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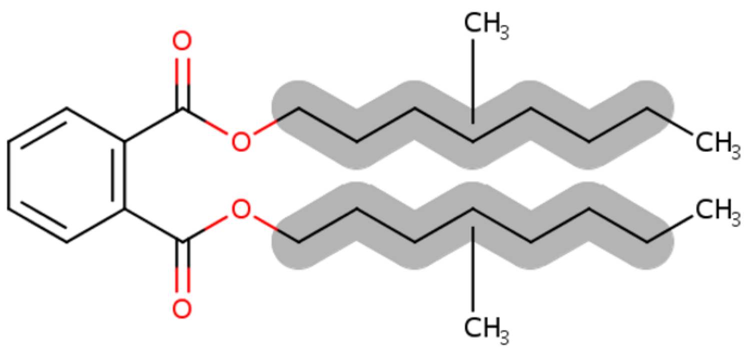
Pollution Prevention

Consumer and Indoor Exposure Assessment for Diisononyl Phthalate (DINP)

Technical Support Document for the Risk Evaluation

CASRNs: 28553-12-0 and 68515-48-0



(Representative Structure)

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KEY ABBREVIATIONS AND ACRONYMS

ACC	American Chemical Council
ACC HPP	American Chemistry Council's High Phthalates Panel
ADR	Average dose rate
CADD	Chronic Average Daily Dose
CDC	Center for Disease Control and Prevention
CDR	Chemical Data Reporting
CEM	Consumer Exposure Model
CPSC	Consumer Product Safety Commission (U.S.)
CPSIA	Consumer Product Safety Improvement Act
COU	Condition of use
DBP	Dibutyl phthalate
DEHP	Di-(2-ethylhexyl) phthalate
DINP	Diisononyl phthalate
DIY	Do-it-yourself
ECHA	European Chemicals Agency
EPA	Environmental Protection Agency (U.S.) (or the Agency)
MCCEM	Multi-Chamber Concentration and Exposure Model
OCSPP	Office of Chemical Safety and Pollution Prevention
OPPT	Office of Pollution Prevention and Toxics
PVC	Polyvinyl chloride
QSAR	Quantitative structure-activity relationship
SDS	Safety data sheet
SVOC	Semi volatile organic compound
TSCA	Toxic Substances Control Act

SUMMARY

This technical support document (TSD) is for the TSCA *Risk Evaluation for Diisononyl Phthalate (DINP)* (U.S. EPA, 2025e). This document provides detailed descriptions of DINP consumer and indoor exposure assessment. DINP is a C9 dialkyl phthalate esters with two CASRNs numbers, 11,2-benzenedicarboxylic acid, 1,2-isononyl ester (CASRN 28553-12-0) and 1,2-benzenedicarboxylic acid, di-C9-11-branched alkyl esters, C9-rich (CASRN 68515-48-0). DINP is primarily used as a plasticizer in polyvinyl chloride (PVC) in consumer, commercial, and industrial applications—although it is also used in adhesives, sealants, paints, coatings, rubbers, and non-PVC plastics as well as for other applications. It is added to certain products because its large molecular size and strongly hydrophobic chemical structure result in waterproof qualities in the finished good. As such, products containing DINP tend to be specialized in their intended use. For instance, all caulking compounds identified with DINP were intended for outside use or high moisture, indoor environments and spray paints identified were for waterproofing metal and wood surfaces.

This assessment considers human exposure to DINP 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. 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 in a spreadsheet (U.S. EPA, 2025a) 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 1 day, chronic exposures are for an exposure duration of 1 year, and intermediate are for an exposure duration of 30 days. Confidence in the CEM inhalation and ingestion modeling 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 *Consumer Exposure Analysis for Diisononyl Phthalate (DINP)* (U.S. EPA, 2025a). CEM dermal modeling uses a dermal model approach that assumes infinite DINP migration from product to skin without considering saturation that would result in an overestimation of dose and subsequent risk (see Section 2.3 for a detailed explanation). Low, medium, and high exposure scenarios were developed for each product and article scenario by varying values for duration and frequency of dermal contact and area of exposed skin. Confidence in the dermal exposure estimates were moderate depending on uncertainties associated with input parameters.

The highest exposures estimated for all lifestages infant to adult was for inhalation exposure to indoor scenario articles such as carpet backing, children's legacy toys, indoor furniture, wall coverings, and vinyl flooring. Inhalation doses of suspended dust for children's toys differs by an order of magnitude with the only difference in these two scenarios the weight fraction, which is a noteworthy pattern to consider when estimating risks. Inhalation of DINP-contaminated dust is an important contributor to indoor exposures. Ingestion of DINP has the overall second highest doses for articles assessed for mouthing, such as toys, furniture, wire insulation, and rubber erasers. Because mouthing tendencies decrease or cease entirely for children 6 to 10 years exposure from mouthing is expected to be larger for infants to 5-year-old children. Most of the products/articles do not have a mouthing estimate, but ingestion doses of settled dust remain comparable to those from mouthing suggesting settled dust ingestion is an important contributor to DINP exposures. Dermal doses covered a large range, for children under 10 years, dermal doses were always lower than inhalation and ingestion for the same

product/article as well as in general. The highest dermal doses for children under 10 years originated from contact with furniture, cushions, and clothing, while other articles and products dermal doses were significantly lower than inhalation and ingestion. For people older than 10 years, dermal doses when using, applying, and engaging in do-it-yourself (DIY) projects with products—such as adhesive caulks, paints and lacquers, resins, scented oils, and roofing adhesives—are comparable to the inhalation dose range. The exception was for paints for large projects in which inhalation exposure was higher likely because of the use of spray paints and the volatilization of the paint and subsequent inhalation of mist and droplets. The largest dermal dose is for roofing adhesives and polyurethane injection resins (to fix cracks in outdoor settings like pools).

1 INTRODUCTION

DINP is assigned two CASRNs that contain C9 dialkyl phthalate esters: 11,2-benzenedicarboxylic acid, 1,2-isononyl ester (CASRN 28553-12-0) and 1,2-benzenedicarboxylic acid, di-C9-11-branched alkyl esters, C9-rich (CASRN 68515-48-0). DINP is primarily used as a plasticizer in polyvinyl chloride (PVC) in consumer, commercial, and industrial applications—although it is also used in adhesives, sealants, paints, coatings, rubbers, and non-PVC plastics as well as for other applications.

The request for risk assessment of DINP was submitted to EPA by the American Chemistry Council's High Phthalates Panel (ACC HPP), which represents major manufacturers, importers, and users of DINP and other high molecular weight phthalates. In their request, ACC HPP identified specific products and articles likely to contain DINP. These included PVC used in solid articles such as wire and cable jacketing, vinyl tiles, resilient flooring, PVC backed carpeting, wall coverings, roofing, pool liners, tool handles, flexible tubes and hoses, and children's toys; liquid products including window glazing, underbody coatings, inks and pigments, adhesives, sealants, and paints; and coated textile products, including clothing. EPA further assembled reasonably available information from 2016 and 2020 data reported in the Chemical Data Reporting (CDR) database and consulted a variety of other sources (including published literature, company websites, and government and commercial trade databases and publications) to identify additional conditions of use (COUs) of DINP for inclusion in the risk evaluation (see Table 1-1 for consumer-specific COUs). Consumer products and articles were identified and matched to COUs. Weight fractions of DINP in specific items were then gathered from a variety of sources. These data were used in this assessment in a tiered approach as described in Section 2.1.

The migration of DINP from consumer products and articles has been identified as a potential mechanism of exposure. However, the relative contribution of various consumer goods to overall exposure to DINP has not been well characterized. The identified uses can result in exposures to consumers and bystanders (*i.e.*, non-product users that are incidentally exposed to the product). For all the DINP 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 DINP across COUs and various age groups.

Because PVC and plastic products are ubiquitous in modern indoor environments, and since DINP is not chemically bound to many consumer products and articles in which it is incorporated, it can leach, migrate, or evaporate (albeit to a lesser extent given its physical and chemical properties) into indoor air and concentrate in household 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. Children in this age group also frequently place their hands and objects in their mouths. Therefore, estimated exposures were assessed and compared for children below and above 2 years old.

Table 1-1. Consumer Conditions of Use Table

Life Cycle Stage[a]	Category[b]	Subcategory of Use[c e]	Reference(s) (CASRN 28553-12-0)	Reference(s) (CASRN 68515-48-0)
Consumer Uses	Construction, paint, electrical, and metal products	Adhesives and sealants[d]	(U.S. EPA, 2019a, b)	(U.S. EPA, 2019a, b)
		Building construction materials (wire and cable jacketing, wall coverings, roofing, pool applications, etc.)[d]	(ACC HPP, 2023; U.S. EPA, 2020, 2019a, b)	(ACC HPP, 2023; U.S. EPA, 2019a, b)
		Electrical and electronic products[d]	(U.S. EPA, 2019a, b)	(U.S. EPA, 2020, 2019a, b)
		Paint and coatings[d]	(U.S. EPA, 2019a, b)	(U.S. EPA, 2019a, b)
	Furnishing, cleaning, treatment/care products	Foam seating and bedding products; furniture and furnishings (furniture and furnishings including plastic articles (soft); leather articles)	(ACC HPP, 2023; U.S. EPA, 2019a; U.S. CPSC, 2015) EPA-HQ-OPPT-2018-0436-0046; EPA-HQ-OPPT-2018-0436-0047; EPA-HQ-OPPT-2018-0436-0048; EPA-HQ-OPPT-2018-0436-0049; EPA-HQ-OPPT-2018-0436-0050	(ACC HPP, 2023; U.S. EPA, 2019a; U.S. CPSC, 2015) EPA-HQ-OPPT-2018-0436-0046; EPA-HQ-OPPT-2018-0436-0047; EPA-HQ-OPPT-2018-0436-0048; EPA-HQ-OPPT-2018-0436-0049; EPA-HQ-OPPT-2018-0436-0050
		Floor coverings; plasticizer in construction and building materials covering large surface areas including stone, plaster, cement, glass and ceramic articles; fabrics, textiles and apparel (vinyl tiles, resilient flooring, PVC-backed carpeting)[d]	(ACC HPP, 2023; U.S. EPA, 2019a, b)	(ACC HPP, 2023; U.S. EPA, 2019a, b)
		Air care products		(Rustic Escentuals, 2015)
		Fabric, textile, and leather products (apparel and footwear care products) [d]	(ACC HPP, 2023; U.S. EPA, 2020, 2019a)	(ACC HPP, 2023; U.S. EPA, 2019a)
	Packaging, paper, plastic, hobby products	Arts, crafts, and hobby materials	(U.S. EPA, 2021)	(U.S. EPA, 2021)
		Ink, toner, and colorant products[d]	(ACC HPP, 2023; Evonik Industries, 2019; U.S. EPA, 2019b; Porelon, 2007) EPA-HQ-OPPT-2018-0436-0055	(ACC HPP, 2023; U.S. EPA, 2019b; Polyone, 2018) EPA-HQ-OPPT-2018-0436-0055
		Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard); vinyl tape; flexible tubes; profiles; hoses[d]	(U.S. EPA, 2019a, b)	(U.S. EPA, 2020, 2019a, b)

Life Cycle Stage[a]	Category[b]	Subcategory of Use[c e]	Reference(s) (CASRN 28553-12-0)	Reference(s) (CASRN 68515-48-0)
Consumer Uses	Packaging, paper, plastic, hobby products	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	(U.S. EPA, 2020)	
		Toys, playground, and sporting equipment[d]	(ACC HPP, 2023; U.S. EPA, 2019a, b)	(ACC HPP, 2023; U.S. EPA, 2019a, b)
	Other uses	Novelty Articles	(Stabile, 2013)	(Stabile, 2013)
		Automotive articles	(U.S. EPA, 2019b)	(U.S. EPA, 2019b)
Disposal	Disposal	Disposal		

[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 DINP in industrial and/or commercial settings.

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

[d] Circumstances on which ACC HPP is requesting that EPA conduct a risk evaluation. DINP is no longer processed into toys (processing into articles); however, EPA evaluated risk from toys already in commerce that contain DINP. In addition, DINP processing into sporting equipment is ongoing.

[e] In the final scope for DINP, EPA added the following conditions of use: processing aids not otherwise listed (mixed metal stabilizer); and foam seating and bedding products, air care products, furniture and furnishings not covered elsewhere. Due to additional information from stakeholder outreach, public comments, and further research, the following COU was removed after the publication of the draft scope document: personal care products.

2 CONSUMER EXPOSURE APPROACH AND METHODOLOGY

The main steps in performing a consumer exposure assessment are summarized below:

1. Identification and mapping of product and article examples following the consumer COU table (Table 1-1), product and article identification.
2. Compilation of products and articles manufacturing use instructions to determine patterns of use.
3. Selection of exposure routes and exposed populations according to product/article use descriptions.
4. Identification of data gaps and further search to fill gaps with studies, chemical surrogates or product and article proxies, or professional judgement.
5. Selection of appropriate modeling tools based on available information and chemical properties.
6. Gathering of input parameters per exposure scenario.
7. Parameterization of selected modeling tools.

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

A quantitative analysis was conducted when the exposure route was deemed relevant based on product or article use description and there was sufficient data to parameterize the model. A qualitative analysis was done when data was not available for modeling. The qualitative analysis allowed for a discussion of exposure potential based on physical and chemical properties, or available monitoring data should monitoring data be available—even in the absence of quantitative modeling estimates. When a quantitative analysis was conducted, exposure from the consumer COUs was estimated by modeling. Each product or article was individually assessed to determine whether all or some exposure routes were applicable, and approaches were developed accordingly.

Exposure via inhalation and ingestion routes were modeled using EPA's CEM Version 3.2 (U.S. EPA, 2023). Dermal exposure to DINP-containing consumer products was estimated using a computational framework implemented within a spreadsheet. Refer to Dermal Modeling Approach in Section 2.3 for a detailed description of dermal approaches, rationale for analyses conducted 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, etc.) to characterize low, medium, and high exposure, where possible and according to condition of use. Should only a range be reported, the Agency used the minimum and maximum of the range as the low and high values, with the average of the minimum and maximum used for the medium scenario. See Section 2.1 for details about the identified weight fraction data and statistics used in the low, medium, and high exposure scenarios. All CEM and dermal spreadsheet calculations inputs, sources of information, assumptions, and exposure scenario descriptions are available in the *Consumer Exposure Analysis for Diisononyl Phthalate (DINP)* (U.S. EPA, 2025a).

Based on reasonably available information from the systematic review on consumer conditions of use and indoor dust studies, inhalation of DINP is possible through DINP emitted from products and articles and DINP sorbed to indoor dust and particulate matter. A detailed discussion of indoor dust references, sources, and concentrations is available in Section 4. Due to DINP's low volatility, there is expected to be negligible or very small gas-phase inhalation exposures. However, DINP's physical and chemical properties, such as low vapor pressure, low solubility, and high K_{OA} suggest a high affinity for organic matter that is typically present in household dust. The likelihood of sorption to suspended and settled dust is supported by indoor monitoring data. Section 4.1 reports concentrations of DINP in settled dust from indoor environments. Due to the presence of DINP in indoor dust, inhalation and ingestion of suspended dust as well as ingestion of settled dust, are both considered as exposure routes in this consumer assessment.

Oral exposure to DINP is also possible through incidental ingestion during product 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 DINP, oral and dermal exposures to consumers were assessed.

Qualitative analysis describing low exposure potential were discussed in Section 2.1, mainly based on physical and chemical properties or product and article use descriptions. For example, given the low volatility of DINP, emissions to air from solid articles are expected to be relatively low. As such, articles with a small surface area (less than ≈1 m^2) and articles used outdoors were not assessed for inhalation exposure. For items with small surface area for emissions and dust collection, the potential for emission to air and dust is further reduced. To verify this assumption, a CEM test run for a generic 1 m^2 item with 30 percent DINP content by weight was carried out. The combined doses from inhalation and dust ingestion ranged four orders of magnitude less than the point of departure (POD) used to assess human health risk in this assessment and are likely to be negligeable as compared to potential exposure by dermal and mouthing routes, which were assessed as appropriate, see *Risk Evaluation for Diisononyl Phthalate (DINP)* (U.S. EPA, 2025e). Similarly, solid articles not expected to be mouthed (*e.g.*, building materials, outdoor furniture) were not assessed for mouthing exposure. Furthermore, as DINP is a low volatility solid that is used primarily as a plasticizer in manufacturing, potential take-home exposures are likely too small in comparison to the scenarios considered in this assessment; thus, take-home exposures were not further explored.

EPA assessed acute, chronic, and intermediate exposures to DINP from consumer COUs. For the acute dose rate calculations, an averaging time of 1 day is used to represent the maximum time-integrated dose over a 24-hour period in which the exposure event occurs. 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 and averaged over 1 year. Professional judgment and product use descriptions were used to estimate number of events per day and per month for each product as well as for use in the calculation of the intermediate dose. Whenever professional judgment was used, EPA provided a rationale and description of selected parameters.

2.1 Products and Articles with DINP Content

Products are generally consumable liquids, aerosols, or semi-solids that are used a given number of times before they are exhausted/depleted. 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. The preferred data sources for DINP content in U.S. consumer goods were (1) safety data sheets (SDSs) for specific products or articles with reported DINP content, (2) peer-reviewed literature providing measurements of DINP in consumer goods purchased in the United States, and (3) government reports originating in the United States with manufacturer reported concentrations. In instances where these data from preferred sources were not available, DINP contents in specific products and articles provided in peer review literature and government reports originating from Canada and the European Union were used. Manufacturing practices and regulations for DINP in consumer goods are comparable between these regions and the United States, so it is reasonable to assume that similarly formulated products may be available across these regions. When no data could be found for a specific type of product or article identified as likely to contain DINP, weight fractions provided by ACC HPP for general classes of items was used. DINP weight fractions reported in the CDR database (see Table 1-1 for COU-specific references) were used only when no other data could be found for a reported product category. The weight fraction data reported in the CDR database may pertain to a finished good in the product category reported, or it could represent a chemical additive that is added to other components during the manufacturing process of the finished good. There are considerable uncertainties in weight fraction when using CDR data. The concentration value reported in CDR may be regarded as an upper boundary for the DINP content in finished consumer goods.

EPA further evaluated the products and articles identified to ensure that data were representative of currently available items that may expose U.S. consumers to DINP. SDSs were cross-checked with company websites to ensure that each product SDS was current and whether the item was still available for purchase. In instances where a product or article could not be purchased by a consumer, EPA did not evaluate the item in a DIY or application scenario but did determine whether consumers might reasonably be exposed to the specific item as part of a purchased good, including homes and automobiles. For data reported in literature and government reports, recent regulations, such as Consumer Product Safety Improvement Act (CPSIA), for DINP and other phthalates content in specific items was considered when determining weather data were likely to be relevant to the current U.S. consumer market. For solid articles with recently enacted limits on DINP content (*e.g.*, children's toys and childcare items), it was considered reasonable that consumers might be exposed to older items with DINP content higher than current limits via secondhand purchases or long-term use. For these items, exposure was considered separately to provide estimates for consumers exposed to DINP from either new or legacy items.

In addition to DINP weight fractions, EPA obtained additional information about physical characteristics and potential uses of specific products and articles from technical specifications, manufacturer websites, and vendor websites. These data were used in the assessment to define exposure scenarios. The following sections provides a summary of specific products and articles with DINP content identified for each item.

2.1.1 Solid Articles

Adult Toys

Adult toys were assessed for DINP exposure by dermal and mouthing routes. DINP content in adult toys was not provided in any sources specific to the United States. However, DINP was reported by the Danish EPA at a weight fraction of 50 percent in one adult toy sample (Nilsson et al., 2006). Given the dearth of data available on these items as a whole and the lack of any relevant regulations for phthalate content, the Agency considers it likely that adult toys with DINP content may be sold in the United States as well. Although this value is not used directly in dermal or mouthing exposure calculations, it is provided here for context and to confirm DINP presence in these products. Details about the mouthing exposure approaches and input parameters are provided in Section 2.2.3.1, dermal exposure approaches are provided in Section 2.3.2, and input parameters are provided in Section 2.3.4.

Carpet Backing

Carpet backing was assessed for DINP exposure by inhalation, dust ingestion, and dermal exposure routes. Although this material is expected to have an overlying layer of carpet, due to the permeable nature of carpeting, it could not be assumed that this presents a significant barrier to emissions and thus emissions were modeled without occlusion. DINP concentrations in carpet backing were obtained from values reported by Interface Inc. and Tandus Centiva, Inc. in their applications for Safe Use Determinations (SUD) for diisononyl phthalate (DINP) in modular carpet tiles to the California Office of Environmental Health Hazard Assessment (Oehha, 2016a). DINP weight fractions for 3 products were reported with values of 9, 9, and 16 percent DINP by weight; based on these data, the weight fractions of DINP used in low, medium, and high exposure scenarios were 9, 11.3, and 16 percent, respectively.

Children's Toys

Children's toys were assessed for DINP exposure by inhalation, dust ingestion, dermal and mouthing routes of exposure. Under the Consumer Product Safety Improvement Act of 2008 (CPSIA), Congress permanently prohibited the sale of children's toys or childcare articles containing concentrations of more than 0.1 percent DINP. However, it is possible that some individuals may still have children's toys in the home that were produced before regulatory limitations and/or individuals may import toys not marketed to the United States. While the latter possibility has not been observed in U.S. markets, it has been reported in other countries with similar regulatory limits. A recent survey by the Danish EPA of PVC products purchased from foreign online retailers found that DINP content in two of the toy items tested exceeded the current Danish regulatory limit of 1 percent DINP, with 14.5 percent in bath ducks and 1.4 percent in a football (Danish EPA, 2020). In addition, a 2015 study conducted in Germany reported DINP contents in a toy bat and beachball of 30.5 percent and 31.5 percent, respectively—both of which are significantly above the EU standard of 0.1 percent that was in place at the time the study was conducted (Schulz et al., 2015).

As such, EPA assessed exposure to DINP in children's toys under two scenarios. In the first exposure scenario, new toys produced for the U.S. market are assumed to comply with regulatory limits and are therefore assessed with DINP weight fractions of 0.1 percent in low, medium, and high exposure scenarios. In the second scenario, legacy and non-compliant toys are assessed with weight fractions reported by the Consumer Product Safety Commission (CPSC) for toy items purchased shortly before the regulatory limit was enacted. Across the two studies the minimum observed weight fraction was 13 percent, mean weight fraction was 30 percent, and maximum observed weight fraction was 41.9 percent (Babich et al., 2020) and (Babich et al., 2004). These weight fractions were used in low, medium, and high exposure scenarios.

Coated Textiles

Coated textiles for indoor use including PVC coated fabrics and leather were assessed for DINP exposure. DINP content in polyurethane leather was reported by the ACC to range from 30 to 35 percent by weight. In addition, Lam-A-Lite™ vinyl coated polyester has a manufacturer disclosed DINP content of 16 percent. Because these products likely have similar applications, they were grouped together for modeling. Based on these data, DINP weight fractions of 16, 23, and 35 percent were applied for these materials in low, medium, and high exposure scenarios, respectively. Although specific uses for these materials were not provided, EPA assumes that uses may include furniture coverings, clothing, steering wheel covers, and accessory items such as handbags and backpacks. Rather than modeling all possible uses for these textiles, they were assessed under a limited number of scenarios likely to have the greatest potential for exposure as indicated by large surface areas emitting DINP to air and expected long dermal contact times. Based on these criteria, indoor furniture and clothing were chosen as the representative items to model. DINP in clothing is expected to be limited to waterproof items such as raincoats and boots and synthetic leather clothing and is therefore not expected to comprise a significant portion of an individuals' wardrobe. As such, total surface area emitting to air is likely to be relatively small and these items were assessed for dermal contact only. However, due to the large surface area of indoor furniture, these items were assessed for DINP exposure by inhalation, dust ingestion, as well as dermal and mouthing exposure routes.

Coated textiles for outdoor use were also assessed for DINP exposure. DINP concentrations in coated textiles for outdoor furniture were obtained from values reported by Phifer Incorporated ("Phifer") for a SUD for DINP in Phifertex® fabric used in outdoor furniture products (OEHHA, 2017). The DINP content of the PVC coating for this fabric ranged from 20 to 25 percent, depending on the particular mesh of the fabric. DINP was also reported by ACC to be present in coated textiles used for outdoor awnings at 30 to 35 percent by weight (ACC HPP, 2023). Because these fabrics are specific to outdoor use, inhalation exposure is expected to be minimal and they are modeled only for dermal exposure. However, as dermal contact times are expected to be quite different for these items, they were not grouped together for modeling. Weight fractions are not used directly in estimates for dermal exposure but are provided to provide context for modeling.

Erasers

Erasers were assessed for DINP exposure by dermal and mouthing exposure routes. A 2007 study by the Danish EPA found measurable concentrations of DINP in eight erasers with weight fractions ranging from trace levels to 70 percent by weight (Danish EPA, 2020). The average weight fraction of DINP reported (excluding trace values) was 47.7 percent. However, very little recent data were available with DINP measurements in eraser products sold in the United States. Data obtained from the Washington State Consumer Product Monitoring database contained four eraser products with measurable DINP content—all of which were below 0.01 percent (Danish EPA, 2020). It is unclear whether the lower values observed for DINP contents in erasers sold in the United States as compared to Denmark are representative of lower concentrations in the products or the lack of measurement data available. As such, the Agency assessed exposure to DINP through mouthing of erasers under the assumption that significant contents could be present in some products. Because weight fractions are not used directly in estimates for exposure by mouthing or dermal exposure, these values are not used directly in the assessment, but are provided here to provide context for products that may be sold.

Foam Cushions

Foam bedding and seating materials were assessed for DINP exposure by inhalation, dust ingestion, and dermal exposure routes. DINP concentrations in foam cushions and mattresses were estimated based on values measured in foam mattresses for infants (Boor et al., 2015). Of 20 mattresses manufactured between 2000 and 2011, 4 were found to have measurable concentrations of DINP. The minimum value observed was 0.6 mg/g, mean value observed was 22.3 mg/g, and the maximum value observed was 63.6 mg/g; these values were used in low, medium, and high exposure scenarios for foam household products, respectively. Although foam cushion products could be found and it was stated that they do have DINP content, specific weight fractions were not provided for these items. As such, the weight fractions reported for foam mattresses were used as a proxy for foam seating and bedding products in general. While consumers may have a variety of foam products in the home, the data reported in Boor (2015) indicates that DINP is not ubiquitous in foam products. As such, rather than modeling multiple foam products in a home, it was assessed under a single scenario likely to have significant potential for exposure as indicated by large surface areas emitting DINP to air and long dermal contact times. Based on these criteria, indoor furniture was chosen as the representative items to model. Although these items are likely to be encased in a fabric liner, due to the permeable nature of textiles it could not be assumed that this presents a significant barrier to emissions and thus emissions were modeled without occlusion.

PVC Articles with Potential for Semi-regular Dermal Contact

DINP has been measured in a variety of consumer goods that may be used on a semi-regular basis and were assessed for dermal contact only. These items are either too small to have a significant impact on inhalation exposure or made for outdoor use but may contribute to dermal exposure. While dermal contact with these individual items is expected to be short and/or irregular in occurrence, it is reasonable to assume that due to the widespread nature of the items an individual could have significant daily contact with some combination of these items and/or with other similar items that have not been measured during monitoring campaigns. As such, these items have been grouped together for modeling but represent a variety of TSCA COUs. DINP contents in a variety of consumer goods ordered from online retailers was measured in a recent study by the Danish EPA; DINP was reported at 2.9 percent in a pet chew toy, 2.27 percent in a garden hose, 1.4 percent and 1.6 percent in hobby cutting boards, 29.4 percent and 30.6 percent in storage and packaging bags, and 21.8 percent in a tarpaulin (Danish EPA, 2020). Additional Danish EPA studies reported DINP in PVC soap packaging at 10 and 8.75 percent (Danish EPA, 2009); a cell phone cover at 1.4 percent (Danish EPA, 2012); and in PVC work gloves at weight fractions of 30 and 0.9 percent (Danish EPA, 2012) and 7.4 percent (Danish EPA, 2020). In a study originating in Japan, DINP content in disposable PVC gloves was reported at 0.4, 0.4, 0.13, and 7.48 percent (Tsumura et al., 2001). Additionally, EPA identified electrical tape with DINP content of 3 percent and PVC spline with DINP content of 14 percent. Water supply piping can contain DINP, EPA-HQ-OPPT-2018-0436-0095. Exposure from water pipes is expected to be from dermal contact and drinking water ingestion. EPA assessed dermal contact in the articles with potential for semi-regular contact scenario, as a potential home renovation project in which people may be removing or installing pipes. Drinking water ingestion exposures are discussed in Section 6 in the *Environmental Media and General Population Exposure for Diisononyl Phthalates (DINP)* (U.S. EPA, 2025c) TSD. As weight fractions of DINP are not used in dermal exposure calculations, they are provided here only to demonstrate the broad range of both product types, formulations, and DINP contents that may be captured in this model scenario.

Roofing Membranes

Roofing membranes were assessed for DINP exposure by dermal contact only as they are expected to be used only in well-ventilated outdoor environments. DINP contents in roofing membranes were obtained from values reported by the Chemical Fabrics & Film Association, Inc. (CFFA) for a SUD for the use of DINP in PVC roofing membrane products (OEHHA, 2015). CFFA reported a maximum value for DINP weight fraction in PVC roofing membranes of 15 percent. As no other values were reported, this value was used in low, medium, and high exposure scenarios. Weight fractions are not used directly in estimates for dermal exposure but are given here to provide context for products that may be sold.

Rubber Mats

Several styles of rubber mat including scraper mats, car floor mats, and sports mats were assessed for DINP exposure. Although scraper style floor mats commonly found in home entranceways with DINP content were identified, only one product was found that provided a weight fraction of DINP. The range provided was 0.5 to 3 percent. As these items are expected to be too small to significantly contribute to inhalation exposure, they were modeled only for dermal contact. Weight fractions are not used directly in estimates for dermal exposure but are given here to provide context for products that may be sold.

Car floor mats were assessed for DINP exposure by inhalation, dust ingestion, and dermal pathways. Numerous instances of commercially available car floor mats containing DINP were found, but none disclosed specific contents. The only available data for DINP content in one car mat was a single measurement of car mats purchased from an internet vendor in Denmark with a reported weight fraction of 3.6 percent DINP (WA DOE, 2019). As data specific to the U.S. market is lacking, this value was used in low, medium, and high scenarios.

Sports mats were assessed for DINP exposure by inhalation, dust ingestion, and dermal pathways. DINP content in sports mats was reported by ACC to be 30 to 40 percent by weight (ACC HPP, 2023). Although products could be found (floating exercise mats, gym mats) that stated that they have DINP content, specific weight fractions were not provided. As such, the values provided by ACC were used to assess exposure to these kinds of products; the weight fractions of DINP used in low, medium, and high exposure scenarios were 30, 35, and 40 percent.

Shower Curtains

Shower curtains were assessed for DINP exposure by inhalation, dust ingestion, and dermal exposure routes. DINP weight fractions in PVC shower curtains were estimated based on values measured in five shower curtains purchased from major U.S. retailers (Premium Weight Vinyl Shower Curtain Liner, Bed Bath and Beyond (BB&B); Martha Stewart Everyday Vinyl Shower Curtain, Bath Bliss, Kmart; Whole Home Deluxe Vinyl Stall Liner, Sears; Contemporary Home Shower Curtain, Metro Blocks, Target; HomeTrends Kids Vinyl Shower Curtain, Under the Sea, Wal-Mart) (Camann et al., 2008). Of the five curtains tested, all had measurable DINP contents. The minimum value observed was 0.1 percent, mean value observed was 15.9 percent, and maximum value observed value was 39 percent; these values were used in low, medium, and high exposure scenarios for PVC shower curtains.

Specialty Wall Coverings

Specialty wall coverings including soundproofing fabric and calendared PVC sheets used to finish wall, cabinet, and furniture surfaces. These were assessed for DINP exposure by inhalation, dust ingestion, and dermal exposure routes. These materials are expected to cover a single room or only a portion of a room. LG Premium PVC High Glossy Deco Sheet (G200) has a manufacturer disclosed DINP content of 0 to 2 percent by weight. Product research indicated that this is most often used for kitchen wall and cabinet surfaces. Alpha Style 3478-VS-2 coated fiberglass fabric is a noise attenuating fabric that may be installed in home recording studios or media rooms and was reported to have a DINP content of 9.4 to 10.2 percent by weight. Additional sound attenuating materials for wall with stated that they have DINP content were identified, but the specific concentration of DINP was not disclosed. Specialty wall coverings were considered together, with DINP weight fractions of 2, 6.1, and 10.2 percent applied in low, medium, and high exposure scenarios.

Vinyl Flooring

Vinyl flooring was assessed for DINP exposure by inhalation, dust ingestion, and dermal exposure routes. DINP concentrations in vinyl flooring products were obtained from values reported by the Resilient Floor Covering Institute (RFCI) in their SUD for DINP in vinyl flooring products to the California Office of Environmental Health Hazard Assessment (OEHHA, 2016b). RFCI reported DINP content in four categories of commonly sold vinyl flooring products. Heterogeneous vinyl flooring (in sheets) is typically available in 6- or 12-foot-wide rolls and consists of multiple layers; the DINP content in heterogeneous vinyl flooring varies from 3.5 to 22.0 percent by weight of the product, with an average DINP content of 21.2 percent. Homogeneous vinyl flooring (in sheets) is typically available in 6- or 12-foot-wide rolls, and consists of a single layer with a uniform structure and composition from top to bottom and a clear top layer coating; the DINP content in homogeneous vinyl flooring varies from 14 to 19 percent by weight of the product, with an average plasticizer content of 15.6 percent. Vinyl tile is typically available in 1-foot squares and may be constructed as either a single layer (solid vinyl tile) or multiple layers (luxury vinyl tile); the DINP content in vinyl tile varies from 6 to 21 percent by weight of the product, with an average plasticizer content of 7.3 percent. Vinyl composition tile is typically available in 1-foot squares consisting of a single layer made primarily from limestone with a smaller amount of PVC, resin, plasticizers, pigments, and stabilizers. RFCI did not report the range of DINP content in vinyl composition tile but reported the average plasticizer content as 3.5 percent by weight of the product and noted that some products have as little as 0.07 percent DINP. RFCI. Based on these data, the weight fractions of DINP used in low, medium, and high exposure scenarios were 0.07, 11.9, and 22 percent.

Wallpaper

Wallpaper was assessed for DINP exposure by inhalation, dust ingestion, and dermal exposure routes. Wallpaper with manufacturer disclosed DINP content was identified from multiple consumer retailers, but specific DINP concentrations were not reported for any products. A previous risk assessment carried out by the European Chemicals Agency. ECHA reported that the content of DIDP and DINP in wallpaper is 23 to 26 percent (ECHA, 2012). Based on this data the weight fractions used in low, medium, and high exposure scenarios were 23, 24.5, and 26 percent.

Wire Insulation

Wire Insulation was assessed for DINP exposure by inhalation, dust ingestion, dermal and mouthing (primarily of concern for children under <5 years) exposure routes. 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. Because data for U.S.-specific products was lacking, it was assumed that these values could also be applied to U.S.-manufactured products; weight fractions of 25, 37.5, and 50 percent DINP were applied in low, medium, and high exposure scenarios.

2.1.2 Liquid and Paste Products

Adhesives and Sealants for Home DIY Projects

A number of adhesives and sealants containing DINP were identified. Products were grouped together for modeling based on differences in formulation and anticipated use patterns. Five waterproof caulking compounds with a variety of applications in home DIY projects were identified and assessed for DINP exposure by inhalation and dermal pathways. The weight fractions of DINP reported for these products were 1 to 2.5 percent, 1 to 5 percent, less than 5 percent, 10 to 15 percent, and 3 to 10 percent. Based on these data, the weight fractions of DINP used in low, medium, and high exposure scenarios for these products were 1, 5.9, and 15 percent, respectively. Although these products could be used in indoor or outdoor environments they were modeled indoors as inhalation exposure is not expected to be significant in outdoor use.

One concrete and masonry repair caulk for outdoor use was identified with a DINP content of no more than 15 percent; this value was used in low, medium, and high exposure scenarios for this product. One foaming adhesive product with DINP content was identified for indoor and outdoor use. The DINP content reported for this product was 0.1 to 1 percent. Based on this data, the weight fractions of DINP used in low, medium, and high exposure scenarios for these products were 0.1, 0.55, and 1 percent. Because all anticipated uses for this product are outdoors, inhalation is expected to be negligible and it was modeled for dermal exposure only.

Two products with DINP content were identified for adhesion of roofing membranes during roof repairs. In both products, the DINP content reported was 30 to 31 percent. Based on these data, the DINP weight fractions applied in low, medium, and high exposure scenarios were 30, 30.5, and 31 percent. Outdoor uses inhalation exposure is not expected to be significant due to a combination of small surface area, amount of product used, weight fraction, and large ventilation rate; however, for roofing adhesives the expected surface area, amount of product used, and weight fraction are significantly larger than other adhesives. Hence, EPA assessed inhalation exposures.

Adhesives for Small Repairs

Two products were identified for small repairs. These included a spackling paste for patching minor blemishes in finished drywall and a liquid electrical tape for repairing damaged cords and cables. The DINP content reported for the spackling paste product and liquid electrical tape were 2 percent and 1 to 10 percent, respectively. Based on these data weight fractions of DINP used in low, medium, and high exposure scenarios were 1, 3.5, and 10 percent. Due to the small amount of product required for use, inhalation exposure is expected to be too small to pose exposure and these products was modeled for dermal exposure only.

Automotive Adhesives and Sealants
Four adhesive/sealant products for automotive applications were identified with DINP content. Reported DINP contents were 15 to 25 percent, 25 to 30 percent, 5 to 24 percent, and 3 to 7 percent. Based on these data, the DINP weight fractions used in low, medium, and high exposure scenarios for these products were 3, 16.6, and 30 percent, respectively.

Paint and Lacquer
Three paint and lacquer products containing DINP were identified with different applications for home DIY projects. Two products were identified in spray cans appropriate for small scale refinishing products. The DINP content reported for these products were 1 to 2.5 percent and 1 to 5 percent. Based on these data, the DINP weight fractions used in low, medium, and high exposure scenarios for these products were 1, 2.1, and 5 percent.

One product for spray on refinishing of wood floors and decks containing DINP was identified. The reported content of DINP in this product was 3.9 percent; this value was used in low, medium, and high exposure scenarios for this product type.

Craft Resins
Several products were identified that may be used for home crafting such as model casting and mold production for resin and concrete projects. The reported weight fractions in these products were 15 to 40 percent, 10 to 30 percent, 25 percent maximum, and 10 percent maximum. Based on these data the DIDP weight fraction used in resin crafting scenarios is 10, 20.6, and 40 percent.

Table 2-1 provides a summary of TSCA COUs determined for each item type and exposure pathways modeled.

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

Consumer Condition of Use Category	Consumer Condition of Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes					
						Ingestion			
				Inhalation	Dermal	Suspended Dust	Settled Dust	Mouthing	Qualitative / Quantitative [f]
Construction, paint, electrical, and metal products	Adhesives and sealants	Adhesive foam	Use of product in DIY [e] large-scale home repair activities. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗	Quantitative
Construction, paint, electrical, and metal products	Adhesives and sealants	Adhesives for small repairs	Use of product in DIY [e] small-scale home repair activities. Direct contact during use	✗	✓	✗	✗	✗	Quantitative
Construction, paint, electrical, and metal products	Adhesives and sealants	Automotive adhesives	Use of product in DIY [e] small-scale auto repair. Direct contact during use; inhalation of emissions	✓	✓	✗	✗	✗	Quantitative
Construction, paint, electrical, and metal products	Adhesives and sealants	Caulking compounds	Use of product in DIY [e] home repair activities. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗	Quantitative
Construction, paint, electrical, and metal products	Adhesives and sealants	Polyurethane injection resin	Use of product in DIY [e] home repair activities. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗	Quantitative
Construction, paint, electrical, and metal products	Adhesives and sealants	Roofing adhesives	Use of product in DIY [e] home repair. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗	Quantitative
Construction, paint, electrical, and metal products	Building construction materials (wire and cable jacketing, wall coverings, roofing, pool applications, water supply piping, etc.)	Roofing membranes (also fabrics and film)	Direct contact while repairing or maintenance	✗ [d]	✓	✗	✗	✗	Quantitative
Construction, paint, electrical, and metal products	Building construction materials (wire and cable jacketing, wall coverings, roofing, pool applications, water supply piping, etc.)	Electrical tape, spline	Direct contact during application.	✗	✓	✗	✗	✗	Quantitative
Construction, paint, electrical, and metal products	Building construction materials (wire and cable jacketing, wall coverings, roofing, pool applications,	PVC pipes	Direct contact while repairing or maintenance and drinking water ingestion	✗	✓		✓ [b]		Quantitative

Consumer Condition of Use Category	Consumer Condition of Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes					
						Ingestion			
				Inhalation	Dermal	Suspended Dust	Settled Dust	Mouthing	Qualitative / Quantitative [f]
	water supply piping, etc.)								
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	Lacquer sealer spray (large project)	Application of product in house via spray. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗	Quantitative
Construction, paint, electrical, and metal products	Paints and coatings	Paint and lacquer spray (small project)	Application of product in house via spray. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗	Quantitative
Furnishing, cleaning, treatment/care products	Foam seating and bedding products; furniture and furnishings (furniture and furnishings including plastic articles (soft); leather articles)	Foam cushions	Direct contact, inhalation of emissions / ingestion of dust adsorbed chemical	✓[a]	✓	✓[a]	✓[a]	✗	Quantitative
Furnishing, cleaning, treatment/care products	Foam seating and bedding products; furniture and furnishings (furniture and furnishings including plastic articles (soft); leather articles)	Indoor furniture	Direct contact during use; inhalation of emissions / ingestion of airborne particulate; ingestion by mouthing	✓[a]	✓	✓[a]	✓[a]	✓	Quantitative
Furnishing, cleaning, treatment/care products	Foam seating and bedding products; furniture and furnishings (furniture and furnishings including plastic articles (soft); leather articles)	Outdoor furniture	Direct contact during use	✗[d]	✓	✗	✗	✗	Quantitative
Furnishing, cleaning, treatment/care products	Foam seating and bedding products; furniture and furnishings (furniture and furnishings including plastic articles (soft); leather articles)	Truck awning	Direct contact during use	✗[d]	✓	✗	✗	✗	Quantitative
Furnishing, cleaning, treatment/care products	Floor coverings/Plasticizer in construction and building materials covering large surface areas including stone,	Carpet backing tiles	Direct contact, inhalation of emissions / ingestion of dust adsorbed chemical	✓[a]	✓	✓[a]	✓[a]	✗	Quantitative

Consumer Condition of Use Category	Consumer Condition of Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes					
						Ingestion			
				Inhalation	Dermal	Suspended Dust	Settled Dust	Mouthing	Qualitative / Quantitative [f]
	plaster, cement, glass, and ceramic articles; fabrics, textiles, and apparel (vinyl tiles, resilient flooring, PVC-backed carpeting)								
Furnishing, cleaning, treatment/care products	Floor coverings/Plasticizer in construction and building materials covering large surface areas including stone, plaster, cement, glass, and ceramic articles; fabrics, textiles, and apparel (vinyl tiles, resilient flooring, PVC-backed carpeting)	Solid (resilient) vinyl flooring tiles	Direct contact, inhalation of emissions / ingestion of dust adsorbed chemical	✓ [a]	✓	✓ [a]	✓ [a]	✗	Quantitative
Furnishing, cleaning, treatment/care products	Floor coverings/Plasticizer in construction and building materials covering large surface areas including stone, plaster, cement, glass, and ceramic articles; fabrics, textiles, and apparel (vinyl tiles, resilient flooring, PVC-backed carpeting)	Specialty wall coverings	Direct contact during installation (teenagers and adults) and while in place; inhalation of emissions / ingestion of dust adsorbed chemical	✓ [a]	✓	✓ [a]	✓ [a]	✗	Quantitative
Furnishing, cleaning, treatment/care products	Floor coverings/Plasticizer in construction and building materials covering large surface areas including stone, plaster, cement, glass, and ceramic articles; fabrics, textiles, and apparel (vinyl tiles, resilient flooring, PVC-backed carpeting)	Wallpaper	Direct contact during installation (teenagers and adults) and while in place; inhalation of emissions / ingestion of dust adsorbed chemical	✓ [a]	✓	✓ [a]	✓ [a]	✗	Quantitative
Furnishing, cleaning,	Air care products	Oil fragrances (making homemade	Direct dermal while DIY project (making of a product)	✓	✓	✗	✗	✗	Quantitative

Consumer Condition of Use Category	Consumer Condition of Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes					
						Ingestion			
				Inhalation	Dermal	Suspended Dust	Settled Dust	Mouthing	Qualitative / Quantitative [f]
treatment/care products		product)							
Furnishing, cleaning, treatment/care products	Fabric, textile, and leather products (apparel and footwear care products)	Clothing	Direct contact during use	✗ [c]	✓	✗	✗	✗	Quantitative
Furnishing, cleaning, treatment/care products	Fabric, textile, and leather products (apparel and footwear care products)	Footwear, steering wheel covers, bags	Direct contact during use	✗ [c]	✓	✗	✗	✗	Quantitative
Packaging, paper, plastic, hobby products	Arts, crafts, and hobby materials	Rubber eraser	Direct contact during use; rubber particles may be inadvertently ingested during use. Eraser may be mouthed by children	✗ [c]	✓	✗	✗	✓	Quantitative
Packaging, paper, plastic, hobby products	Arts, crafts, and hobby materials	Crafting resin	Direct contact and inhalation of emissions during use	✓	✓	✗	✗	✗	Quantitative
Packaging, paper, plastic, hobby products	Arts, crafts, and hobby materials	Hobby cutting board	Direct contact during use	✗	✓	✗	✗	✗	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 paints (small projects) because similar use patterns are expected.	See lacquers, and paints (small and large projects)					
Packaging, paper, plastic, hobby products	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard); vinyl tape; flexible tubes; profiles; hoses	Shower curtain	Direct contact during use. See routine contact scenario inhalation of emissions / ingestion of dust adsorbed chemical while hanging in place	✓ [a]	✓	✓ [a]	✓ [a]	✗	Quantitative
Packaging, paper, plastic, hobby products	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard); vinyl tape; flexible tubes; profiles;	Work gloves, pet chewy toys, garden hose, cell phone cover, tarpaulin	Direct contact during use.	✗	✓	✗	✗	✗	Quantitative

Consumer Condition of Use Category	Consumer Condition of Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes					
				Inhalation	Dermal	Ingestion			Qualitative / Quantitative [f]
						Suspended Dust	Settled Dust	Mouthing	
	hoses								
Packaging, paper, plastic, hobby products	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	PVC soap packaging	Direct contact during use.	✗	✓	✗	✗	✗	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
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	Sporting mats	Direct contact during use, inhalation of emissions / ingestion of dust adsorbed chemical while hanging in place	✓ [a]	✓	✓ [a]	✓ [a]	✗	Quantitative
Other uses	Novelty articles	Adult toys	Direct contact during use, ingestion by mouthing	✗ [c]	✓	✗	✗	✓	Quantitative
Other uses	Automotive articles	Car mats	Direct contact during use. See routine contact scenario inhalation of emissions / ingestion of dust adsorbed chemical	✓ [a]	✓	✓ [a]	✓ [a]	✗	Quantitative
Disposal	Disposal	Down the drain products and articles	Down the drain and releases to environmental media	✗	✗	✗	✗	✗	Qualitative
Disposal	Disposal	Residential end-of-life disposal, product demolition for disposal	Product and article end-of-life disposal and product demolition for disposal	✗	✗	✗	✗	✗	Qualitative

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

✓ [a] Scenario used in Indoor Dust Exposure Assessment. 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. For these articles dust can deposit and contribute to significantly larger concentration of dust than single small articles.

✓ [b] Scenario was assessed for drinking water ingestion in Section 6 in the *Environmental Media and General Population Exposure for Diisononyl Phthalates (DINP)*, (U.S. EPA, 2025c) technical support document.

Consumer Condition of Use Category	Consumer Condition of Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes					
						Ingestion			
				Inhalation	Dermal	Suspended Dust	Settled Dust	Mouthing	Qualitative / Quantitative [f]

✘ Scenario was deemed unlikely based on 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/or low possibility of dust on surface due to barriers or low surface area for dust ingestion.

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

✘[d] Outdoor use with significantly higher ventilation minimizes inhalation.

[e] Do-it-Yourself

[f] Quantitative applies to green check marks and qualitative applies to red "x" marks for the routes that were deemed unlikely (Sections 2.1.1 and 2.1.2) or assessed qualitatively using physical and chemical properties (Disposal).

Non-qualitative Assessments

EPA perform qualitative assessments of the COU summarized in Table 2-2. A qualitative discussion using physical and chemical properties and monitoring data for environmental media was performed 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	No assessment done due to limited information on source attribution of the consumer COUs in drain water or wastewater.
Disposal	Disposal	Residential end-of-life disposal, product demolition for disposal	No assessment done due to limited information on source attribution of the consumer COUs in landfills.

Environmental releases may occur from consumer products and articles containing DINP via the end-of-life disposal and demolition of consumer products and articles in the built environment or landfills, as well as from the associated down-the-drain release of DINP. 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 scenarios where it can be assumed the consumer products (*e.g.,* paints, sealants, oils) may be discarded directly down-the-drain. For example, paints, sealants, and oils can be disposed down-the-drain when users wash their hands, brushes, sponges, and other product applying tools. Although EPA acknowledges that there may be DINP releases to the environment via the cleaning and disposal of adhesives and sealants, the Agency did not quantitatively assess these scenarios due to limited information, monitoring data, or modeling tools. In addition, DINP-containing products can be disposed and taken to landfills when users no longer have use for them or the products have reached the product shelf life. All other solid products and articles in Table 2-1 can be disposed in landfills, or other waste handling locations that properly manage the disposal of products like adhesives, sealants, paints, lacquers, and coatings. DINP is expected to be persistent as it leaches from consumer products disposed of in landfills. As a results, DINP is likely to be present in landfill leachate up to its aqueous limit of solubility (0.00061 to 0.20 mg/L, see Section 2.2.6 of *Physical Chemistry Assessment for Diisononyl Phthalate (DINP)* (U.S. EPA, 2025d). However, due to its affinity for organic carbon, DINP is expected to be immobile in groundwater—and even in cases where landfill leachate containing DINP were to migrate to groundwater, DINP would likely partition from groundwater to organic carbon present in the subsurface (U.S. EPA, 2025c).

2.2 Inhalation and Ingestion Modeling Approach

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

- CEM model has been peer-reviewed, (ERG, 2016);
- CEM accommodates the distinct inputs available for the products and articles containing DINP, such as weight fractions, product density, room of use, frequency and duration of use, see Section 2.2.3 for specific product and article scenario inputs; 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 DINP).

CEM has capabilities to model exposure to DINP from both products and articles containing the chemical. 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 that 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.

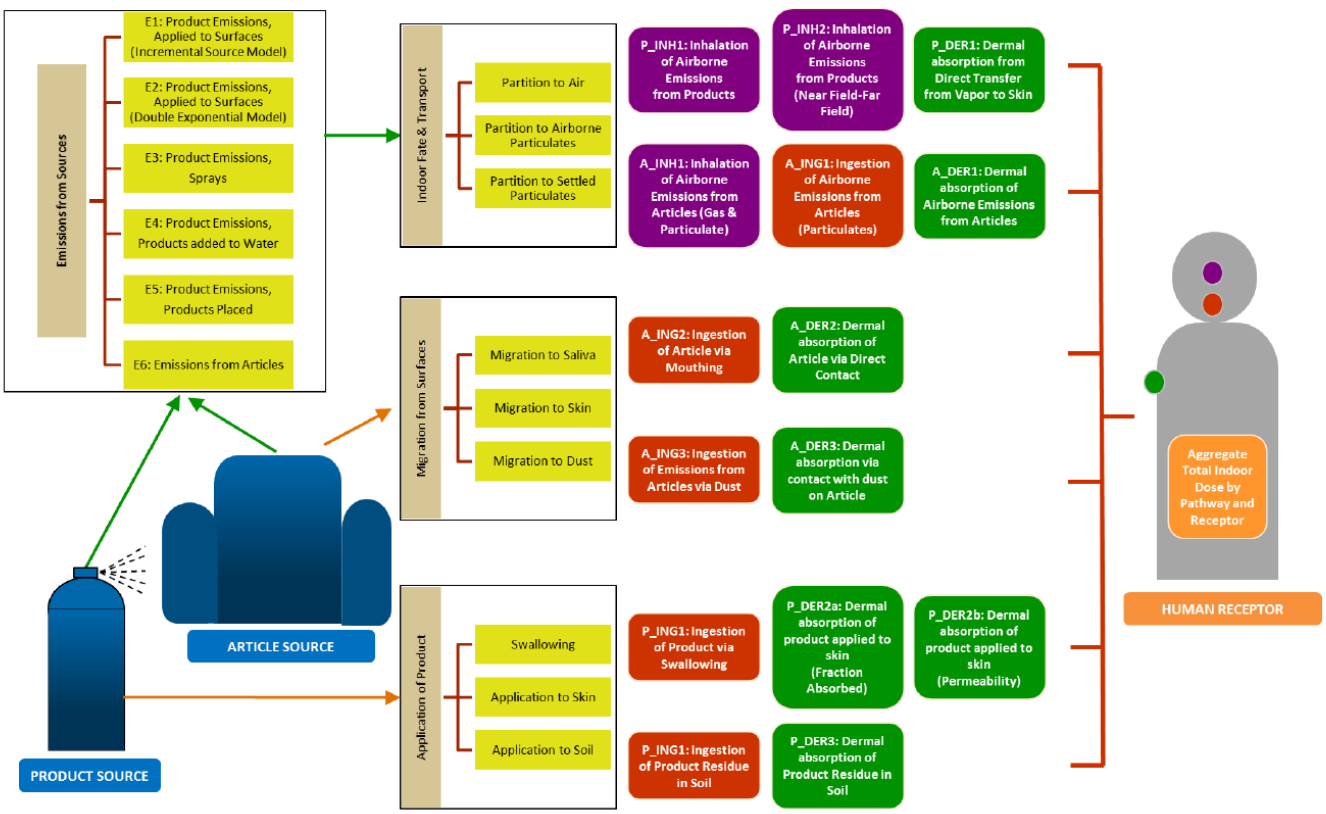

Figure 2-1. Consumer Pathways and Routes Evaluated in this Assessment

Note that the green squares in the figure refer to dermal exposures, red squares refer to ingestion exposures, and purple squares refer to inhalation exposures within CEM.

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 or article 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 semi volatile organic compounds (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.

CEM 3.2 estimates acute dose rates and chronic average daily doses for inhalation, ingestion, and dermal exposures of consumer products and articles. However, for the purpose of this assessment, EPA perform dermal calculations outside of CEM, see Section 2.3 for approach description and input parameters. 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 U.S. Centers 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 (16–20 years) → Teenager and young adult
- Youth 1 (11–15 years) → Young teen
- Child 2 (6–10 years) → Middle childhood
- Child 1 (3–5 years) → Preschooler
- Infant 2 (1–2 years) → Toddler
- Infant 1 (<1 year) → Infant

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

2.2.1 Inhalation and Ingestion Modeling for Products

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 1 into 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 outdoor air, and the air flows between the two zones. Following product use, the user and bystander may follow one of three pre-defined activity patterns: full time worker, part time worker, and stay-at-home. The activity use pattern determines which Zone is relevant for the user and bystander and the duration of the exposures. The user and bystander inhale airborne concentrations within these zones, which can vary over time, resulting in the overall estimated exposure for each individual. The stay-at-home activity pattern was selected for this assessment for all scenarios as the most conservative behavior pattern for a screening approach, with the option for further refinement should risk be identified in the screening-level analysis. 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).

CEM default air exchange rates for the building are from EPA's *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), see Section 2.2.3 for product scenario specific selections of environment such as living room vs. whole house, or indoor vs. outdoor and the air exchange rate used per environment selection. Kitchens, living rooms, and the garage area are considered more open, with an interzonal ventilation rate of 109 m^3/hour. 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 1×10^{-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.

2.2.2 Inhalation and Ingestion Modeling for Articles

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 by increasing 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. Abraded particles are first emitted to the air and thereafter may deposit and resuspend from the surfaces. Abraded particles like suspended and settled particulate, are subject to cleaning and ventilation losses. Abraded particles, both in the suspended and settled phases, are not assumed to be in equilibrium with the air phase. Hence, the chemical transfer between particulates and the air phase is kinetically modeled in terms of two-phase mass transfer theory. In addition, abraded particles settled on surfaces are assumed to have a hemispherical area available for emission, whereas those suspended in the air have a spherical area available for emission.

In inhalation scenarios where DINP is released from an article into the gas-phase, the article inhalation scenario tracks chemical transport between the source, air, airborne and settled particles, and indoor sinks by accounting for emissions, mixing within the gas phase, transfer to particulates by partitioning, removal due to ventilation, removal due to cleaning of settled particulates and dust to which DINP has partitioned, and sorption or desorption to/from interior surfaces. The emissions from the article were modeled with a single exponential decay model. This means that the chronic and acute exposure duration scenarios use the same emissions/air concentration data based on the weight fraction of the chemical in the article but have different averaging times. The acute data uses concentrations for a 24-hour period at the peak of the simulated emissions, while the chronic data was averaged over the entire one-year period. Because air concentrations for most of the year are significantly lower than the peak value, the air concentration used in chronic dose calculations are usually lower than that used to calculate an acute dose.

2.2.3 CEM Modeling Inputs and Parameterization

The COUs that were evaluated for DINP consisted of both products and articles. The embedded models within CEM 3.2 that were used for DINP are listed in Table 2-3. As dermal exposure was modeled separately, only inhalation and ingestion routes were evaluated in CEM.

Table 2-3. 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 2-4 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 2-4 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 would 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 DINP 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 2.3.

Table 2-4. Crosswalk of COU Subcategories, CEM 3.2 Scenarios, and Relevant CEM 3.2 Models Used for Consumer Modeling

Consumer COU Category and Subcategory	Product/Article	Emission Model	Exposure Pathway Model and CEM Saved Analysis
Automotive, fuel, agriculture, outdoor use products; Automotive care products	Car mats	E6	A_INH1, A_ING1, A_ING3; Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)
Construction, paint, electrical, and metal products; Adhesives and sealants	Adhesives for small repairs	NA	Only dermal
	Adhesive foam	E1	P_INH2 (Near-field, users), P_INH1 (bystanders); Glue and adhesives (large scale)
	Automotive adhesives	E1	P_INH2 (Near-field, users), P_INH1 (bystanders); Glue and adhesives (small scale)
	Caulking compounds	E1	P_INH2 (Near-field, users), P_INH1 (bystanders); Generic P1
	Polyurethane injection resin	E1	P_INH2 (Near-field, users), P_INH1 (bystanders); Glue and adhesives (small scale)
	Roofing adhesives	E3	P_INH2 (Near-field, users), P_INH1 (bystanders); Generic P3
Construction, paint, electrical, and metal products; Building construction materials (wire and cable jacketing, wall coverings, roofing, pool applications, etc.)	Roofing membranes	NA	Only dermal
	Wallpaper in-place and specialty wall coverings in-place	E6	A_INH1, A_ING1, A_ING3; Fabrics: curtains, rugs, wall coverings
	Wallpaper installation and specialty wall coverings installation	NA	Only dermal
	Electrical Tape, Spline	NA	Only dermal
Construction, paint, electrical, and metal products; Electrical and electronic products	Wire insulation	E6	A_INH1, A_ING1, A_ING2, A_ING3, Plastic articles: other objects with potential for routine contact (toys, foam blocks, tents)
Construction, paint, electrical, and metal products; Paints and coatings	Paint/lacquer (large and small projects)	E3	P_INH2 (Near-field, users), P_INH1 (bystanders); Generic P3

Consumer COU Category and Subcategory	Product/Article	Emission Model	Exposure Pathway Model and CEM Saved Analysis
Furnishing, cleaning, treatment/care products; Foam seating and bedding products	Foam cushions	E6	A_INH1, A_ING1, A_ING3, Generic
Furnishing, cleaning, treatment/care products; Floor coverings/Plasticizer in construction and building materials covering large surface areas including stone, plaster, cement, glass, and ceramic articles; fabrics, textiles, and apparel (vinyl tiles, resilient flooring, PVC-backed carpeting)	Solid (resilient) vinyl flooring tiles and Carpet backing tiles	E6	A_INH1, A_ING1, A_ING3; Plastic articles: vinyl flooring
Furnishing, cleaning, treatment/care products; Air care products	Oil fragrances (making homemade product)	E2	P_INH2 (Near-field, users), P_INH1 (bystanders); Generic P2
Furnishing, cleaning, treatment/care products; Fabric, textile, and leather products (apparel and footwear care products)	Clothing	NA	Only dermal
	Footwear, steering wheel covers, bags,	NA	Only dermal
Furnishing, cleaning, treatment/care products; Furniture and furnishings (furniture and furnishings including plastic articles (soft); leather articles)	Indoor furniture	E6	A_INH1, A_ING1, A_ING2, A_ING3; Leather Furniture
	Outdoor furniture and truck awnings	NA	Only dermal
Packaging, paper, plastic, hobby products; Arts, crafts, and hobby materials	Rubber eraser	NA	A_ING2; Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)
	Crafting resin	E2	P_INH2 (Near-field, users), P_INH1 (bystanders); Generic P2
	Hobby cutting board	NA	Only dermal
Packaging, paper, plastic, hobby products; Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard); vinyl tape; flexible tubes; profiles; hoses	Shower curtains	E6	A_INH1, A_ING1, A_ING3; Plastic articles: other objects with potential for routine contact (toys, foam blocks, tents)
	Work gloves, pet chewy toys, garden hose, cell phone cover, tarpaulin	NA	Only dermal
Packaging, paper, plastic, hobby products; Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	PVC soap packaging	NA	Only dermal
Packaging, paper, plastic, hobby products; Toys, playground, and sporting equipment	Sports mats; children toys-legacy/non-compliant; and children toys-new	E6	A_INH1, A_ING1, A_ING2, A_ING3; Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)
Other; Novelty Products	Adult toys	NA	A_ING2; Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)

In total, the specific products representing three (5) COUs categories and seven (15) subcategories for DINP were mapped to 34 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 Sections

2.2.3.1 and Section 2.2.3.2.

2.2.3.1 Key Parameters for Articles Modeled in CEM

Key input parameters for articles vary based on the exposure pathway modeled. For inhalation and dust ingestion, higher concentrations of DINP in air and dust result in increased exposure. This may occur due to article specific characteristics that allow for higher emissions of DINP to air and/or environment specific characteristics such as smaller room volume and lower ventilation rates. Key parameters that control DINP emission rates from articles in CEM 3.2 models are weight fraction of DINP in the material, density of article material (g/cm^3), article surface area (m^2), and surface layer thickness (cm); an increase in any of these parameters results in increased emissions and greater exposure to DINP. A detailed description of derivations of key parameter values used in CEM 3.2 models for articles is provided below, and a summary of values can be found in Table 2-5. Note that articles not modeled for inhalation exposure are not included in the table.

Weight fractions of DINP were calculated for each article as outlined in Section 2.1.1. Material density was assumed to be a standard value for PVC of 1.4 g/cm^3 in all articles except foam seating and bedding material, where it was assumed to be 0.05 g/cm^3. Values for article surface layer thickness were taken from CEM default values for scenarios with emissions from the same or similar solid material. CEM default values for parameters used to characterize the environment (use volume, air exchange rate, and interzonal ventilation rate) were used for all models except gym mats. Exposure to DINP in gym mats is potentially higher in gym environments than a home due to the significantly higher surface area of mats found in these environments. As such, the exposure models for gym mats assumed a commercial space with 10,000 ft^2 of floor space and 25-foot ceiling height. The CEM environment "office" was selected for this scenario as the behavioral patterns for this environment assume 2 hours of exposure five times per week, which may be appropriate for high-end gym users.

Due to the high variability and uncertainty of article surface areas high, medium, and low values were generally estimated for each item with the goal of capturing a reasonable range of values for this parameter. Assumptions for surface area estimates are outlined below.

Building Materials

To estimate surface areas for flooring materials (vinyl tile and carpet backing), it was assumed that the material was used in 100, 50, and 25 percent of the total floor space. The value for whole house floor space was back calculated from the CEM house volume (492 m^3) and an assumed ceiling height of 8 ft, and the resulting values were applied in high, medium, and low exposure scenarios.

Specialty wall coverings were estimated using a similar methodology. High, medium, and low surface areas assumed that 100, 50, and 25 percent of the kitchen wall was covered; these values were once again back calculated from the CEM 3.2 room volume for a kitchen assuming a ceiling height of 8 ft.

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 EPA's *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.

Furniture

Measurements of textile and foam furniture components were assumed to be the same. Each scenario consisted of a couch and loveseat set, with the surface area 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. The measurements were compiled from furniture retail stores descriptions. EPA added the lowest values for couch and loveseat to estimate exposures to smaller furniture in the low-end scenario, and similarly for the medium and high estimates. The difference between furniture textile and foam surface area is due to the consideration of all four sides of the prism shape for foam and only three sides for furniture. EPA assumes the bottom side is not covered with the same material.

Article Collections

Children’s toys and insulated wires generally have a small surface area for an individual item, but consumers may have many of the same type of item in a home. As phthalates are ubiquitous in PVC material, it is reasonable to assume that in a collection of toys or insulated cords and cables all of the items may have DINP content. As such, surface area for these items was estimated by assuming that a home has several of these items rather than one.

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. 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.

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, intensity use scenario was based on 5 small toys measuring 15 cm × 10 cm × 5 cm, the medium intensity use scenario was based on 20 medium toys measuring 20 cm × 15 cm × 8 cm, and high intensity use scenario was based on 30 large toys measuring 30 cm × 25 cm × 15 cm.

Mats

Based on a survey of car mat sets available on manufacturers websites, there was little variability in surface area and mats were sold in sets with two front mats ~30” × 20” and two back floor mats ~20” × 20”. Based on these dimensions the total surface area models was 1.29 m^2. As there was little observed variation in dimensions, this value was used in low, medium, and high scenarios.

DINP content in sports mats was reported by the ACC to be 30 percent by weight. While products could be found (floating exercise mats, gym mats) that stated that they do have DINP content, specific weight fractions were not provided. As such, the values provided by ACC were used to assess exposure to these kinds of products; the weight fractions of DINP used in low, medium, and high exposure scenarios were 30, 35, and 40 percent.

While consumers may be exposed to sports mats in the home, it was expected that greater exposure might occur in a gym due to the high surface area of mats present. To estimate total surface area of mats, it was assumed that mats covered 100, 50, and 25 percent of a 10,000 ft^2 floor space in the gym to account for the various kinds of gyms known to have significant but varying amounts of these items present (gymnastics gyms, rock climbing gyms, standard exercise gyms, etc).

Shower Curtains

Based on a survey of shower curtains available on manufacturers websites, there was little variability in surface area. EPA used manufacturer specifications for a shower curtain’s dimensions (1.83 m × 1.78m) to estimate surface area and multiplied by 2 to account for both sides. As there was little variability for this item, this surface area value was used in low, medium, and high exposure scenario models.

Table 2-5. Summary of Key Parameters for Inhalation and Dust Ingestion Exposure to DINP from Articles Modeled in CEM 3.2

Article	Exposure Scenario Level	Weight Fraction [a]	Density (g/cm^3) [b]	Article Surface Area (m^2) [c]	Surface Layer Thickness (cm) [d]	Use Environment [e]	Use Environment and Volume (m^3) [d]	Interzone Ventilation Rate (m^3/h) [d]
Car mats	High	0.036	1.4	1.29	0.01	Automobile	2.4	9.4872
	Med	0.036		1.29				
	Low	0.036		1.29				
Carpet backing	High	0.16	1.4	202	0.01	Whole House	492	1E−30
	Med	0.113		202				
	Low	0.09		202				
Children's toys (legacy) [f]	High	0.419	1.4	9.45	0.01	Bedroom	36	107.01
	Med	0.4045		2.32				
	Low	0.13		0.28				
Children's toys (new) [g]	High	0.01	1.4	9.45	0.01	Bedroom	36	107.01
	Med	0.01		2.32				
	Low	0.01		0.28				
Indoor furniture (foam components)	High	0.0636	0.05	20.9	0.01	Living Room	50	108.98
	Med	0.0223		14.7				
	Low	0.0006		9.6				
Indoor furniture (textile components)	High	0.35	1.4	20.9	0.01	Living Room	50	108.98
	Med	0.23		14.7				
	Low	0.16		9.6				
Shower curtain	High	0.102	1.4	6.5	0.01	Bathroom	15	107.01
	Med	0.051		6.5				
	Low	0.04		6.5				
Specialty wall coverings (in-place)	High	0.38	1.4	39.3	0.01	Kitchen	50	1E−30
	Med	0.3725		19.7				
	Low	0.23		9.8				
Sports mats	High	0.3	1.4	929	0.01	Office	23,225	1E−30
	Med	0.3		464				
	Low	0.3		232				
Vinyl flooring	High	0.25	1.4	202	0.01	Whole House	492	1E−30
	Med	0.1402		202				
	Low	0.0007		202				
Wallpaper (in	High	0.26	1.4	200	0.01	Whole House	492	1E−30

Article	Exposure Scenario Level	Weight Fraction [a]	Density (g/cm³) [b]	Article Surface Area (m²) [c]	Surface Layer Thickness (cm) [d]	Use Environment [e]	Use Environment and Volume (m³) [d]	Interzone Ventilation Rate (m³/h) [d]
place)	Med	0.245		100				
	Low	0.23		50				
Wire insulation	High	0.5	1.4	3.7	0.01	Whole House	492	1E−30
	Med	0.38		1.9				
	Low	0.25		1.4				

[a] See Section 2.1.1 for weight fraction sources and discussion.
[b] Used density of PVC for all articles except foam from various sources, see *Consumer Exposure Analysis Spreadsheet Diisononyl Phthalate (DINP)* (U.S. EPA, 2025a).
[c] See text related to article in this section.
[d] CEM default for the emission scenario and saved analysis.
[e] Professional judgment based on likeliness of article presence.
[f] 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.
[g] New toys scenarios consider a potential future application of the U.S. 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 DINP).

For mouthing exposure, key parameters include the rate of chemical migration from the article to saliva (ug/cm²/h), surface area mouthed (cm²), and duration of mouthing (min/day). Derivation of these inputs is outlined below.

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 physical and chemical 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), and chemical makeup of saliva. In addition, physical and chemical properties of the specific phthalate such as size, molecular weight, and solubility have a strong impact on migration rate to saliva.

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 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 DINP was estimated based on data compiled in a review published by the Denmark EPA 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 4 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 mouthing approaches, such as sucking, or chewing, or liking. These values were then subdivided into mild, medium, and harsh categories based on the mouthing approach used to estimate migration as shown in Table 2-6. There is considerable variability in the measured migration rates, but there was not a clear correlation between weight fraction of DINP and chemical migration rate.

The same chemical migration rates were applied to all articles regardless of DINP weight fraction. Mean values for chemical migration rates of DINP under mild, medium, and harsh mouthing assay conditions were used in the low, medium, and high exposure scenarios, respectively and these values are expected to capture the range of reasonable values for this parameter.

Table 2-6. Chemical Migration Rates Observed for DINP under Mild, Medium, and Harsh Extraction Conditions

Mouthing Approach	Migration Rate (μg/cm²/h) [a]		
	Min	Mean [b] (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

[a] Information from Tables 17, 18, and 19 in (Danish EPA, 2016).
[b] Selected values for assessment.

Mouthing Surface Area

The parameter "mouthing surface area" refers to the specific area of an object that comes into direct contact with the mouth during a mouthing event. A standardized value of 10 cm² for mouthing surface area is commonly used in studies to estimate mouthing exposure in children. This standard value is based on empirical data reflecting typical mouthing behavior in young children, providing a reliable basis for estimating exposure levels and potential health risks associated with mouthing activities. The value of 10 cm² was thus chosen for all mouthing exposure models for children.

Mouthing of adult toys was only modeled for adults and teenagers. Object mouthing is not commonly observed behavior in adults and teens, and as such there are not standard values for mouthing surface area. To determine a reasonable value 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 approximately 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 that would be in contact with an object. As such, it was assumed that 50 percent 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, although slightly lower than the value of 125 cm^2 used for adult toy mouthing area in the ECHA assessment.

Mouthing Duration

Mouthing durations were obtained from the EPA *Exposure Factors Handbook* Table 4-23 (U.S. EPA, 2011c) that provides mean mouthing durations for children between 1 month and 5 years of age, broken down by age groups 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 age groups than CEM. For example, it provides different mouthing durations for infants 12 to 15 months, 15 to 18 months, 18 to 21 months, and 21 to 24 months of age; CEM, in contrast, has only one age group 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 age group was used in the low exposure scenario, maximum value was used in the high exposure scenario, and the mean value (average across the age groups provided in the *Exposure Factors Handbook*) was used in the medium exposure scenario as shown in Table 2-7. For mouthing of adult toys, values of 60, 30, and 15 minutes 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 2-7. 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) [a]				**Mouthing Durations for CEM Age Groups (min/day)**		
Item Mouthed	**Reported Age Group**				**CEM Age Group: Infants <1 year**		
	1–3 Months	**3–6 Months**	**6–9 Months**	**9–12 Months**	**High Exposure Scenario** [b]	**Med Exposure Scenario** [c]	**Low Exposure Scenario** [d]
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 Age Group**				**CEM Age Group: 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 Age Group**				**CEM Age Group: Small Child 3–5 years**		
	2 Years	**3 Years**	**4 Years**	**5 Years**	**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

[a] Table 4-23 in **Exposure Factors Handbook**
[b] High exposure scenario value was the largest of the reported mouthing durations for each age group.
[c] Med (medium) exposure scenario was calculated as the mean of the high and low exposure scenarios selected values.
[d] Low exposure scenario value was the lowest of the reported mouthing durations for each age group.

2.2.3.2 Key Parameters for Liquid and Paste Products Modeled in CEM

CEM models for liquid and paste products only evaluated exposure by on, while dermal exposures were modeled outside of CEM, see Section 2.3. Higher concentrations of DINP in air and dust results in increased inhalation exposure. This may occur due to product formulation or use patterns that allow for higher emissions of DINP to air and/or environment specific characteristics such as smaller room volume and lower ventilation rates. Key parameters that control DINP emission rates from products in CEM 3.2 models are weight fraction of DINP in the formulation, duration of product use, mass of product used, and frequency of use. Any increase in these parameters results in higher chemical exposure from product use.

DINP is typically added to products because its large molecular size and strongly hydrophobic chemical structure result in waterproof qualities in the finished good. As such, products containing DINP tend to be specialized in their intended use. For instance, all caulking compounds identified with DINP were intended for outside use or high moisture indoor environments and spray paints identified were for waterproofing metal and wood surfaces. Default values in CEM for general use products were not considered applicable. Values for exposure scenario key parameters were based on professional judgement that incorporated information from several sources. These sources included product labels, information obtained from an informal survey of customer reviews on e-commerce sites, information from internet forums specific to resin hobby enthusiasts. Product densities were taken from product specific technical specification when possible. In instances where no data were available for a product type a density obtained for a similar product was used. A detailed description of derivations of other key parameter values used in CEM 3.2 models for liquid and paste products is provided below, and a summary of values be found in Table 2-8. Note that articles not modeled for inhalation exposure are not included in the table. Adhesive for small repairs products, assessed for dermal contact only (see Table 2-1), were not modeled with CEM. In the dermal exposure modeling the weight fraction data are used to confirm the presence of DINP in the product but are not used as a model input (see Section 2.3). Dermal exposure assessments include high, medium, and low intensity use scenarios for each product using a range of modeling input parameters described in Section 2.3, such as dermal absorption, duration, frequency of the contact. Automotive adhesives, caulking products, crafting resins, and lacquers were assessed for inhalation exposures in addition to dermal exposures using the available weight fraction ranges, and various CEM inputs for the high, medium, and low intensity use scenarios as shown in Table 2-8

Mass of Product Used

For automotive adhesives and products used for home maintenance and repairs, including adhesive foams, caulking compounds, and spray paints and lacquers, the mass of product used was based on the reasonable assumption that the volume in which products are sold is adequate for the tasks they are intended for. For high exposure scenarios, it was assumed that the entire mass of the product container is used, reflecting scenarios where a large project or extensive application is undertaken. Medium exposure scenarios assumed half the container's mass was used, representing more common or average usage for routine maintenance or smaller projects. Low exposure scenarios assumed a quarter of the container's mass was used, corresponding to minimal use for minor repairs or touch-ups. This approach is consistent with observations of consumer reviews for individual products on vendor websites, which indicated diverse usage patterns among consumers including small, medium, and large projects.

For resin products used in DIY arts and crafts projects, an informal review of online community postings in model making forums and homemade products available on e-commerce platforms was conducted. This approach allowed for an understanding of how resins are commonly utilized in crafting, ensuring that the modeling assumptions align with practical usage patterns observed in these communities. Based on this information, resin casting and mold making projects may be carried out across a variety of scales ranging from small models to furniture pieces and may be sold on e-commerce platforms after production. Given this wide range in usage, the same approach was taken as previously described for automotive adhesives and products for home maintenance; high, medium, and low exposure scenarios assumed that the whole container, half container, and a quarter of a product container were used during each use event.

Duration of Use

For adhesive foam products, large projects such as flooring or drywall installation could be a full day of work, while smaller projects may be accomplished more quickly, so duration of use for high, medium, and low exposure scenarios were assumed to be 480, 240, and 120 minutes respectively. Automotive adhesives, and paints and lacquers sold in small format spray cans are expected to be used in comparatively smaller scale projects and were thus modeled at use durations of 120, 60, and 30 minutes for the high, medium, and low intensity use scenarios respectively. Waterproof caulking compounds are expected to be limited to use for small scale repairs of sinks and bathtubs and were thus modeled at durations of 60, 30, and 15 minutes for the high, medium, and low intensity use scenarios respectively. For crafting resin, the working time after mixing is relatively short; however, an informal review of information on internet forums for resin model making enthusiasts indicates that it is common to make many small models concurrently, and some individuals make larger pieces by pouring layer of resin mixed in different batches. Based on this information, the working time of the resin could not be considered the limiting factor for use. In addition, a survey of e-commerce sites found that resin arts and crafts items are sold by individuals presumably making the items at home, which supports a longer duration of use. Crafting resin duration of use was modeled at 120, 60, and 30 minutes where the upper boundary represents many small craft pieces or 1 large, layered piece, for the high intensity use scenario and the lower values represent smaller projects for the medium and low intensity use scenarios.

Frequency of Use

For foam adhesives and automotive adhesives, use is not anticipated to be routine. However, an informal survey of reviews posted by customers on e-commerce sites indicated that both product types are used for a wide variety of applications. As such, it was assumed that individuals may use these products for more than one project on a yearly basis, and both were modeled as twice per year. For all other liquid and paste products, daily use was not considered likely, but routine use was. Therefore, all were modeled at a use frequency of 52 times per year or once a week per year. For all liquid and paste products, acute frequency was modeled as one use per day.

Table 2-8. Summary of Key Parameters for Products Modeled in CEM 3.2

Product	Exposure Scenario Level	Weight Fraction [a]	Density (g/cm^3) [b]	Duration of Use (Hr)	Product Mass Used (g)	Freq. of Use (year^{-1})	Freq. of Use (day^{-1})	Use Environ. Volume (m^3) [c]	Air Exchange Rate, Zone 1 and Zone 2 (hr^{-1})[d]	Interzone Ventilation Rate (m^3/h) [d]
Adhesive foam	High	0.01	0.726	480	5,000	2	1	Living Room; 50	0.45	108.98
	Med	0.0055		240	500					
	Low	0.001		120	100					
Automotive adhesives	High	0.3	1.38	120	300	2	1	Garage; 90	0.45	108.98
	Med	0.16625		60	150					
	Low	0.03		30	75					
Caulking compounds	High	0.15	1.35	60	300	52	1	Bathroom; 20	0.45	107.01
	Med	0.059		30	150					
	Low	0.01		15	75					
Crafting resin	High	0.4	0.88	120	5,000	52	1	Utility Room; 20	0.45	107.01
	Med	0.20625		60	500					
	Low	0.1		30	100					
Paint/lacquer (small project)	High	0.05	0.95	120	320	52	1	Garage; 90	0.45	108.978
	Med	0.02125		60	160					
	Low	0.01		30	80					
Roofing adhesives	High	0.31	0.88	480	18,000	365	1	Outside, 1E100	0.45	1E-30
	Med	0.305		240	5,000					
	Low	0.3		120	2,500					

[a] See Section 2.1.2. High intensity use value is the reported range maximum, the low intensity use value is the reported range minimum, and the medium intensity use value is the mean from the reported maximum and low.
[b] See Section 2.2.3.2. Used product SDS reported density value.
[c] Use environment was determined based on product manufacturer use description.
[d] CEM default. 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 m^3 was selected.

2.3 Dermal Modeling Approach

While inhalation and ingestion pathways were modeled using CEM, see Section 2.2, dermal modeling for liquid and solid products was done using the approach described in this section. This section summarizes the available dermal absorption data related to DINP, the interpretation of the dermal absorption data, and dermal absorption modeling efforts, while uncertainties associated with dermal absorption estimation are available in Section 5.1. Dermal data were sufficient to characterize consumer dermal exposures to liquids or formulations containing DINP; however, dermal data were not sufficient to estimate dermal exposures to solids or articles containing DINP. Therefore, modeling efforts described in Section 2.3.2 were used to estimate dermal exposures to solids or articles containing DINP. Dermal exposures to vapors are not expected to be significant due to the extremely low volatility of DINP, and therefore, are not included in the dermal exposure assessment of DINP.

2.3.1 Dermal Absorption Data

Dermal absorption data related to DINP were limited. Specifically, EPA identified only one acceptable study directly related to the dermal absorption of DINP (Midwest Research Institute, 1983), which was an *in vivo* absorption study using male F344 rats. For each *in vivo* dermal absorption experiment, neat DINP was applied to a freshly shaven area of 3 cm × 4 cm at doses varying from approximately 8 mg/cm^2 (*i.e.*, 0.1 mL of neat DINP per rat) to 16 mg/cm^2 (*i.e.*, 0.2 mL of neat DINP per rat) and the site of application was covered with a styrofoam cup lined with aluminum foil. Rats were then monitored for durations of 1, 3, and 7 days to determine the quantity of DINP absorbed during those durations.

Because EPA expects finite dose exposures (*i.e.*, <10 µL/cm^2 for liquids (OECD, 2004)) in consumer exposure settings, only data from finite dose experiments (*i.e.*, ~8 mg/cm^2 doses) were considered for the consumer dermal exposure assessment. Also, to provide the most protective assessment, the highest absorptive flux value calculated from the finite dose experiments was utilized for consumer dermal exposure assessment of liquids containing DINP. More specifically, the highest average absorptive flux value from the finite dose experiments was measured from the 7-day exposure period finite dose experiment, where there was 3.06 percent absorption of ~8 mg/cm^2 over the 7-day duration (*i.e.*, 1.46E−03 mg/cm^2/h). For all dermal absorption experiments with DINP, material recovery fell within the OECD 156 (2022) guidelines of 90 to 110 percent for non-volatile chemicals.

2.3.1.1 Dermal Absorption Data Interpretation and Liquids Flux-Limited Data

With respect to interpretation of the DINP dermal absorption data reported in Midwest Research Institute (1983), it is important to consider the relationship between the applied dermal load and the rate of dermal absorption. Specifically, the work of Kissel (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 2-1. 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 excess 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.

Using an estimate of 3.06 percent absorption of 8 mg/cm^2 of DINP over a 7-day period, the steady-state flux of neat DINP is estimated as 1.46×10^{-3} mg/cm^2/h. The application of N_{derm} to the DINP dermal absorption data reported in Midwest Research Institute (1983) is shown below.

$$N_{derm} = \frac{8\ mg/cm^2}{1.46E-03\,\frac{mg}{cm^2 \cdot hr} \times 7\ days\ \times 24\,\frac{hr}{day}} = 33$$

Because N_{derm} exceeds 1 for the experimental conditions of Midwest Research Institute (1983), it is shown that the absorption of DINP is considered flux-limited even at finite doses (*i.e.*, <10 µL/cm^2 (OECD, 2004)).

The range of estimated steady-state fluxes of DINP presented in this section, based on the results of Midwest Research Institute (1983), is representative of exposures to liquid materials or formulations only. Dermal exposures to liquids containing DINP are described in Section 2.3.2. Regarding dermal exposures to solids containing DINP, there were no available data and dermal exposures to solids are modeled as described in Section 2.3.3.

2.3.2 Dermal Contact with Liquids

The work of the Midwest Research Institute (1983) showed that the highest expected steady-state absorptive flux of neat DINP from a *finite dose application* (*i.e.*, approximately 8 mg/cm^2) *was estimated as 1.46×10^{-3} mg/cm^2/h.* EPA considers the dermal absorption data from the Midwest Research Institute (1983) to be representative of consumer dermal exposures to liquids or formulations containing DINP. Though it is possible that lower concentration materials exhibit higher fluxes than the neat material due to the properties of the vehicle of absorption, the flux of the neat material serves as a reasonable upper bound of potential flux across concentrations.

2.3.3 Dermal Absorption Modeling for Solids

The equation used to estimate the dermal dose of DINP associated with routine use of consumer liquid products and articles is as follows:

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

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

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, hour
SA	=	Surface area of body parts in direct contact with product/article, cm^2
BW	=	Body weight by lifestage, kg

For cases of dermal absorption of DINP from a solid matrix, EPA assumes that DINP first migrates from the solid matrix to a thin layer of moisture on the skin surface. Therefore, absorption of DINP 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/h). EPA utilized the CEM K_p equation (U.S. EPA, 2023) to estimate the steady-state aqueous permeability coefficient of DINP. Next, EPA relied on Equation 3.2 from 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 over some duration (t_{abs}, hours) as shown below.

Equation 2-3. 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 = 0.75 (see Exhibit A-5 of U.S. EPA (2004))
K_p	=	Permeability coefficient = 0.0081 cm/h (calculated using CEM (U.S. EPA, 2023))
S_w	=	Water solubility = 0.20 mg/L (see DINP Section 2.2.6 of (U.S. EPA, 2025d))
t_{lag}	=	$0.105*10^{0.0056MW} = 0.105*10^{0.0056*446.68} = 23.2$ 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 for DINP.

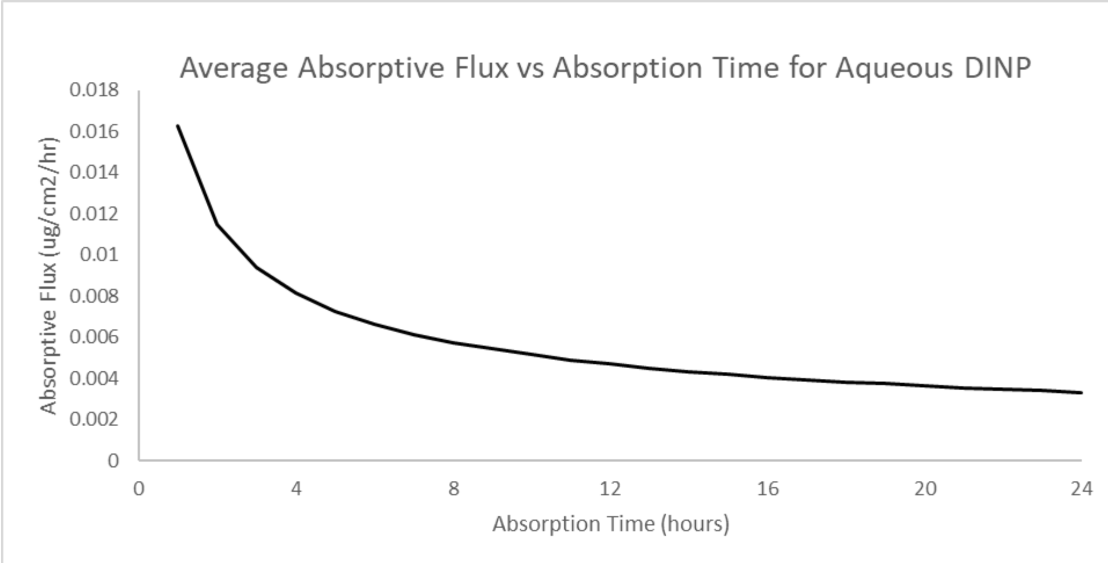

Figure 2-2. Average Absorptive Flux Absorbed into and through Skin as Function of Absorption Time

Figure 2-2 shows that the average absorptive flux for aqueous DINP is expected to vary between 0.003 and 0.016 µg/cm^2/h for durations between 1-hour and 1-day, and the average absorptive flux for an 8-hour exposure is 0.00575 µg/cm^2/h. 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, see Section 2.3.4 for dermal contact duration per product and article. The range of estimated steady-state fluxes of DINP presented in this section, based on modeling from (U.S. EPA, 2004), is considered representative of dermal exposures to solid materials or articles containing DINP.

Exposures durations to solids containing DINP reach 8 hours for the high intensity use scenarios for the identified products and articles, see Section 2.3.4. The aqueous dermal exposure model assumes that DINP absorbs as a saturated aqueous solution (*i.e.*, concentration of absorption is equal to water solubility), which would be the maximum concentration of absorption of DINP expected from a solid material. Also, EPA used the maximum value of water solubility from available data, as shown in Equation 2-3, rather than a value near the low-end of the range of available data. Therefore, the estimates of dermal exposure to DINP from solid materials are considered realistic but on the conservative end of expected dermal exposures.

2.3.4 Modeling Inputs and Parameterization

Key parameters for the dermal model include duration of dermal contact, frequency of dermal contact, total contact area, and dermal flux; an increase in any of these parameters results in an increase in exposure. Key parameter values used in models are shown in Table 2-9. For contact area, professional judgement, based on product use descriptions from manufacturers and article typical use, was applied to determine reasonable contact areas for each product or article. In addition to considering typical product and article use, EPA used conservative contact area options with the possibility of further refining the scenario should risk be identified in Section 4 of the *Risk Evaluation for Diisononyl Phthalate (DINP)* (U.S. EPA, 2025e). For items that were considered to have a high level of uncertainty, different surface areas were assumed in high, medium, and low scenarios. The subsections under Table 2-9 provide details on assumptions used to derive other key parameters. Calculations, sources, input parameters and results are also available in *Consumer Exposure Analysis for Diisononyl Phthalate (DINP)* (U.S. EPA, 2025a). 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 in Appendix 6A.4.

Table 2-9. Key Parameters Used in Dermal Models

Product	Scenario	Duration of Contact (min)	Frequency of Contact ($year^{-1}$)	Frequency of Contact (day^{-1})	Dermal Absorption[a] or Flux[b] ($mg/cm^2/hour$)	Contact Area
Adult toys	High	60	365	1	1.62E−5	Inside of one hand (palms, fingers)
	Medium	30			1.14E−5	
	Low	15			8.09E−6	
Carpet backing	High	120	365	1	2.29E−5	Inside of one hand (palms, fingers)
	Medium	60			1.62E−5	
	Low	30			1.14E−5	
Car mats	High	60	52	1	1.62E−5	10% of hands (some fingers)
	Medium	30			1.14E−5	
	Low	15			8.09E−6	
Children's toys (legacy)	High	137	365	1	2.44E−5	Inside of two hands (palms, fingers)
	Medium	88			1.96E−5	
	Low	24			1.02E−5	
Children's toys (new)	High	137	365	1	2.44E−5	Inside of two hands (palms, fingers)
	Medium	88			1.96E−5	
	Low	24			1.02E−5	
Clothing	High	480	52	1	4.58E−5	50% of entire body surface area
	Medium	240			3.24E−5	25% of face, hands, and arms
	Low	120			2.29E−5	Inside of two hands (palms, fingers)
Foam cushions	High	480	365	1	4.58E−5	50% of entire body surface area
	Medium	240			3.24E−5	25% of face, hands, and arms
	Low	120			2.29E−5	Inside of two hands (palms, fingers)
Indoor furniture	High	480	365	1	4.58E−5	50% of entire body surface area
	Medium	240			3.24E−5	25% of face, hands, and arms
	Low	120			2.29E−5	Inside of two hands (palms, fingers)
Outdoor furniture	High	120	208	1	2.29E−5	50% of entire body surface area
	Medium	60			1.62E−5	25% of face, hands, and arms
	Low	30			1.14E−5	Inside of two hands (palms, fingers)
Roofing membrane	High	480	1	1	4.58E−5	Inside of one hand (palms, fingers)
	Medium	240			3.24E−5	Inside of one hand (palms, fingers)
	Low	120			2.29E−5	Inside of one hand (palms, fingers)
Rubber eraser	High	60	365	1	1.62E−5	Inside of two hands (palms, fingers)
	Medium	30			1.14E−5	
	Low	15			8.09E−6	

Product	Scenario	Duration of Contact (min)	Frequency of Contact (year^{-1})	Frequency of Contact (day^{-1})	Dermal Absorption[a] or Flux[b] (mg/cm^2/hour)	Contact Area
Shower curtain	High	60	365	1	1.62E−5	Inside of one hand (palms, fingers)
	Medium	30			1.14E−5	
	Low	15			8.09E−6	
Small articles with potential for semi-routine contact	High	120	365	1	2.29E−5	Both hands (entire surface area)
	Medium	60			1.62E−5	Inside of two hands (palms, fingers)
	Low	30			1.14E−5	10% of hands (some fingers)
Specialty wall coverings (in-place)	High	60	365	1	1.62E−5	Inside of one hand (palms, fingers)
	Medium	30			1.14E−5	
	Low	15			8.09E−6	
Specialty wall coverings (installation)	High	480	1	1	4.58E−5	Inside of two hands (palms, fingers)
	Medium	240			3.24E−5	
	Low	120			2.29E−5	
Sports mats	High	120	208	1	2.29E−5	Inside of one hand (palms, fingers)
	Medium	60			1.62E−5	
	Low	30			1.14E−5	
Track awning	High	60	52	1	1.62E−5	Inside of two hands (palms, fingers)
	Medium	30			1.14E−5	
	Low	15			8.09E−6	
Vinyl flooring	High	120	365	1	2.29E−5	Inside of one hand (palms, fingers)
	Medium	60			1.62E−5	
	Low	30			1.14E−5	
Wallpaper (in place)	High	60	365	1	1.62E−5	Inside of one hand (palms, fingers)
	Medium	30			1.14E−5	
	Low	15			8.09E−6	
Wallpaper (installation)	High	480	1	1	4.58E−5	Inside of two hands (palms, fingers)
	Medium	240			3.24E−5	
	Low	120			2.29E−5	
Wire insulation	High	60	365	1	1.62E−5	Inside of one hand (palms, fingers)
	Medium	30			1.14E−5	
	Low	15			8.09E−6	
Adhesives for small repairs	High	60	12	1	1.46E−3	10% of hands (some fingers)
	Medium	30				
	Low	15				
Adhesive foam	High	480	2	1	1.46E−3	Inside of two hands (palms, fingers)
	Medium	240				Inside of one hand (palms, fingers)
	Low	120				10% of hands (some fingers)
Automotive adhesives	High	120	2	1	1.46E−3	10% of hands (some fingers)
	Medium	60				
	Low	30				

Product	Scenario	Duration of Contact (min)	Frequency of Contact ($year^{-1}$)	Frequency of Contact (day^{-1})	Dermal Absorption[a] or Flux[b] ($mg/cm^2/hour$)	Contact Area
Caulking compounds	High	60	52	1	1.46E−3	10% of hands (some fingers)
	Medium	30				
	Low	15				
Crafting resin	High	120	52	1	1.46E−3	Inside of two hands (palms, fingers)
	Medium	60				Inside of one hand (palms, fingers)
	Low	30				10% of hands (some fingers)
Paint/laquer (large project)	High	1	365	1	1.46E−3	Inside of two hands (palms, fingers)
	Medium	1				Inside of one hand (palms, fingers)
	Low	1				10% of hands (some fingers)
Paint/lacquer (small project)	High	120	52	1	1.46E−3	Inside of two hands (palms, fingers)
	Medium	60				Inside of one hand (palms, fingers)
	Low	30				10% of hands (some fingers)
Polyurethane injection resin	High	480	365	1	1.46E−3	Inside of two hands (palms, fingers)
	Medium	240				Inside of one hand (palms, fingers)
	Low	120				10% of hands (some fingers)
Roofing adhesives	High	480	1	1	1.46E−3	Inside of two hands (palms, fingers)
	Medium	240				Inside of one hand (palms, fingers)
	Low	120				10% of hands (some fingers)
Scented oil	High	480	52	1	1.46E−3	Inside of two hands (palms, fingers)
	Medium	240				Inside of one hand (palms, fingers)
	Low	120				10% of hands (some fingers)

Duration of Use/Article Contact Time

For liquid and paste products, it was assumed that contact with the product occurs at the beginning of the period of use and the product is not washed off until use is complete. As such, the duration of dermal contact for these products is equal to the duration of use applied in CEM modeling for products. For products not modeled in CEM (roofing membrane adhesive and polyurethane injection resin) it was assumed that a large project could be a full day of work, while smaller projects may be accomplished more quickly, so contact time for high, medium, and low exposure scenarios were assumed to be 480, 240, and 120 minutes, respectively. For scented oil used in candle making, it was similarly assumed that individuals making a large batch of candles that may be sold on e-commerce could be in contact with the oil during a full day of work, while smaller projects may be accomplished more quickly, so contact time for high, medium, and low exposure scenarios were assumed to be 480, 240, and 120 minutes.

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. For flooring products (carpeting and vinyl tiles), values for dermal contact time are based on EPA's Standard Operating Procedures for Residential Pesticide Exposure Assessment for the high exposure level (2 hours; time spent on floor surfaces), ConsExpo for the medium exposure level (1 hour; time a child spends crawling on treated floor), and professional judgement for the low exposure level (0.5 hour) (U.S. EPA, 2012). For articles used in large home DIY projects (wallpaper and specialty wall covering installation, roofing membrane installation) it was assumed that a large project could be a full day of work, while smaller projects may be accomplished more quickly, so contact time for high, medium, and low exposure scenarios were assumed to be 480, 240, and 120 minutes. Similarly, clothing and indoor furniture have the potential for long durations of dermal contact but may be also used for shorter periods and were thus modeled at 480, 240, and 120 minutes for high, medium, and low intensity use scenarios. Outdoor furniture was considered less likely to be used for extended periods and was modeled at 120, 60, and 30 minutes per use for high, medium, and low intensity use scenarios. Values of 60, 30, and 15 minutes were assigned to articles anticipated to have low durations of contact (car mats, truck awnings, rubber eraser, shower curtain, wire insulation, and routine (in-place) contact with wallpaper and specialty wall coverings) for high, medium, and low intensity use scenarios respectively.

In addition to the scenarios for dermal exposure to DINP from specific articles, a scenario was modeled in which consumers may have semi-routine contact with one or more small items containing DINP. A complete list of articles and associated COUs modeled under this scenario is outlined in Section 2.1. While dermal contact with individual items is expected to be short and/or irregular in occurrence, use of these articles is not well documented, and there is likely to be significant variability in use patterns between individual consumers. However, given the number and variety of small items identified with DINP content, EPA considers it reasonable to assume that an individual could have significant daily contact with some combination of these items and/or with other similar items that have not been measured during monitoring campaigns. As such, articles modeled under this scenario were assumed to have dermal contact times of 120, 60, and 30 minutes per day.

Frequency of Use

For liquid and paste products modeled in CEM, frequency of contact was assumed to be equal to the frequency of use (per year and per day) that was applied in CEM modeling. For scented oils used in candle making, it was assumed that individuals might be in contact once per week. For products used in potentially large outdoor DIY projects (roofing membrane adhesive and polyurethane injection resin) due to significant work required to prepare and clean-up afterwards it was assumed that these projects were carried out over a single day once per year.

For articles, assumptions about frequency of use were made based on professional judgement based on one contact per event duration as a conservative screening approach, further refinement is considered at the risk calculation stage, see *Risk Evaluation for Diisononyl Phthalate (DINP)* (U.S. EPA, 2025e). For articles that are expected to be used on a routine basis, such as children's toys, indoor furniture, shower curtains, rubber erasers, and adult toys, use was assumed to be once per day every day, while changing the duration of contact for the high, medium, and low intensity scenarios. For children's toys, data was obtained from the Children's Exposure Factors Handbook Table 16-26. Reported values for playtime for children under 15 ranged from 24 min/day to 137 min/day, with a mean value of 88 min/day; these values were used in the low, high, and medium exposure scenarios. The playtime duration used for children under 15 was also used for children 16 to 20 years due to lack of playtime duration information for this age range and as conservative assumption that can be further refined should risk be identified in the risk characterization stage of this assessment, see Section 4 of *Risk Evaluation for Diisononyl*

Phthalate (DINP) (U.S. EPA, 2025e). For articles used in large home DIY projects (wallpaper and specialty wall covering installation, roofing membrane installation), due to significant work required to prepare and clean-up afterwards it was assumed that these projects were carried out over a single day once per year. DINP is expected to be present in polyurethane leather and waterproof garments such as raincoats and boots. These garments are not expected to be worn daily but could reasonably be worn on a routine basis. As such, dermal contact with clothing was modeled as one wear every week. Similarly, car mats and truck awnings were modeled as a single use each week, to represent an individual who does a weekly car cleaning or uses their vehicle awning for outdoor activities on a weekly basis. For sports mats and outdoor furniture, it was assumed that individuals would use these items several times per week on average as such dermal contact with these articles was modeled at four times per week.

2.4 Key Parameters for Intermediate Exposures

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 2-8 for inhalation and Table 2-9 for dermal. EPA used professional judgment based on manufacturer and online product use descriptions to estimate events per day and per month for the calculation of the intermediate dose, see Appendix 6A.3.

Table 2-10. 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

3 CONSUMER EXPOSURE MODELING RESULTS

This section summarizes the dose estimates from inhalation, ingestion, and dermal exposure to DINP in consumer products and articles. Exposure via the inhalation route occurs from inhalation of DINP gas-phase emissions or when DINP partitions to suspended particulate from direct use or, application, or installation 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 DINP migrates from a product or article to dust or partitions from gas-phase to dust.

3.1 Acute Dose Rate Results, Conclusions and Data Patterns

DINP Consumer Risk Calculator (U.S. EPA, 2025b) summarizes all the high, medium, and low acute dose rate results for all lifestages from CEM modeling for inhalation and ingestion exposures, and computational modeling for all dermal exposures. Products and articles marked with a dash (-) did not have dose results because the product or article was not evaluated quantitatively, see Section 2.1 for discussion about qualitative assessments and rationale for not evaluating certain exposure routes. Dose results applicable to bystanders are highlighted. Bystanders are people that are not in direct use or application of a product but can be exposed to DINP by proximity to the use of the product via inhalation of gas-phase emissions or suspended dust. Some product scenarios were assessed for bystanders for children under 10 years and as users older than 11 years because the products were not targeted for very young children (<10 years). 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 as compared to a bystander. The main purpose of *DINP Consumer Risk Calculator* (U.S. EPA, 2025b) is to summarize acute dose rate results, show which products or articles did not have a quantitative result, and that results are used for bystanders. Data patterns are illustrated in figures in this section and includes summary descriptions of the patterns by exposure route and population or lifestage.

Figure 3-1 through Figure 3-4 show acute dose rate data for all products and articles modeled in all lifestages. For each lifestage, figures are provided that 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 that showed a single exposure pathway most likely to drive exposure. However, for teens and adults, dermal contact was a strong driver of exposure to DINP, with the dose received being generally higher than or similar to the dose received from exposure via inhalation or ingestion.

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 DINP 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 Sections 2.2.3 and 2.3.4. Key differences in exposures among lifestages include designation as a 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 that may not be appropriate for some lifestages. Figures and observations specific to each lifestage are below.

Infants, Toddlers, Preschoolers, and Middle Childhood (1–10 Years)

Figure 3-1 and Figure 3-2 show all exposure routes for infants less than 1 year old to 10 years old children. Dose result patterns were very similar for the same products or articles and routes of exposure across these three lifestages, see *DINP Consumer Risk Calculator* (U.S. EPA, 2025b) doses per lifestage. EPA averaged the three lifestages into one dose result for all in Figure 3-1 and Figure 3-2. Ingestion route acute dose results in the figure show the sum of all ingestion scenarios (mouthing, suspended dust, and surface dust). Inhalation exposure from toys, flooring, carpet backing, indoor furniture, cushions, wallpaper, shower curtains, and wire insulation include a consideration of dust collected on the surface, settled dust, of a relatively large area, like flooring and wallpaper, but also multiple toys and wires collecting dust with DINP and subsequent inhalation and ingestion.

Compared to all exposure routes inhalation is the highest exposure dose per product and articles, except for new children's toys and wire insulation ingestion via mouthing. The highest ADR estimated for these lifestages was for inhalation of suspended dust exposure to carpet backing, children's toys, indoor furniture, wallpaper and coverings, vinyl flooring, sports mats, and wire insulation. Inhalation of DINP-contaminated dust is an important contributor to indoor exposures. Inhalation doses of adhesives and lacquers for this lifestages represent bystander exposures, which is a person in the proximity of someone else using such products. These products inhalation doses are overall lower than the articles used for indoor inhalation of suspended dust.

Ingestion of DINP has the overall second highest doses. For articles assessed for mouthing, such as toys, furniture, wire insulation, and rubber erasers exposure from mouthing is expected to have a larger impact in the overall ingestion dose. Mouthing tendencies decrease or cease entirely for children 6 to 10 years old. Ingestion of DINP via mouthing of legacy and new toy, have similar high intensity use doses because the same chemical migration rates were used for all scenarios. However, it is noteworthy that the concentration of DINP in new toys is below the range of values used to derive the chemical migration rates and it is likely that the high intensity use mouthing exposure estimates are not representative of actual doses that would be received from these items. Articles that were not assessed for mouthing were assessed for ingestion of settled and suspended dust, in which the settled dust exposures tend to be larger than ingestion from suspended dust, see Table 2-1, for indoor settled dust ingestion exposure results.

The dermal ADR is the lowest dose in comparison to inhalation and ingestion per product and articles, except for cushions. The dermal assessment of cushions considered direct contact like that of furniture, which may be an overestimation. The ADR range is similar for shower curtains, flooring, wallpaper and specialty coverings, and wire insulation, because of similar contact patterns and frequencies, and from using the same dermal flux rates.

Figure 3-1. Acute Dose Rate for DINP from Ingestion, Inhalation, Dermal Exposure Routes in Infants Aged Less than 1 Year and Toddlers Aged 1 to 2 Years

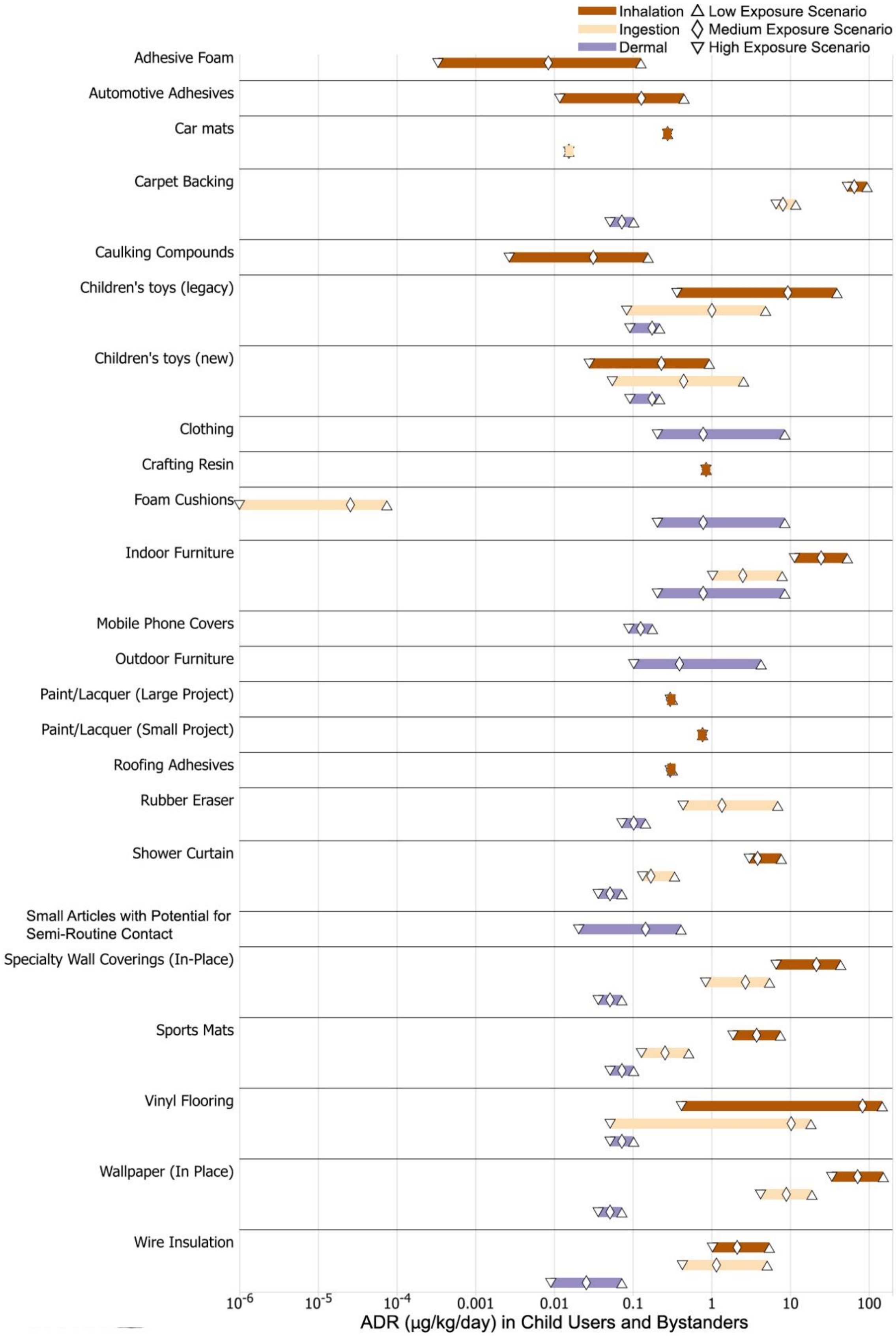

Figure 3-2. Acute Dose Rate of DINP from Ingestion, Inhalation, and Dermal Exposure Routes for Preschoolers Aged 3 to 5 Years and Middle Childhood Aged 6 to 10 Years Old

Young Teens, Teenagers, Young Adults, and Adults (11–21 Years and 21+ Years)
Figure 3-3 and Figure 3-4 show all exposure routes for young teens (11–15 years) to adults above 21 years old. Dose result patterns were very similar for the same products or articles and routes of exposure across young teens, teenagers and young adults, 11 to 20 years old, see *DINP Consumer Risk Calculator* (U.S. EPA, 2025b) doses per lifestage. EPA averaged two lifestages 11 to 20 years old, except adults that 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. Inhalation exposure as a bystander for these lifestages were not targeted for adhesives and lacquers for small projects. Young adults (16–20 years old) can use these products in similar capacity as adults during DIY projects and as bystanders; hence this lifestage was modeled as a user of the product rather than a bystander. Users have higher exposure doses when considering direct contact and use. Dermal exposure resulted in the highest doses overall, for DIY products such as adhesives, paints, lacquers, scented oils, except for paints for large projects in which inhalation exposure was higher likely because of the use of spray paints and the volatilization of the paint and subsequent inhalation of mist and droplets.

For articles considered in the indoor assessment inhalation and ingestion of suspended and settled dust exposure doses were higher than dermal, which decreases significantly. Ingestion via mouthing is either not considered or significantly lower that is expected due to a decrease or ceased in mouthing behavior. Mouthing tendencies decrease significantly for theses lifestages; thus, most scenarios do not estimate exposure via mouthing. Mouthing is still an important exposure route for adult toys and teenagers and adults. Ingestion of settled dust is the only ingestion pathway for other products and articles other than adult toys, which suggests that indoor dust ingestion and inhalation are an important contributor to DINP exposures.

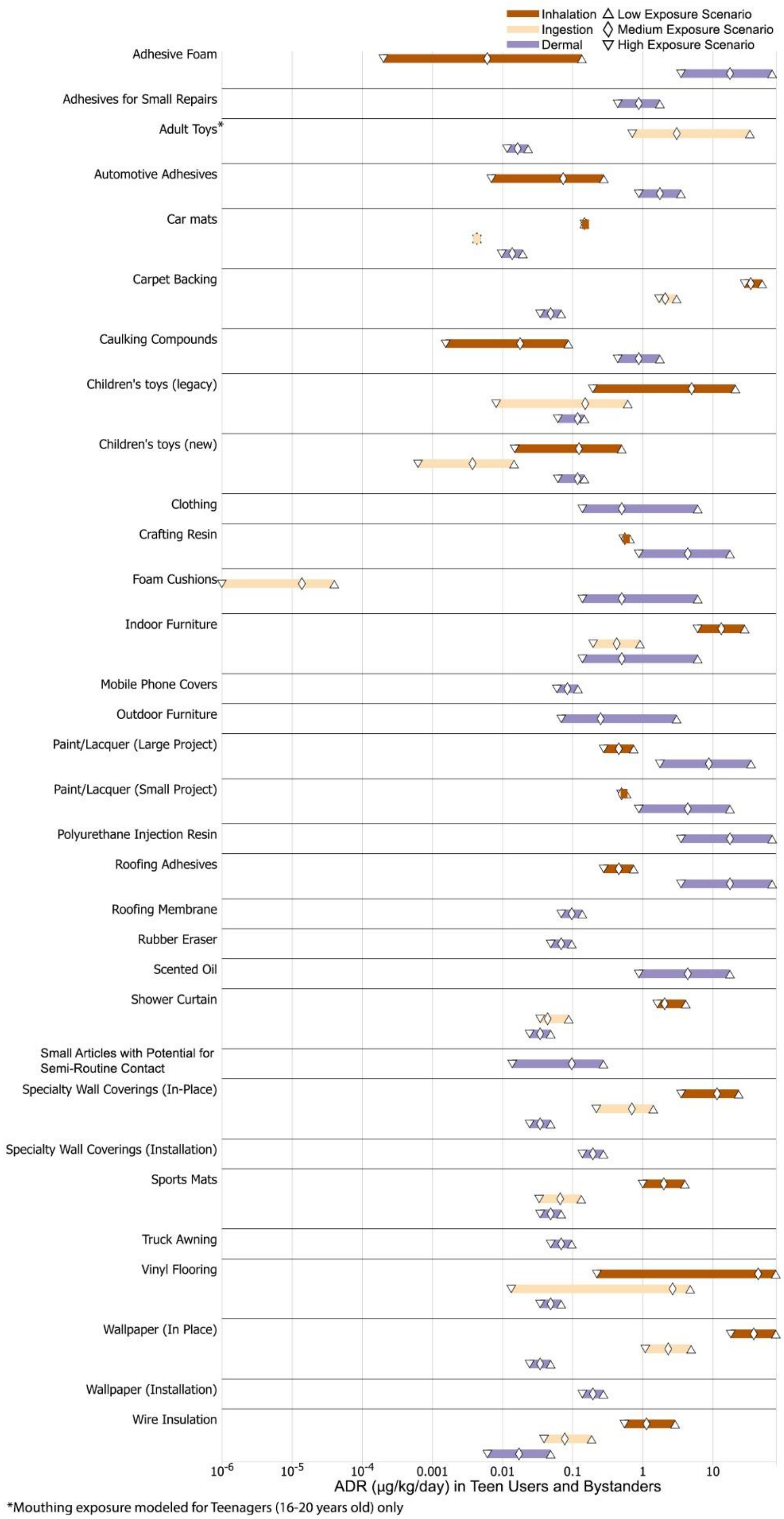

Figure 3-3 Acute Dose Rate of DINP from Ingestion, Inhalation, and Dermal Exposure Routes for Young Teens Aged 11 to 15 Years Old and for Teenagers and Young Adults Aged 16 to 20 Years

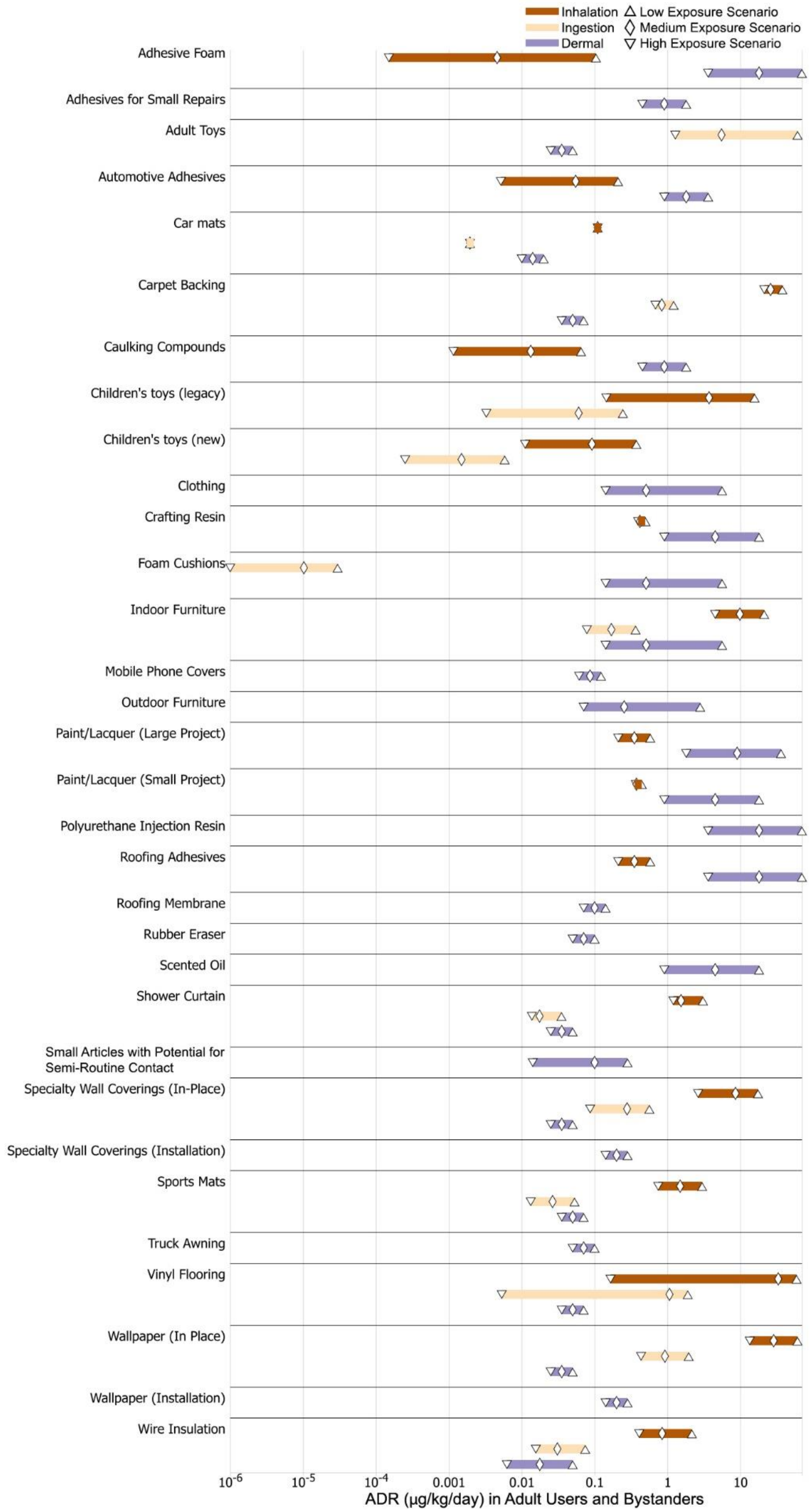

Figure 3-4. Acute Dose Rate of DINP from Ingestion, Inhalation, and Dermal Exposure Routes in Adults Older than 21 Years

3.2 Intermediate Average Daily Dose Conclusions and Data Patterns

DINP Consumer Risk Calculator (U.S. EPA, 2025b) summarizes all the high, medium, and low acute dose rate results for all lifestages from CEM modeling for inhalation and ingestion exposures, and computational modeling for all dermal exposures. Only three products under the Construction, paint, electrical, and metal products adhesives and sealants COU were assessed for intermediate exposures. Intermediate exposure scenarios were built for products used between 30 and 60 days, and EPA used 30 days or approximately 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 (-).

Only automotive adhesives and construction adhesives 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 automotive and construction adhesives 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. Direct dermal contact has a larger dose than inhalation for the uses during application. See Figure 3-5 to Figure 3-8 for intermediate dose visual representation.

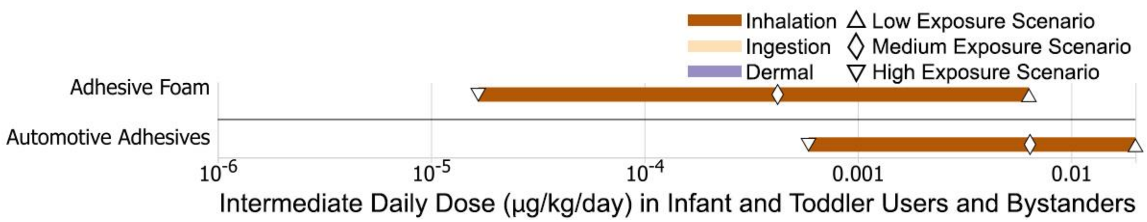

Figure 3-5. Intermediate Dose Rate for DINP from Inhalation Exposure Route in Infants Aged Less Than 1 Year and Toddlers Aged 1 to 2 Years

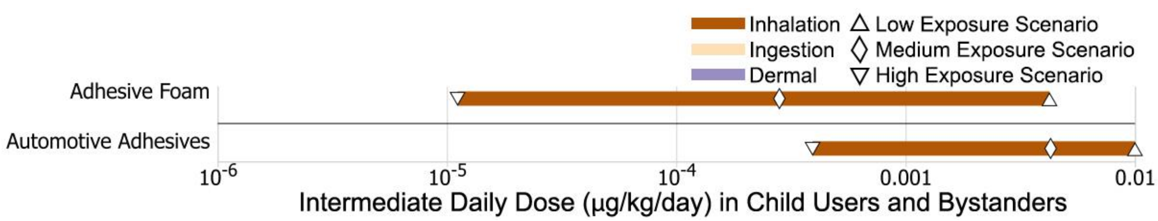

Figure 3-6. Intermediate Dose Rate for DINP from Inhalation Exposure Route in Preschoolers Aged 3 to 5 Years and Middle Childhood Aged 6 to 10 Years

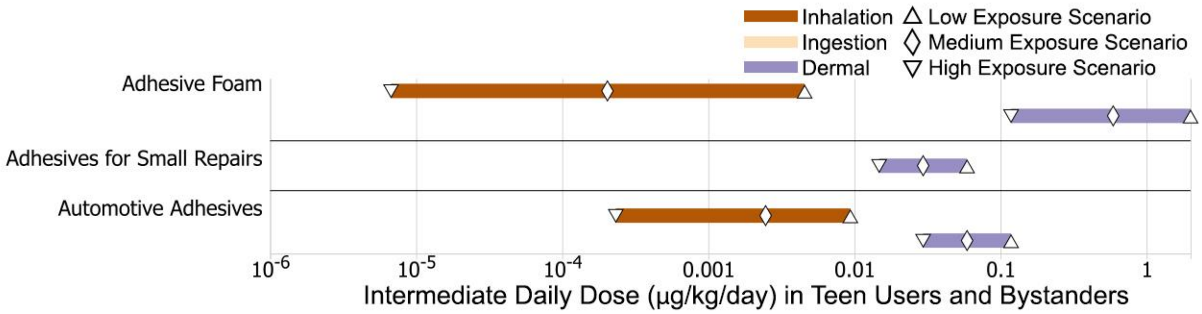

Figure 3-7. Intermediate Dose Rate of DINP from Inhalation, and Dermal Exposure Routes for Young Teens Aged 11 to 15 Years and for Teenagers and Young Adults Aged 16 to 20 Years

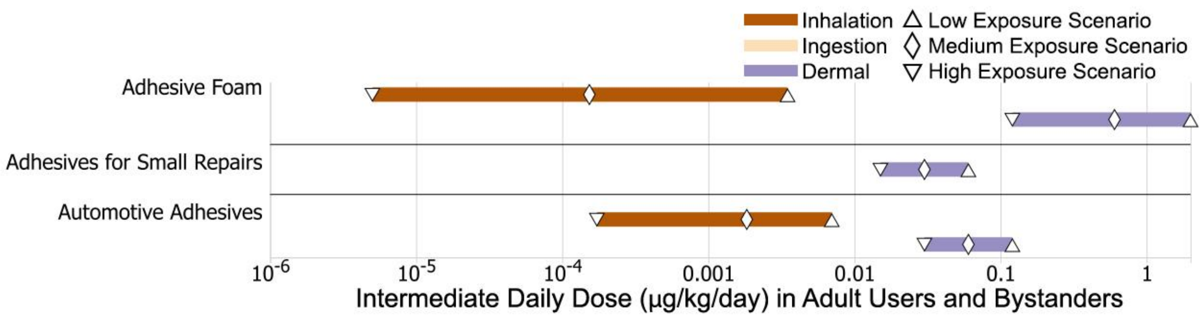

Figure 3-8. Intermediate Dose Rate of DINP from Inhalation, and Dermal Exposure Routes for Adults Older than 21 Years

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

Consumer Risk Calculator for DINP (U.S. EPA, 2025b) summarizes all the high, medium, and low acute dose rate results for all lifestages from CEM modeling for inhalation and ingestion exposures, and computational modeling for all dermal exposures. 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 DINP 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 *DINP Consumer Risk Calculator* (U.S. EPA, 2025b) 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 in this section and includes summary descriptions of the patterns by exposure route and population or lifestage. The following set of figures (Figure 3-9 to Figure 3-12) show chronic average daily dose data for all products and articles modeled in all lifestages. For each lifestage, figures are provided that 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 similar overall data patterns as the acute doses.

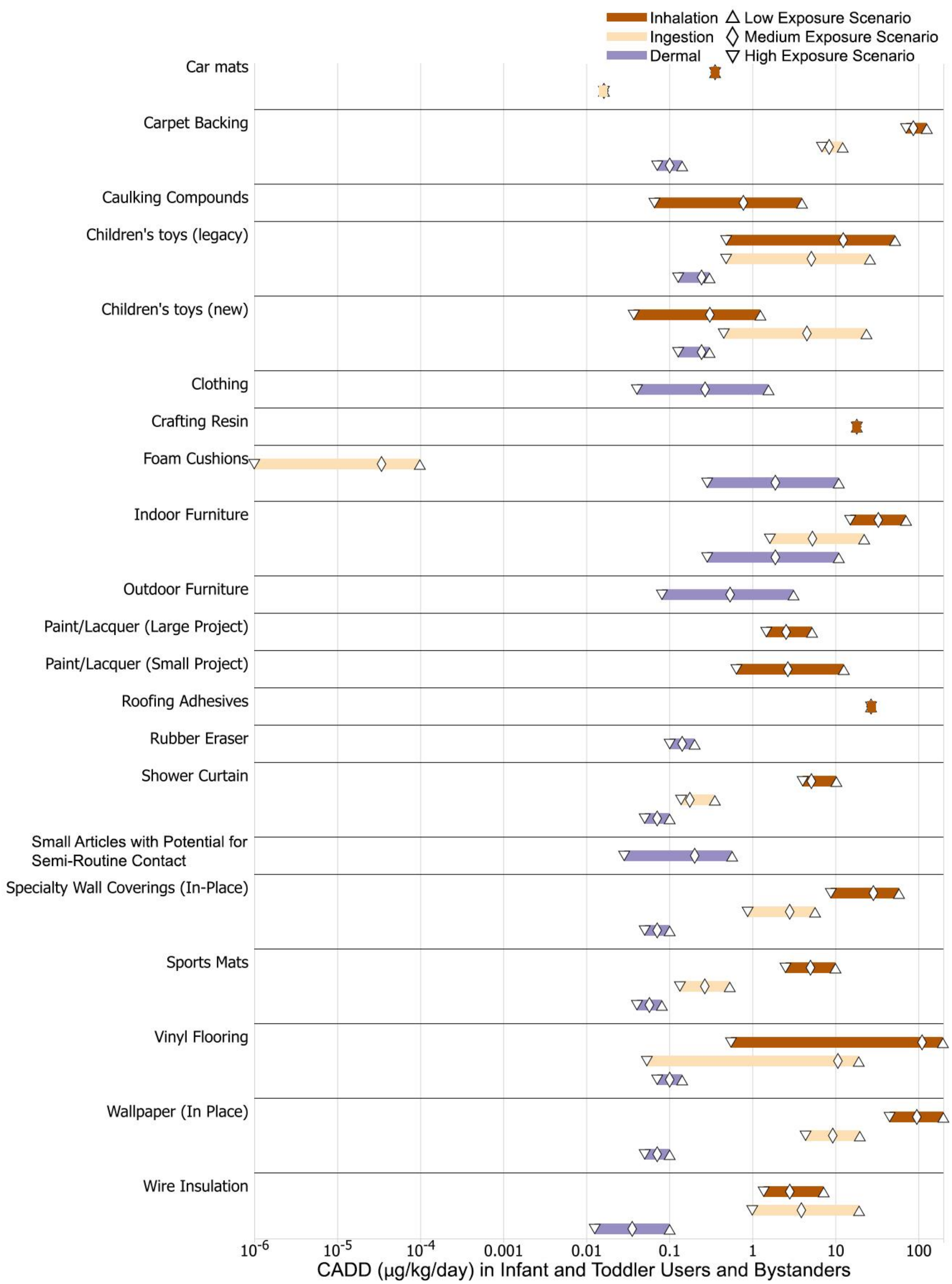

Figure 3-9. Chronic Dose Rate for DINP from Ingestion, Inhalation, Dermal Exposure Routes in Infants Aged Less than 1 Year and Toddlers Aged 1 to 2 Years

Figure 3-10. Chronic Dose Rate of DINP from Ingestion, Inhalation, and Dermal Exposure Routes for Preschoolers Aged 3 to 5 Years and Middle Childhood Aged 6 to 10 Years Old

Figure 3-11. Chronic Dose Rate of DINP from Ingestion, Inhalation, and Dermal Exposure Routes for Young Teens Aged 11 to 15 Years and for Teenagers and Young Adults Aged 16 to 20 Years

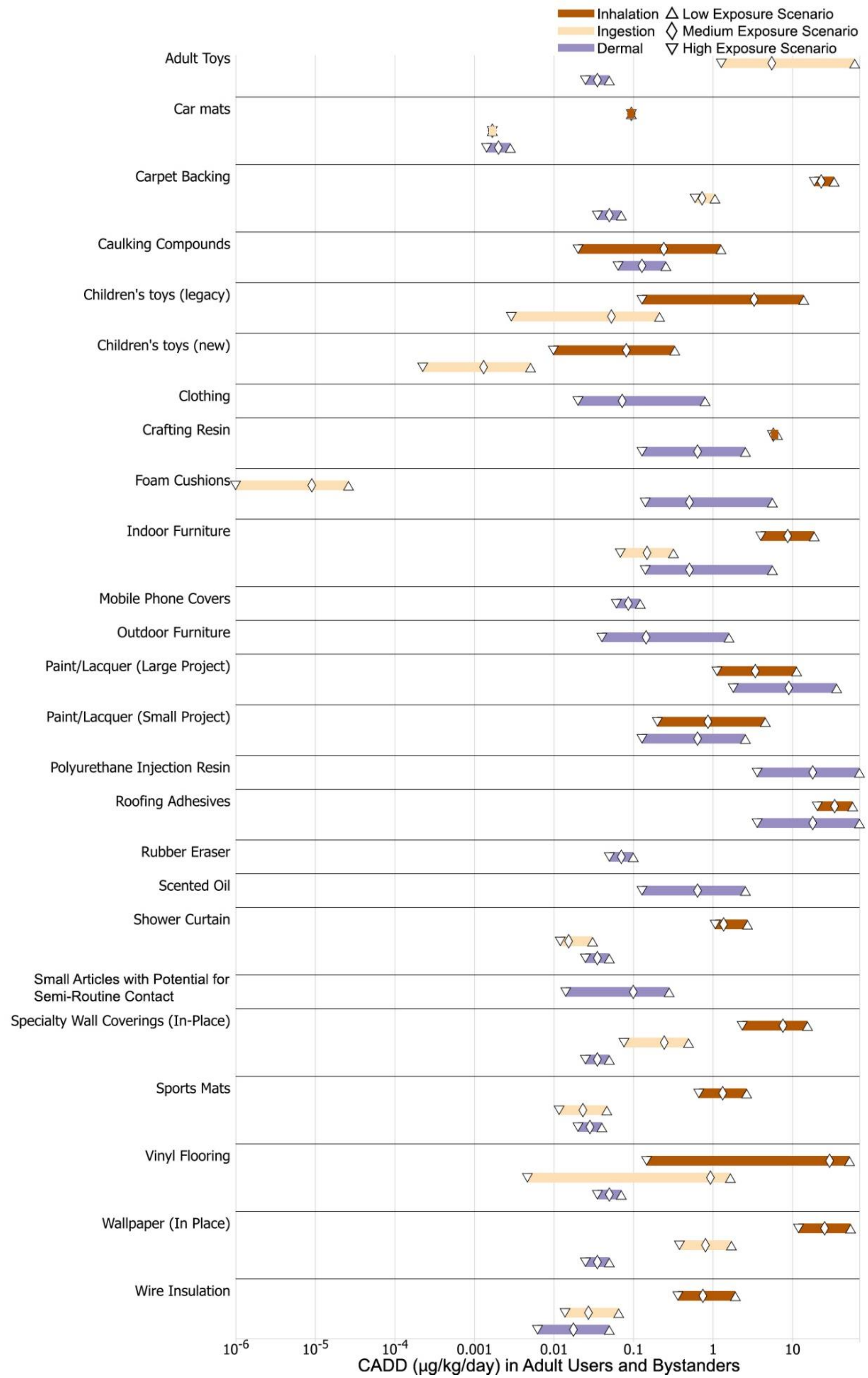

Figure 3-12. Chronic Dose Rate of DINP from Ingestion, Inhalation, and Dermal Exposure Routes in Adults Older than 21 Years

4 INDOOR DUST MODELING AND MONITORING COMPARISON

In this indoor dust exposure assessment, EPA compared modeling and monitoring data. Modeling data used in this comparison originated from the consumer exposure assessment, Table 2-1, to reconstruct major indoor sources of DINP in dust and obtain COU and product specific exposure estimates for ingestion and inhalation of dust. Exposure to DINP via ingestion of dust was assessed for all articles expected to contribute significantly to dust concentrations due to high surface area (exceeding ≈1 m^2) for either a single article or collection of like articles as appropriate. These included

- wallpaper;
- specialty wall coverings;
- wire insulation;
- foam cushions;
- solid vinyl flooring tiles;
- carpet backing tiles;
- indoor furniture;
- car mats;
- shower curtains;
- sporting mats; and
- children's toys, both legacy and new.

These exposure scenarios were modeled in CEM for inhalation, ingestion of suspended dust, and ingestion dust from surfaces. See Section 2.2.3.1 for CEM parameterization, input values, and article specific scenario assumptions and sources and *DINP Consumer Risk Calculator* (U.S. EPA, 2025b) summarizes ingestion of settled dust doses used in this comparison. Other non-residential environments can have these articles, such as daycares, offices, malls, schools, car interiors, and other public indoor spaces. The indoor consumer articles exposure scenarios were modeled with stay-at-home parameters that consider use patterns similar or higher than those in other indoor environments. Therefore, EPA concludes that exposures to similar articles in other indoor environments are included in the residential assessment as a health protective upper bound scenario.

The monitoring data considered are from residential dust samples from U.S.-based studies. Measured DINP concentrations were compared to evaluate consistency among data sets. EPA used three U.S. monitoring studies to generate an estimate of overall DINP exposure from ingestion of indoor dust and performed a monitoring and modelling comparison (Section 4.3). The monitoring studies and assumptions made to estimate exposure are described in Section 4.1.

4.1 Indoor Dust Monitoring Data

Thirty-eight studies were identified as containing measured DINP concentrations in dust during systematic review. Of these, three studies were identified as containing United States data on residential measured DINP concentrations in dust (Hammel et al., 2019; Dodson et al., 2017; Shin et al., 2014). The remaining 35 studies measured DINP dust concentrations in non-residential buildings such as offices, schools, businesses, and day cares, did not present original data, and/or were not conducted in the United States. The studies that contained residential DINP dust monitoring data were compared 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 conducted on broadly representative populations (*i.e.*, not focused on a particular subpopulation).

Of the three studies that were identified as containing United States data on residential measured DINP concentrations, two had small sample sizes and sampled particular subpopulations that were not necessarily broadly representative of the U.S. population. Shin et al. (2014) sampled 30 residences in Northern California, Southeastern Pennsylvania, and Northeastern Maryland from 2009 and 2010. Study participants were women participating in the Early Autism Risk Longitudinal Investigation Study and were mothers who had a child with an autism spectrum disorder and were pregnant with another child at the time of sample collection. The focus of this study was developing SVOC emission rate equations from articles in the home, but dust concentrations for DINP were provided as well. Dodson et al. (2017) collected surface dust wipe samples and air samples from 27 renovated low-income housing apartments in Boston, Massachusetts, between 2013 and 2014. A survey was issued to the tenants with self-reported characteristics including appliance and product use, and samples were taken pre-occupancy and post-renovation. Because both of these studies were conducted on small sample sizes (30 residences or fewer) and sampled non-representative populations, they were not considered for use in developing a consumer exposure assessment for indoor dust ingestion of DINP.

Hammel et al. (2019) was the only U.S. study identifying DINP concentrations in residential dust that was not focused on a subpopulation. This study collected paired house dust, hand wipe, and urine samples from 203 children aged 3 to 6 years from 190 households in Durham, North Carolina, between 2014 and 2016, and additionally analyzed product use and presence of materials in the house. The households were participants in the Newborn Epigenetics Study (NEST), a prospective pregnancy cohort study that was conducted between 2005 and 2011. Participants were re-contacted and invited to participate in a follow-up study on phthalate and SVOC exposure, which was titled the Toddlers' Exposure to SVOCs in the Indoor Environment (TESIE) Study. That study involved home visits conducted between 2014 and 2016. DINP measurements from the Hammel et al. (2019) study are provided in Table 4-1.

Table 4-1. Detection and Quantification of DINP in House Dust from Hammel et al. (2019)

N	Detection Frequency (%)	Method Detection Limit (µg/g) [a]	Median (µg/g)	Minimum (µg/g)	95th Percentile (µg/g)
188	96	0.2	78.8 [b]	ND	787.6 [b]

ND = not detected
[a] In the study, concentrations were provided in units of ng/g, and are rounded to the nearest tenth of a µg/g.
[b] Used in dust ingestion calculations for central tendency (mean) and high-end tendency (95th percentile), see Equation 4-1.

Study participants were instructed to not mop or vacuum their homes at least 2 days prior to the scheduled visit so that dust had time to accumulate. The exposed floor area of the room in which the participant child spent the most time active and awake was vacuumed and dust samples retained for extraction and analysis via GC/MS. Internal standards for house dust reference material (SRM 2585 National Institute of Standards and Technology [NIST]) were used in addition to laboratory blanks for quality control.

4.2 Indoor Dust Monitoring Ingestion Dose Results

To estimate DINP dust ingestion, the mean ingestion from the measured concentrations for residential (homes) in Table 4-1 (footnote b) was used. Studies that did not report means were not used in the calculation and only residential values were used to later compare to modeling results (Section 4.1). The same equation was used to calculate the 95th percentile.

EPA obtained U.S. sources for dust ingestion rate and body weight to conduct allometric exposure estimates. In their study, Özkaynak et al. (2022) parameterized the Stochastic Human Exposure Dose Simulation (SHEDS) Model to estimate dust and soil ingestion for children ages 0 to 21 years 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 DINP intakes in dust (Table 4-2). The geometric mean was used as the measure of central tendency because the distribution of intakes is skewed.

Body weights representative of the U.S. population were taken from the *Exposure Factors Handbook* (U.S. EPA, 2011b). DINP ingestion via dust was calculated according to Equation 4-1 for two scenarios: (1) central tendency (GM dust ingestion, median DINP concentration in dust); and (2) high-end (GM dust ingestion, 95th percentile DINP concentration in dust).

Equation 4-1. Calculation of DINP Intake

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

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 DINP intake for 21 to greater than 80 years (Table 4-3).

Table 4-2. Estimates of DINP Dust Ingestion Per Day from Monitoring, Age 0 to 21 Years

Age Range		0 to <1 Months	1 to <3 Months	3 to <6 Months	6 Months to <1 year	1 to <2 Years	2 to <3 Years	3 to <6 Years	6 to <11 Years	11 to <16 Years	16 to <21 Years
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
DINP Ingestion (µg/kg-day)	Central tendency (78.8 µg DINP/g dust)	0.31	0.28	0.24	0.22	0.16	0.080	0.064	0.032	0.012	0.0039
	High end (787.6 µg DINP/g dust)	3.12	2.80	2.45	2.23	1.59	0.80	0.64	0.32	0.12	0.039

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

Table 4-3. Estimates of DINP Dust Ingestion Per Day from Monitoring, Age 21 to 80+ Years

Age Range		21 to <30 Years	30 to <40 Years	40 to <50 Years	50 to <60 Years	60 to <70 Years	70 to <80 Years	>80 Years
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
Body weight (kg) [b]		78.4	80.8	83.6	83.4	82.6	76.4	68.5
DINP Ingestion (µg/kg-day)	Central tendency (78.8 µg DINP/g dust)	0.0034	0.0033	0.0033	0.0033	0.0033	0.0036	0.0040
	High-end (787.6 µg DINP/g dust)	0.035	0.034	0.033	0.033	0.033	0.036	0.040

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

4.3 Indoor Dust Comparison between Monitoring and Modeling Ingestion Exposure Estimates

The exposure dose estimates for indoor dust from the CEM model are larger than those indicated by the monitoring approach. Table 4-4 compares the sum of the chronic 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 4-4. Comparison between Modeled and Monitored Daily Dust Intake Estimates for DINP

Lifestage	Daily DINP Intake Estimate from Dust, µg/kg-day, Modeled Exposure[a]	Daily DINP Intake Estimate from Dust, µg/kg-day, Monitoring Exposure[b]	Margin of Error (Modeled ÷ Monitoring)
Infant (<1 year)	31.03	0.25[c]	124.1
Toddler (1–2 years)	38.42	0.16	240.2
Preschooler (3–5 years)	43.38	0.080	542.3
Middle Childhood (6–10 years)	15.22	0.064	237.9
Young Teen (11–15 years)	8.52	0.032	266.4
Teenager (16–20 years)	6.76	0.012	563.5
Adult (21+ years)	3.03	0.0034[d]	990.0

[a] Sum of chronic 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 21–80 years

The sum of DINP 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 124 times in infants less than 1 year old, to a high of 990 times in adults 21 years and older. These discrepancies partially stem from differences in the exposure assumptions of the CEM model vs. 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. Another source of the margin between the two approaches is the assumption that the sum of the indoor dust sources in the CEM modeled scenario is representative of items found in typical indoor residences. It is likely that individual residences have varying assortments and amounts of the products and articles that are sources of DINP, resulting in lower and higher exposures.

In the indoor dust modeling assessment, EPA reconstructed the scenario using consumer articles as the source of DINP 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 DINP 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 DINP 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 DINP-containing dust. The use of a weighted dust concentration can also introduce discrepancies between monitoring and modeling results.

5 WEIGHT OF SCIENTIFIC EVIDENCE

5.1 Consumer Exposure Analysis Weight of the 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. 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.

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 DINP 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 the 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 the 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. Table 5-1 summarizes the overall uncertainty per COU, and a discussion of rationale used to assign the overall uncertainty. The subsections ahead of the table describe sources of uncertainty for several parameters used in consumer exposure modeling that apply across COUs and provide an in depth understanding of sources of uncertainty and limitations and strengths within the analysis. The confidence to use the results for risk characterization ranges from moderate to robust, see Table 5-1. The basis for the moderate to robust confidence in the overall exposure estimates is a balance between using parameters that represent various populations, use patterns, and lean on protective assumptions that are not outliers, 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 sometimes limited for weight fractions of DINP in consumer goods. EPA obtained DINP weight fractions in various products and articles from material safety sheets, data bases, and existing literature (Section 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. EPA decreased uncertainty in exposure and subsequent risk estimates in the high, medium, and low intensity use scenarios by capturing the weight fraction variability and obtaining a better characterization of the products and articles varying composition within one COU. Overall weight fraction confidence is *moderate* for products/articles with only one source and *robust* for products/articles with more than one source. *Slight* confidence is assigned to products and articles that source generically identifies products and articles without specific descriptions of uses and targeted age groups or when is unclear if the reported concentration is a total phthalate or DINP specific, like for wallpaper, erasers, and wire insulation.

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. EPA decreased uncertainty by selecting use pattern inputs that represent product and article use descriptions and furthermore capture the range of possible use patterns in the high to low intensity use scenarios. Exposure and risk estimates are considered representative of product use patterns and well characterized. Most use patterns overall confidence is rated *robust*.

Article Surface Area

The surface area of an article directly affects the potential for DINP emissions to the environment. For each article modeled for inhalation exposure, low, medium, and high estimates for surface area were calculated (Section 2.2.3.1). This approach relied on manufacturer-provided dimensions where possible, or values from EPA's *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 for multiple items of the same type were calculated for surface area. Overall confidence in surface area is *moderate* for articles like wires because there is less understanding of the number of wires exposed to collect dust and the great variability that is expected may not be well represented. Overall confidence in surface area is *robust* for articles like furniture, wall coverings, flooring, toys, and shower curtains because there is a good understanding of the presence and dimensions in indoor environments.

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 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 for 15-minute sessions, for a total of 20 sessions (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 to 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 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 to 4.4 minutes per day for other soft plastic objects (excluding 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 DINP.

Modeling Tool

Confidence in the model used considers whether the model has been peer reviewed, as well as whether it is being applied in a manner appropriate to its design and objective. For example, the model used (CEM 3.2) has been peer reviewed (ERG, 2016), is publicly available, and has been applied in a manner intended by estimating exposures associated with uses of household products and/or articles. This also considers the default values data source(s) such as building and room volumes, interzonal ventilation rates, and air exchange rates. Overall confidence in the proper use of CEM for consumer exposure modeling is *robust*.

Dermal Modeling for DINP

Experimental dermal data was identified via the systematic review process to characterize consumer dermal exposures to liquids or mixtures and formulations containing DINP, see Section 2.3.1. EPA has moderate understanding of the scientific evidence and the uncertainties, the supporting scientific evidence against the uncertainties is reasonably adequate to characterize exposure estimates. The confidence in dermal exposure to liquid products model used in this assessment is *moderate*.

EPA identified only one set of experimental data related to the dermal absorption of neat DINP (Midwest Research Institute, 1983). 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. For example, rat skin was up to 30 times more permeable than human skin for DEP, and rat skin was up to 4 times more permeable than human skin for DEHP. Although there is uncertainty regarding the magnitude of difference between dermal absorption through rat skin vs. human skin for DINP, EPA is confident that the *in vivo* dermal absorption data using male F344 rats (Midwest Research Institute, 1983) provides an upper bound of dermal absorption of DINP based on the findings of Scott (1987).

Another source of uncertainty regarding the dermal absorption of DINP from products or formulations stems from the varying concentrations and co-formulants that exist in products or formulations containing DINP. For purposes of this risk evaluation, EPA assumed that the absorptive flux of neat DINP 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 DINP 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 lower concentrations of DINP might exhibit lower rates of flux because 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 DINP would result in decreased or increased dermal absorption. Based on the available dermal absorption data for DINP, EPA has made assumptions that result in exposure assessments that are the most human health protective in nature.

Experimental dermal data were not identified via the systematic review process to estimate dermal exposures to solid products or articles containing DINP and a modeling approach was used to estimate exposures, see Section 2.3.2. EPA has a *slight* confidence in the dermal exposure to solid products or articles modeling approach.

Lastly, EPA notes that there is uncertainty with respect to the modeling of dermal absorption of DINP from solid matrices or articles. Because there were no available data related to the dermal absorption of DINP from solid matrices or articles, EPA has assumed that dermal absorption of DINP from solid objects would be limited by aqueous solubility of DINP. Therefore, to determine the maximum steady-state aqueous flux of DINP, the Agency utilized the CEM (U.S. EPA, 2023) to first estimate the steady-state aqueous permeability coefficient of DINP. The estimation of the steady-state aqueous permeability coefficient within CEM (U.S. EPA, 2023) 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 DINP falls within the range suggested by ten Berge (2009), but the log(K_{OW}) of DINP 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 DINP.

Modeling Parameters for DINP Chemical Migration

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 it may also differ even among similar items due to variations in chemical makeup and polymer structure. As such, an effort was made to choose DINP 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 DINP. The 2003 EU Risk Assessment for DINP used a migration rate of 53.4 µg/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, 2003; RIVM, 1998). The RIVM study measured DINP in saliva of 20 adult volunteers biting and sucking 4 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 µg/cm^2/h, with considerable variability in the results. In a more recent report, ECHA compiled and evaluated new evidence on human exposure to DINP, including chemical migration rates (ECHA, 2013). They concluded that chemical migration rate of 14 µg/cm^2/h was likely to be representative of a “typical mouthing scenario” and a migration rate of 45 µg/cm^2/h was a reasonable worst-case estimate of this parameter. The “typical” value was determined by compiling *in vivo* migration rate data from existing studies (Niino et al., 2003; Sugita et al., 2003; Fiala et al., 2000; Meuling et al., 2000; Chen, 1998; RIVM, 1998). 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 DINP weight fractions for products tested in mouthing studies skew heavily towards relatively high weight fractions (30–60%) and measurements for weight fractions less than 15 percent are very rarely represented in the data set. Thus, it is unclear whether these migration rate values are applicable to consumer goods with low (<15%) weight fractions of DINP, 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 DINP to saliva, the range of values used in this assessment (1.6, 13.3, and 44.8 µg/cm^2/h) are considered likely to capture the true value of the parameter.

Table 5-1. Weight of Scientific Evidence Summary Per Consumer COU

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
Construction, paint, electrical, and metal products; Adhesives and sealants	Six different scenarios were assessed under this COU for products with differing use patterns for which each scenario had varying number of identified product examples (in parenthesis): adhesives for small repairs (2), adhesive foam (1), automotive adhesives (4), caulking compounds (5), polyurethane injection resin (1), and roofing adhesives (2). The six scenarios and the products within capture the variability in product formulation in the high, medium, and low intensity use estimates. The modeling input for roofing adhesives chronic duration events per year was selected as an extremely conservative input for the screening approach used in this assessment, while other inputs are considered representative. The chronic inhalation and dermal events per year input result in a low confidence for roofing adhesives scenarios and the overall confidence in this inhalation and dermal scenario is moderate because there is a relatively good understanding of the overestimation from using 365 events per year for the chronic duration. The overall confidence in this COU inhalation exposure estimate for the other products is robust because the CEM default parameters represent actual use patterns and location of use. For dermal exposure EPA used a dermal flux approach, which was estimated based on DINP *in vivo* dermal absorption in rats. An overall moderate confidence in dermal assessment of adhesives was assigned. Uncertainties about the difference between human and rat skin absorption increase uncertainty. However, other parameters like frequency and duration of use, and surface area in contact are well understood and representative.	Inhalation for adhesives for small repairs, adhesive foam, automotive adhesives, caulking compounds, polyurethane injection resin – Robust Inhalation for roofing adhesives – Moderate Dermal – Moderate
Construction, paint, electrical, and metal products; Building construction materials (wire and cable jacketing, wall coverings, roofing, pool applications, water supply piping, etc.)	Two different scenarios were assessed under this COU for four articles with differing use patterns for which each scenario had varying number of identified article examples (in parenthesis): roofing membranes (1) and electrical tape, spline (4). Of these two scenarios roofing membranes were assessed for dermal exposures only because outdoor inhalation and ingestion would have low exposure potential. When available more than one article input parameters capture the variability in product formulations in the high, medium, and low intensity use estimates. The overall confidence in this COU inhalation and dust ingestion exposure estimate is moderate because although the CEM default parameters represent actual use patterns and location of use. Dermal absorption estimate based on the assumption that dermal absorption of DINP from solid objects would be limited by aqueous solubility of DINP. EPA has slight confidence for solid objects because the high uncertainty in the assumption of partitioning form solid to liquid and subsequent dermal absorption is not well characterized. However, other parameters like frequency and duration of use, and surface area in contact are well understood and representative, making the overall confidence of moderate in a health protective estimate.	Inhalation, dust ingestion, and dermal – Moderate
Construction, paint, electrical, and metal products; Electrical and electronic products	One article was identified for this COU, wire insulation. Inhalation, dust ingestion, mouthing, and dermal exposures were assessed for this article. Inhalation and ingestion of dust scenarios were built to represent indoor presence of this article and therefore this scenario is an aggregate assessment of multiple wire insulations, while mouthing and dermal exposures can only be assessed for the contact area with the article and the frequency and duration of the contact. The weight fraction data used had a large range resulting in higher variability due to changing formulation approaches. The high, medium, and low intensity use scenarios capture the high variability in article formulation. The overall confidence in this COU inhalation and dust ingestion exposure estimate is moderate. Although CEM default parameters are expected to be representative of the use patterns and location of use there are larger uncertainties in the aggregated surface area used. In addition, for dermal and	Inhalation, dust ingestion, mouthing, and dermal – Moderate

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
	mouthing the overall confidence is also moderate from uncertainties from the solid article to dermal and saliva migration approaches and frequency and durations of the exposure.	
Construction, paint, electrical, and metal products; Paints and coatings	Two different scenarios were assessed under this COU for products with differing use patterns for which each scenario had varying number of identified product examples (in parenthesis): paint/lacquer (large project) (1) and paint/lacquer (small project) (2). The two scenarios and the products within capture the variability in product formulation in the high, medium, and low intensity use estimates. The overall confidence in this COU inhalation exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use. For dermal exposure EPA used a dermal flux approach, which was estimated based on DINP *in vivo* dermal absorption in rats. An overall moderate confidence in dermal assessment of adhesives was assigned. Uncertainties about the difference between human and rat skin absorption increase uncertainty. However, other parameters like frequency and duration of use, and surface area in contact are well understood and representative.	Inhalation – Robust Dermal – Moderate
Foam seating and bedding products; furniture and furnishings (furniture and furnishings including plastic articles (soft); leather articles)	Four different scenarios were assessed under this COU for various articles with differing use patterns for which each scenario had varying number of identified article examples (in parenthesis): foam cushions (1), indoor furniture (2), outdoor furniture (1), and truck awnings (1). The outdoor furniture and truck awnings were assessed for dermal exposure only because outdoor inhalation and ingestion would have low exposure potential. Foam cushions and indoor furniture scenarios estimated inhalation, ingestion, and dermal exposures. Foam cushions and indoor furniture scenarios capture potential exposures to their presence in indoor environments. The articles input parameters capture the variability in product formulations and possible surface area present in indoor environments in the high, medium, and low intensity use estimates. The overall confidence in this COU inhalation and dust ingestion exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use, and the estimated surface area for foam cushions and furniture is well characterized and representative of indoor furniture dimensions. Migration of DINP from product to saliva approach has an overall confidence of moderate due to uncertainties from article formulation differences, but the mouthing parameters and durations are well characterized, resulting in an overall moderate confidence for a health protective estimate. Dermal absorption estimate based on the assumption that dermal absorption of DINP from solid objects would be limited by aqueous solubility of DINP. EPA has slight confidence for solid objects because the high uncertainty in the assumption of partitioning form solid to liquid and subsequent dermal absorption is not well characterized. However, other parameters like frequency and duration of use, and surface area in contact are well understood and representative, making the overall confidence of moderate in a health protective estimate.	Inhalation and dust ingestion – Robust Dermal – Moderate
Furnishing, cleaning, treatment/care products; Floor coverings / Plasticizer in construction and building materials covering large surface areas including stone, plaster, cement, glass, and ceramic articles;	Four different scenarios were assessed under this COU for various articles with differing use patterns for which each scenario had varying number of identified article examples (in parenthesis): carpet backing (3), vinyl tiles (flooring) (4), specialty wall coverings (3), wallpaper (1). These four scenarios were assessed for dermal, inhalation, and dust ingestion exposures. These articles capture potential dust inhalation and ingestion in indoor environments. The articles input parameters capture the variability in product formulations and possible surface area present in indoor environments in the high, medium, and low	Inhalation and Dust Ingestion – Robust Dermal – Moderate

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
fabrics, textiles, and apparel (vinyl tiles, resilient flooring, PVC-backed carpeting)	intensity use estimates. The overall confidence in this COU inhalation and dust ingestion exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use and the estimated surface area is well characterized and represents a wide range of plausible uses. Dermal absorption estimate based on the assumption that dermal absorption of DINP from solid objects would be limited by aqueous solubility of DINP. EPA has slight confidence for solid objects because the high uncertainty in the assumption of partitioning form solid to liquid and subsequent dermal absorption is not well characterized. However, other parameters like frequency and duration of use, and surface area in contact are well understood and representative, making the overall confidence of moderate in a health protective estimate.	
Furnishing, cleaning, treatment/care products; Air care products	Two different scenarios were assessed under this COU for one product, scented oil with differing use patterns: scented oil DIY and scented oil in homemade burning candle. The two scenarios capture the variability in product formulation in the high, medium, and low intensity use estimates. The overall confidence in this COU inhalation exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use. Dermal absorption estimate based on the assumption that dermal absorption of DINP from solid objects would be limited by aqueous solubility of DINP. EPA has slight confidence for solid objects because the high uncertainty in the assumption of partitioning form solid to liquid and subsequent dermal absorption is not well characterized. However, other parameters like frequency and duration of use, and surface area in contact are well understood and representative, making the overall confidence of moderate in a health protective estimate.	Inhalation – Robust Dermal – Moderate
Furnishing, cleaning, treatment/care products; Fabric, textile, and leather products (apparel and footwear care products)	Two different scenarios were assessed under this COU for various articles with differing use patterns for which each scenario had varying number of identified article examples (in parenthesis): clothing (2) and small articles with potential for routine contact (4). These two scenarios were assessed for dermal exposures. Dermal absorption estimate based on the assumption that dermal absorption of DINP from solid objects would be limited by aqueous solubility of DINP. 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. However, other parameters like frequency and duration of use, and surface area in contact are well understood and representative, making the overall confidence in a health protective estimate moderate.	Dermal – Moderate
Packaging, paper, plastic, hobby products; Arts, crafts, and hobby materials	Three different scenarios were assessed under this COU for various products with differing use patterns for which each scenario had varying number of identified product examples (in parenthesis): rubber eraser (2), crafting resin (4), and hobby cutting board (1). The hobby cutting board was assessed for dermal contact only because inhalation and ingestion would have low exposure potential for such small surface area product. The scenarios for crafting resin and rubber eraser and the products within capture the variability in product formulation in the high, medium, and low intensity use estimates. The overall confidence in this COU inhalation exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use. For dermal exposure EPA used a dermal flux approach, which was estimated based on DINP *in vivo* dermal absorption in rats. An overall moderate confidence in dermal assessment of adhesives was assigned. Uncertainties about the difference between human and rat skin absorption increase	Inhalation and ingestion – Robust Dermal – Moderate

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
	uncertainty. However, other parameters like frequency and duration of use, and surface area in contact are well understood and representative.	
Packaging, paper, plastic, hobby products; Ink, toner, and colorant products	See Construction, paint, electrical, and metal products; Paints and coatings COU. Current products were not identified. Foreseeable uses were matched with the lacquers, and paints (small and large projects) because similar use patterns are expected.	Inhalation – Robust Dermal – Moderate
Packaging, paper, plastic, hobby products; Other articles with routine direct contact during normal use including rubber articles; Plastic articles (hard); vinyl tape; flexible tubes; profiles; hoses	Two different scenarios were assessed under this COU for various products and articles with differing use patterns for which each scenario had varying number of identified examples (in parenthesis): shower curtains (1) and small articles with potential for semi-routine contact (5). The small articles with potential for semi-routine contact was assessed for dermal contact only because inhalation and ingestion would have low exposure potential for such small surface area products. The scenario for shower curtains is an indoor exposure assessment and it captures possible variability in product formulation in the high, medium, and low intensity use estimates. The overall confidence in this indoor COU inhalation and dust ingestion exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use. Dermal absorption estimate based on the assumption that dermal absorption of DINP from solid objects would be limited by aqueous solubility of DINP. EPA has slight confidence for solid objects because the high uncertainty in the assumption of partitioning form solid to liquid and subsequent dermal absorption is not well characterized. However, other parameters like frequency and duration of use, and surface area in contact are well understood and representative, making the overall confidence of moderate in a health protective estimate.	Inhalation and ingestion – Robust Dermal – Moderate
Packaging, paper, plastic, hobby products; Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	One scenario was built for this COU for PVC soap packaging. This scenario was assessed for dermal only as inhalation and dust ingestion is unlikely for to be significant for the surface area of this article. Dermal absorption estimate based on the assumption that dermal absorption of DINP from solid objects would be limited by aqueous solubility of DINP. 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. However, other parameters like frequency and duration of use, and surface area in contact are well understood and representative, making the overall confidence in a health protective estimate moderate.	Dermal – Moderate
Packaging, paper, plastic, hobby products; Toys, playground, and sporting equipment	Three different scenarios were assessed under this COU for various articles with differing use patterns: sports mats, legacy and non-compliant children's toys, and new children's toys. Inhalation, dust ingestion, mouthing, and dermal were assessed for all three scenarios with varying use patterns and inputs. The high, medium, and low intensity scenarios capture variability and provide a range of representative use patterns. The overall confidence in this COU inhalation and dust ingestion exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use. The overall confidence in this COU mouthing and dermal exposure assessment is robust. The mouthing parameters used like duration and surface area for infants to children are very well understood, while older groups have less specific information because mouthing behavior is not expected. The chemical migration value is DINP specific and only source of uncertainty are related to article formulation and chemical migration dynamics, which may not be very well characterized, but by assessing high, medium, and low intensity scenarios EPA captures that source of uncertainty and increases confidence in the estimates by using representative scenarios.	Inhalation, dust ingestion, and mouthing – Robust Dermal – Moderate

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
	Dermal absorption estimate based on the assumption that dermal absorption of DINP from solid objects would be limited by aqueous solubility of DINP. EPA has slight confidence for solid objects because the high uncertainty in the assumption of partitioning form solid to liquid and subsequent dermal absorption is not well characterized. However, other parameters like frequency and duration of use, and surface area in contact are well understood and representative, making the overall confidence of moderate in a health protective estimate.	
Other; Novelty articles	One scenario was built for this COU for adult toys. This scenario was assessed for dermal only as inhalation and dust ingestion is unlikely for to be significant for the surface area of this article. Dermal absorption estimate based on the assumption that dermal absorption of DINP from solid objects would be limited by aqueous solubility of DINP. 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. However, other parameters like frequency and duration of use, and surface area in contact are well understood and representative, making the overall confidence in a health protective estimate moderate.	Dermal – Moderate
Other; Automotive articles	This COU was assessed with one indoor scenario for one type of article. The scenario for car mats captures variability in product formulation in the high, medium, and low intensity use estimates. The overall confidence in this indoor COU inhalation and dust ingestion exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use. Dermal absorption estimate based on the assumption that dermal absorption of DINP from solid objects would be limited by aqueous solubility of DINP. EPA has slight confidence for solid objects because the high uncertainty in the assumption of partitioning form solid to liquid and subsequent dermal absorption is not well characterized. However, other parameters like frequency and duration of use, and surface area in contact are well understood and representative, making the overall confidence of moderate in a health protective estimate.	Inhalation and ingestion – Robust Dermal – Moderate

5.2 Indoor Dust Monitoring Weight of the Scientific Evidence

The weight of scientific evidence for the indoor dust exposure assessment of DINP (Table 5-2**)** is dependent on studies that include indoor residential dust monitoring data (Table 4-1). Only studies that included indoor dust samples taken from residences were included for data extraction. In the case of DINP, three studies were identified as containing data on residences in the United States. Of these three, one study was selected for use in the indoor dust monitoring assessment as described in Section 4.1 (Hammel et al., 2019). This study was rated "High" quality per the exposure systematic review criteria.

Table 5-2. 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	Robust	Robust	Moderate	Robust

[a] Hammel et al. (2019)
[b] U.S. EPA (2011b)
[c] Özkaynak et al. (2022)

Table 5-2 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 DINP dust monitoring data themselves, the estimates of U.S. body weights, and the estimates of dust ingestion rates, according to the following rubric:

- Robust confidence means the supporting weight of the 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 needs 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.

Monitoring data conducted in the United States was identified for DINP, from the TESIE Study conducted between 2014 and 2016 (Hammel et al., 2019). This study sampled 190 residences in Durham, North Carolina, and included vacuum dust sampling as well as hand wipes and urine samples. Households were selected from participants in the Newborn Epigenetics Study, which is a prospective pregnancy cohort that began in 2005 and recruited pregnant women who received services at Duke University obstetrics facilities. While these facilities are associated with a teaching hospital and university, services are not restricted to students, and the demographic characteristics of the TESIE study population match those of the Durham community (see Table 1 in Hammel et al. (2019)). Because that study carefully selected participants to avoid oversampling subpopulations and investigated a relatively large number of residences for a study of this type, and because EPA identified no reason to believe that households in the study location (Durham, North Carolina) would represent an outlier population that would not adequately represent the consumer practices of the broader U.S. public, EPA has assigned robust confidence to our use of this model input.

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 National Health and Nutrition Examination Survey (NHANES) dataset, EPA has assigned robust confidence to the 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 5-3). 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 5-4). 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 Figure 4 of Özkaynak et al. (2022), non-tracer studies align much more closely with the dust ingestion rates used in this analysis. 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 robust confidence in the DINP concentration monitoring data in indoor residential dust from Hammel et al. (2019), 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 robust confidence in our estimates of daily DINP 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 DINP Concentrations in Indoor Dust

The DINP concentrations in indoor dust were derived from Hammel et al. (2019). In this study, 190 households from the TESIE study conducted between 2014 and 2016 in Durham, North Carolina, were vacuum sampled for indoor residential dust. Study participants were recruited from participants in an existing pregnancy cohort study, and the demographics of the study population matched those of the Durham population. Residents were asked to refrain from vacuuming or otherwise cleaning hard surfaces within the home for 2 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 a single room in each home, which was identified as the room in which the child(ren) residing in the home spent the most time. The study identifies these rooms as typically playrooms or living rooms. A key assumption made in this analysis is that dust concentrations in playrooms and living rooms are representative of those in the remainder of the home.

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 1999-2006 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 12–19 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 4-2 and Table 4-3 and were averaged by sex.

5.2.1.3 Assumptions for Dust Ingestion Rates

To estimate daily intake of DINP in residential indoor dust, a daily rate of dust ingestion is required. EPA used rates from Özkaynak et al. (2022) that 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 5-3 and the statistical distributions chosen are reproduced in detail in the supplemental material for Özkaynak et al. (2022).

Table 5-3. 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/h	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)
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

Variable	Description	Units	Source
F_blanket[b]	Protective barrier factor of blanket when used	–	Professional judgment
Pacifier_size[b]	Area of pacifier surface	–	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			

5.2.1 Uncertainties in Estimating Intakes from Monitoring Data

5.2.1.1 Uncertainties for Monitored DINP Concentrations in Indoor Dust

Indoor dust concentrations were derived from Hammel et al. (2019) that sampled residential house dust in 190 households in Durham, North Carolina, from a population selected from an existing pregnancy cohort study. It is possible that sampling biases were introduced by the choice of study location, by the choice to include only households that contain children, and by differences among the households that chose to participate in the study. Differences in consumer behaviors, housing type and quality, tidiness, and other variables that affect DINP concentrations in household dust are possible between participating households and the general population.

5.2.1.2 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) that may lead to an underestimate of body weight in this analysis. This would lead to an overestimate of DINP dose per unit body weight, because actual body weights in the U.S. population may be larger than those assumed in this analysis.

5.2.1.3 Uncertainties for Dust Ingestion Rates

Dust ingestion rates were obtained from Özkaynak et al. (2022) that uses mechanistic methods (the SHEDS model) to estimate dust ingestion using a range of parameters (Table 5-3). 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 5-4).

Table 5-4. Comparison between Özkaynak et al. 2022 and *Exposure Factors Handbook* Dust Ingestion Rates

Age Range		0 to <1 Month	1 to <3 Months	3 to <6 Months	6 Months to <1 Year	1 to <2 Years	2 to-<3 Years	3 to <6 Years	6 to <11 Years	11 to <16 Years	16 to <21 Years
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 EPA's *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 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).

5.2.1.4 Uncertainties in Interpretation of Monitored DINP 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 DINP that included non-TSCA COUs.
- None of the identified monitoring data contained source apportionment information that could be used to determine the fraction of DINP in dust samples that resulted from a particular TSCA or non-TSCA COU. Therefore, these monitoring data represent background concentrations of DINP 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 vs. 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 CONCLUSION 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 DINP in dust resulting from all sources present in a home. Although 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 and include a consideration of dust collected on the surface of a relatively large area (*e.g.*, flooring, furniture, wallpaper), but also multiple toys and wires collecting dust with DINP and subsequent inhalation and ingestion.

Given the wide discrepancies between monitoring and modeling of DINP in indoor dust, EPA concluded that there is too much uncertainty in this analysis to support derivation of risk estimates for aggregate indoor dust exposure. Despite the robust 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 DINP exposure estimates were health protective relative to residential monitored exposures (Table 4-4). This comparison was a key input to our robust confidence in the overall health protectiveness of our exposure assessment for ingestion of DINP in indoor dust. The individual COU scenarios had a moderate to robust confidence in the exposure dose results and protectiveness of parameters used. Thus, the COU scenarios of the articles used in the indoor assessment were utilized in risk estimates calculations.

Consumer

All COU exposure dose results summarized in Section 3 and *DINP Consumer Risk Calculator* (U.S. EPA, 2025b) have a moderate to robust confidence and therefore 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 that 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 DINP from products/articles to sweat and skin. Low and medium exposure scenarios represent less intensity in use patterns, mouthing behaviors, and conditions that promote DINP migration to sweat and skin, capturing populations with different lifestyles.

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Appendix A ACUTE, CHRONIC, AND INTERMEDIATE DOSE RATE EQUATIONS

The equations provided in this section were taken from the CEM User Guide and associated appendices.

A.1 Acute Dose Rate

Acute dose rate for inhalation of product used in an environment (CEM P_INH1 model), such as indoor, outdoor, living room, garage, kitchen, bathroom, office, etc. was calculated as follows:

Equation_Apx A-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 DINP in air (mg/m^3)
Inh	=	Inhalation rate (m^3/h)
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/h)

For the ADR calculations, an averaging time of 1 day is used. 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. Therefore, in this case, the ADR represents the maximum time-integrated dose over a 24-hour period during the exposure event. CEM calculates ADRs for each possible 24-hour period over the 60-day modeling period (*i.e.*, averaging of hours 1–24, 2–25, 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, where the term "environment" refers to any indoor and outdoor location, such as garage, kitchen, bathroom, living room, car interior, daycare, school room, office, backyard and so on:

Equation_Apx A-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_Apx A-3. Acute Dose Rate for Inhalation from Article Placed in Environment in Particulate

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

Equation_Apx A-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)
$DINPRP_{air\_max}$	=	Maximum DINP 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/h)
CF_1	=	Conversion factor (24 h/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_Apx A-5. Acute Dose Rate from Ingestion after Inhalation

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

Where:

ADR_{IAI}	=	Acute Dose Rate from ingestion and inhalation (mg/kg-day)
$DINPRP_{air\_max}$	=	Maximum DINP in respirable particles (RP) concentration, air (µg/mg)
RP_{air_max}	=	Maximum RP concentration, air (mg/m^3)
IF_{TSP}	=	RP ingestion fraction (unitless)
$DINPDust_{air\_max}$	=	Maximum DINP in dust concentration, air (µg/mg)
$Dust_{air\_max}$	=	Maximum dust concentration, air (mg/m^3)
IF_{Dust}	=	Dust ingestion fraction (unitless)
$DINPAbr_{air\_avg}$	=	Maximum DINP 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/h)
CF_1	=	Conversion factor (24 h/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_Apx A-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/h)
CA	=	Contact area of mouthing (cm^2)
D_m	=	Duration of mouthing (min/h)
ED_{ac}	=	Exposure duration, acute (days)
CF_1	=	Conversion factor (24 h/day)

BW	=	Body weight (kg)
AT_{ac}	=	Averaging time, acute (days)
CF_2	=	Conversion factor (60 min/h)

See Section 2.2.3.1 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 DINP 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 DINP 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 DINP-containing dust. The model uses a weighted dust concentration, shown in the equations below.

Equation_Apx A-7. Acute Dust Concentration

$$Dust_{ac\_wgt} = \frac{(RP_{floor\_max} \times DINPRP_{floor\_max}) + (Dust_{floor\_max} \times DINPDust_{floor\_max}) + (AbArt_{floor\_max} \times DINPAbArt_{floor\_max})}{(TSP_{floor\_max} + Dust_{floor\_max} + AbArt_{floor\_max})}$$

Where:

$Dust_{ac\_wgt}$	=	Acute weighted dust concentration (µg/mg)
RP_{floor_max}	=	Maximum RP mass, floor (mg)
$DINPRP_{floor\_max}$	=	Maximum DINP in RP concentration, floor (µg/mg)
$Dust_{floor\_max}$	=	Maximum dust mass, floor (mg)
$DINPDust_{floor\_max}$	=	Maximum DINP in dust concentration, floor (µg/mg)
$AbArt_{floor\_max}$	=	Maximum abraded particles mass, floor (mg)
$DINPAbArt_{floor\_max}$	=	Maximum floor dust DINP concentration (µg/mg)

Equation_Apx A-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 DINP can volatilize from the DINP-containing article to the air and then partition to dust. Alternately, DINP 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 DINP 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_Apx A-9. Concentration of DINP in Dust

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

Where:

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

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

Equation_Apx A-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 DINP 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_Apx A-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.

A.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_Apx A-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/h)
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/h)

CEM uses two defaults inhalation rates which trace to the *Exposure Factors Handbook* (see Table_Apx A-1), one when the person is using the product and another after the use has ended. Table_Apx A-1 also shows the inhalation rates by age category for during and after product use.

Table_Apx A-1. Inhalation Rates Used in CEM Product Models

Age Group	Inhalation Rate During Use (m^3/h)[a]	Inhalation Rate After Use (m^3/h)[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] See Table 6-2, light intensity values (U.S. EPA, 2011a)
[b] See 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_Apx A-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_Apx A-14. Chronic Average Daily Dose Rate for Inhalation from Article Placed in Environment in Particulate

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

Equation_Apx A-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)
$DINPRP_{air\_avg}$	=	Average DINP 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/h)
CF_1	=	Conversion factor (24 h/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 DINP concentrations in small and large airborne particles. While these particles are expected to be inhaled, not all are able to penetrate the lungs and be trapped in the upper airway and subsequently swallowed. The model estimates the mass of DINP bound to airborne small particles, respirable particles (RP), and large particles (*i.e.*, dust) that are 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_Apx A-16. Chronic Average Daily Dose Rate from Ingestion after Inhalation

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

Where:

$CADD_{IAI}$	=	Chronic Average Daily Dose from ingestion after inhalation (mg/kg-day)
$SVOCRP_{air\_avg}$	=	Average DINP 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 DINP 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 DINP 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/h)
CF_1	=	Conversion factor (24 h/day)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (1,000 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 2.2.3.1 for migration rate inputs and determination of these values.

Equation_Apx A-17. Chronic Average Daily Dose Rate for Ingestion of Article Mouthed

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

Where:

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

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

The article model in CEM E6 calculates DINP 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 DINP 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 DINP-containing dust. The model uses a weighted dust concentration, shown in the equations below.

Equation_Apx A-18. Chronic Dust Concentration

$$Dust_{cr\_wgt} = \frac{(RP_{floor\_avg} \times DINPRP_{floor\_avg}) + (Dust_{floor\_avg} \times DINPDust_{floor\_avg}) + (AbArt_{floor\_avg} \times DINPAbArt_{floor\_avg})}{(RP_{floor\_avg} + Dust_{floor\_avg} + AbArt_{floor\_avg})}$$

Where:

$Dust_{cr\_wgt}$	=	Chronic weighted dust concentration (µg/mg)
RP_{floor_avg}	=	Average RP mass, floor (mg)
$DINPRP_{floor\_avg}$	=	Average DINP in RP concentration, floor (µg/mg)
$Dust_{floor\_avg}$	=	Average dust mass, floor (mg)
$DINPDust_{floor\_avg}$	=	Average DINP in dust concentration, floor (µg/mg)
$AbArt_{floor\_avg}$	=	Average abraded particles mass, floor (mg)
$DINPAbArt_{floor\_avg}$	=	Average floor dust DINP concentration (µg/mg)

Equation_Apx A-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 DINP can volatilize from the DINP-containing article to the air and then partition to dust. Alternately, DINP 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 DINP 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.

A.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 2-8 for inhalation and Table 2-9 for dermal. EPA used professional judgment based on manufacturer and online product use descriptions to estimate events per day and per month for the calculation of the intermediate dose:

Equation_Apx A-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 2-10
$Event\ per\ Day$	=	Events per day, day^{-1}, see Table 2-10

A.4 Acute and Chronic Dermal Dose

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

Equation_Apx A-21. Acute Dose Rate for Dermal

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

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
$Acute\ Frequency$	=	Number of exposure events per averaging period
$Averaging\ Time$	=	Acute averaging time, day^{-1}

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

Equation_Apx A-22. Chronic Average Daily Dose Rate for Dermal

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

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
$Chronic\ Frequency$	=	Number of exposure events per averaging period
$Averaging\ Time$	=	Chronic averaging time, day $^{-1}$