ingestion rates are onE−half to approximately onE−fifth as large, depending on age. This is because the Exposure Factors Handbook rates are a synthesis of several studies in the scientific literature, including tracer studies that use elemental residues in the body to estimate the ingestion of soil and dust. According to the discussion presented in Özkaynak et al. (2022), these tracer studies may be biased high, and in fact as shown in Fig. 4 of Özkaynak et al. (2022), non-tracer studies align much more closely with the dust ingestion rates used in this analysis. These studies include Wilson et al. (2013), which was the source for the Canadian dust ingestion rates used in EC/HC (2015). Because some input variables were unavailable in the literature and had to be based on professional judgment, and the dust ingestion rates differ from those in the Exposure Factors Handbook, EPA has assigned moderate confidence to this model input.

Taken as a whole, with moderate confidence in the DIDP concentration monitoring data in indoor residential dust from Kubwabo et al. (2013), robust confidence in body weight data from the Exposure Factors Handbook U.S. EPA (2011b), and moderate confidence in dust intake data from Özkaynak et al. (2022), EPA has assigned a weight of scientific evidence rating of moderate confidence in our estimates of daily DIDP intake rates from ingestion of indoor dust in residences.

5.2.1 Assumptions in Estimating Intakes from Indoor Dust Monitoring

5.2.1.1 Assumptions for Monitored DIDP Concentrations in Indoor Dust

The DIDP concentrations in indoor dust were derived from Kubwabo et al. (2013). In this study, 126 households from the Canadian House Dust Study conducted between 2007 and 2010 (Rasmussen et al., 2013) were vacuum sampled for indoor residential dust. The aim of the Canadian House Dust Study was to derive a nationally representative sample of residences for Canada, and the authors randomly sampled residences from 13 Canadian cities with a population above 100,000. Residents were asked to refrain from vacuuming or otherwise cleaning hard surfaces within the home for 7 days prior to sampling, and dust sampling was conducted by study technicians according to an internationally recognized sampling method (VDI, 2001). Samples were taken from all residential areas of the home, except for "potentially wet areas" which included kitchens, garages, workshops and unfinished sections of basements.

5.2.1.2 Assumptions for Body Weights

Body weights were taken from the *Exposure Factors Handbook* (U.S. EPA, 2011b), in which they were derived from the NHANES 1999 to 2006 data set. The NHANES studies were designed to obtain a nationally representative data set for the United States and include weight adjustment for oversampling of certain groups (children, adolescents 12 to 19 years, persons 60+ years of age, low-income persons, African Americans, and Mexican Americans). Body weights were aggregated into the age ranges shown in Table 4-4 and Table 4-5 and were averaged by sex.

5.2.1.3 Assumptions for Dust Ingestion Rates

To estimate daily intake of DIDP in residential indoor dust, a daily rate of dust ingestion is required. EPA used rates from Özkaynak et al. (2022) which modeled to estimate dust and soil intakes for children from birth to 21 years old. A probabilistic approach was used in the Özkaynak et al. (2022) study to assign exposure parameters including behavioral and biological variables. The exposure parameters are summarized in Table 5-5 and the statistical distributions chosen are reproduced in detail in the supplemental material for Özkaynak et al. (2022).

Table 5-5. Summary of Variables from Özkaynak et al. 2022 Dust/Soil Intake Model

Variable	Description	Units	Source
Bath_days_max	Maximum # days between baths/showers	days	Ozkaynak et al. (2011), based on Kissel 2003 (personal communication)
Dust_home_hard	Dust loading on hard floors	µg/cm^2	Adgate et al. (1995)
Dust_home_soft	Dust loading on carpet	µg/cm^2	Adgate et al. (1995)
F_remove_bath	Fraction of loading removed by bath or shower	(-)	Professional judgment
F_remove_hand_mouth	Fraction of hand loading removed by one mouthing event	(-)	Kissel et al. (1998) and Hubal et al. (2008)
F_remove_hand_wash	Fraction of hand loading removed by hand washing	(-)	Professional judgment
F_remove_hour	Fraction of dermal loading removed by passage of time	(-)	Ozkaynak et al. (2011)
F_transfer_dust_hands	Fraction of floor dust loading transferred to hands by contact	(-)	Ozkaynak et al. (2011)
F_transfer_object_mouth	Fraction transferred from hands to mouth	(-)	Zartarian et al. (2005), based on Leckie et al. (2000)
Hand_contact_ratio	Ratio of floor area contacted hourly to the hand surface area	1/hr	Freeman et al. (2001)and Zartarian et al. (1997)
Hand_load_max	Maximum combined soil and dust loading on hands	µg/cm^2	Ozkaynak et al. (2011)
Hand_washes_per_day	Number of times per day the hands are washed	1/day	Zartarian et al. (2005)
Object_floor_dust_ratio	Relative loadings of object and floor dust after contact	(-)	Professional judgment, based on Gurunathan et al. (1998)
P_home_hard	Probability of being in part of home with hard floor	(-)	Ozkaynak et al. (2011)
P_home_soft	Probability of being in part of home with carpet	(-)	Ozkaynak et al. (2011)
Adherence_soil [a]	Accumulated mass of soil that is transferred onto skin	mg/cm^2	Zartarian et al. (2005), based on Holmes et al. (1999), Kissel et al. (1996a), and Kissel et al. (1996b)
Hand_mouth_fraction [a]	Fraction of hand area of one hand contacting the inside of the mouth	(-)	Tsou et al. (2017)
Hand_mouth_freq [a] (indoor/outdoor)	Frequency of hand-mouth contacts per hour while awake – separate rate for indoor/outdoor behavior	(-)	Black et al. (2005) and Xue et al. (2007)

Variable	Description	Units	Source
Object_mouth_area [a]	Area of an object inserted into the mouth	cm^2	Leckie et al. (2000)
Object_mouth_freq [a]	Frequency at which objects are moved into the mouth	(-)	Xue et al. (2010)
P_blanket [b]	Probability of blanket use	(-)	Professional judgment
F_blanket [b]	Protective barrier factor of blanket when used	(-)	Professional judgment
Pacifier_size [b]	Area of pacifier surface	cm^2	Özkaynak et al. (2022)
Pacifier_frac_hard [b]	Fraction of pacifier drops onto hard surface	(-)	Professional judgment
Pacifier_frac_soft [b]	Fraction of pacifier drops onto soft surface	(-)	Professional judgment
Pacifier_transfer [b]	Fraction of dust transferred from floor to pacifier	(-)	Extrapolated from Rodes et al. (2001), Beamer et al. (2009), and Hubal et al. (2008)
Pacifier_washing [b]	Composite of the probability of cleaning the pacifier after it falls and efficiency of cleaning	(-)	Conservative assumption (zero cleaning is assumed)
Pacifier_drop [b]	Frequency of pacifier dropping	(-)	Tsou et al. (2015)
P_pacifier [b]	Probability of pacifier use	(-)	Tsou et al. (2015)

[a] Variable distributions differ by lifestage
[b] Variable only applies to children younger than 2 years

5.2.2 Uncertainties in Estimating Intakes from Monitoring Data

5.2.2.1 Uncertainties for Monitored DIDP Concentrations in Indoor Dust

Indoor dust concentrations were derived from Kubwabo et al. (2013), which in turn subsampled the Canadian House Dust Study which was conducted from 2007 to 2010. That study sampled residential house dust in approximately one thousand randomly selected households in 13 large Canadian municipalities. It is possible that sampling biases were introduced by the choice of large municipalities and by differences among households that chose to participate in the study. Differences in consumer behaviors, housing type and quality, tidiness, and other variables that affect DIDP concentrations in household dust are possible between participating households and the general population. Additionally, because the underlying samples for Kubwabo et al. (2013) were taken between 2007-2010, uncertainty is introduced due to the length of time that has elapsed. It is uncertain whether consumer practices, building materials, or other factors affecting the concentration of DIDP in household dust have changed since 2007 to 2010.

The use of non-US data (because no US data were available) introduces uncertainty as to whether Canadian residential and consumer uses of DIDP-containing products are similar to those of US households. In 2008, during the time that sampling was conducted, the United States Congress enacted the Consumer Product Safety Improvement Act (FR, 2008) which contained an interim prohibition on children's toys and childcare articles that contained more than 0.1 percent DIDP. This interim restriction was lifted by the U.S. Consumer Product Safety Commission (CPSC) in 2017 (U.S. CPSC, 2017). Health Canada proposed an equivalent restriction on DIDP in children's toys and childcare articles (1,000 mg/kg, equivalent to 0.1 percent) in 2010 (Governor General in Council of Canada, 2010); however, the restrictions came into effect on June 20, 2011, after the sampling period of the Canadian

House Dust Study that formed the basis for Kubwabo et al. (2013). It is uncertain whether children's toys and childcare articles are a significant source of DIDP in residential indoor dust, and whether the differences in the timing of US and equivalent Canadian regulations on DIDP content in these articles would contribute to differences in relative DIDP concentrations in residential indoor dust between the two countries.

5.2.2.2 Uncertainties for Body Weights

Body weights were obtained from the Exposure Factors Handbook, which contains data from the 1999 to 2006 NHANES. Body weights were aggregated across lifestages and averaged by sex. In general, body weights have increased in the United States since 2006 (CDC, 2013) which may lead to an underestimate of body weight in this analysis. This would lead to an overestimate of DIDP dose per unit body weight, because actual body weights in the US population may be larger than those assumed in this analysis.

5.2.2.3 Uncertainties for Dust Ingestion Rates

Dust ingestion rates were obtained from Özkaynak et al. (2022) which uses mechanistic methods (the SHEDS model) to estimate dust ingestion using a range of parameters (Table 5-5). Each of these parameters is subject to uncertainty, especially those which are derived primarily from the professional judgment of the authors. Because of the wide range of parameters and the lack of comparator data against which to judge, EPA is unable to determine the direction of potential bias in each of the parameters individually. For dust ingestion rates overall, the rates derived from Özkaynak et al. (2022) can be compared to those found in the Exposure Factors Handbook (U.S. EPA, 2017) (Table 5-6).

Table 5-6. Comparison between Özkaynak et al. 2022 and Exposure Factors Handbook Dust Ingestion Rates

Age Range		0-<1m	1-<3m	3-<6m	6m-<1y	1-<2y	2-<3y	3-<6y	6-<11y	11-<16y	16-<21y
Central tendency dust ingestion (mg/day)	Özkaynak et al. (2022)	19	21	23	26	23	14	15	13	8.8	3.5
	U.S. EPA (2017)	20	20	20	20	50	30	30	30	20 [a]	20

[a] The intake for an 11-year old based on the *Exposure Factors Handbook* is 30 mg/day. The age ranges do not align between the two sources in this instance.

The Özkaynak et al. (2022) dust intake estimates for children above 1 year old are substantially lower than those in the Exposure Factors Handbook, while the estimate for children between 1 month and 1 year old are slightly higher. The authors of the Özkaynak et al. (2022) study offer some justification for the discrepancy by noting that the Exposure Factors Handbook recommendations are a synthesis of several types of study, including tracer studies that "[suffer] from various sources of uncertainty that could lead to considerable study-to-study variations". Biokinetic and activity pattern studies, such as Von Lindern et al. 2016 and Wilson et al. 2013 respectively, achieve results that are closer to the Özkaynak et al. (2022) results (see Fig. 4, Özkaynak et al. (2022)).

5.2.2.4 Uncertainties in Interpretation of Monitored DIDP Intake Estimates

There are several potential challenges in interpreting available indoor dust monitoring data. The challenges include the following:

- Samples may have been collected at exposure times or for exposure durations not expected to be consistent with a presumed hazard based on a specified exposure time or duration.
- Samples may have been collected at a time or location when there were multiple sources of DIDP that included non-TSCA COUs.
- None of the identified monitoring data contained source apportionment information that could be used to determine the fraction of DIDP in dust samples that resulted from a particular TSCA or non-TSCA COU. Therefore, these monitoring data represent background concentrations of DIDP and are an estimate of aggregate exposure from all residential sources.
- Activity patterns may differ according to demographic categories (*e.g.*, stay at home/work from home individual versus an office worker) which can affect exposures especially to articles that continually emit a chemical of interest.
- Some indoor environments may have more ventilation than others, which may change across seasons.

5.3 Indoor Dust Modeling Weight of Scientific Evidence

See Section 5.1 for a detailed description of sources of uncertainties from CEM modeling and reconstruction of indoor dust scenarios from uncertainties to data variability.

6 CONCLUSIONS AND STEPS TOWARD RISK CHARACTERIZATION

Indoor Dust

For the indoor exposure assessment, EPA considered modeling and monitoring data. Monitoring data is expected to represent aggregate exposure to DIDP in dust resulting from all sources present in a home. While it is not a good indicator of individual contributions of specific COUs, it provides a real-world indicator of total exposure through dust. For the modeling assessment of indoor dust exposures and estimating contribution to dust from individual COUs, EPA recreated plausible indoor environment using consumer products and articles commonly present in indoor spaces inhalation exposure from toys, flooring, synthetic leather furniture, wallpaper, and wire insulation include a consideration of dust collected on the surface of a relatively large area, like flooring, furniture, and wallpaper, but also multiple toys and wires collecting dust with DIDP and subsequent inhalation and ingestion.

Despite the moderate confidence evaluation of the monitoring assessment, a risk estimate based on these data was not derived. Instead, they were used as a comparator to show that the modeled DIDP exposure estimates were health protective relative to residential monitored exposures (Table 4-8). The individual COU scenarios had a moderate to robust confidence in the exposure dose results and protectiveness of parameters used. Hence, the COU scenarios of the articles used in the indoor assessment were used in risk estimates calculations. Because the modeled DIDP dust risk estimates were higher than the monitored DIDP risk estimates, EPA is confident that the resulting risk characterizations are health protective.

Consumer

All COU exposure dose results summarized in Section 4.1 have a moderate to robust confidence and hence can be used for risk estimates calculations and to determine risk to the various lifestages. The consumer assessment has low, medium, and high exposure scenarios which mainly represent use patterns of high, medium, and low intensity uses. The high exposures scenarios capture use patterns for high exposure potential from high frequency and duration use patterns, extensive mouthing behaviors, and conditions that promote greater migration of DIDP from products/articles to sweat and skin. Low and medium exposure scenarios represent less intensity in use patterns, mouthing behaviors, and conditions that promote DIDP migration to sweat and skin, capturing populations with different lifestyles.

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