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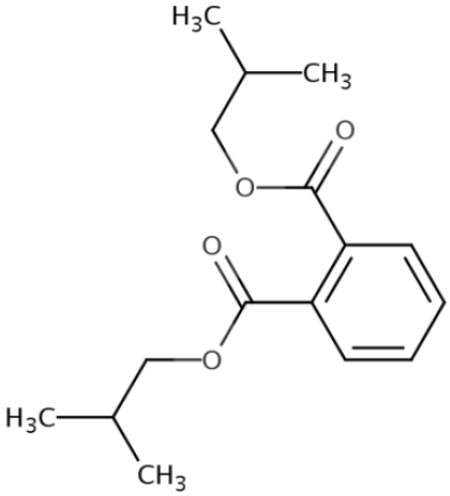
Draft Consumer and Indoor Exposure Assessment for Diisobutyl Phthalate (DIBP)

Technical Support Document for the Draft Risk Evaluation

CASRN 84-69-5



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KEY ABBREVIATIONS AND ACRONYMS

ADR	Average dose rate
CADD	Chronic Average Daily Dose
CASRN	Chemical Abstracts Service Registry Number
CDC	Center for Disease Control and Prevention
CDR	Chemical Data Reporting
CEM	Consumer Exposure Model
CPSC	Consumer Product Safety Commission
CPSIA	Consumer Product Safety Improvement Act
COU	Condition of use
DBP	Dibutyl phthalate
DIBP	Di-(2-ethylhexyl) phthalate; diisobutyl phthalate
DIY	Do-it-yourself
EPA	Environmental Protection Agency (U.S.)
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
SDS	Safety data sheet
SVOC	Semi-volatile organic compound
TESIE	Toddlers' Exposure to SVOCs in the Indoor Environment (Study)
TSCA	Toxic Substances Control Act
TSD	Technical support document
U.S.	United States

SUMMARY

DIBP – Consumer Exposure Assessment Summary: Key Points

EPA (or the Agency) evaluated human exposure to DIBP in consumer products resulting from conditions of use (COUs) as defined under the Toxic Substances Control Act (TSCA). These included solid articles such as air beds, car mats, clothing, footwear, furniture components and textiles, vinyl flooring and carpeting tiles, wallpaper, shower curtains, and children's toys; liquid products including adhesives, sealants, and paints; and coated textile products used in clothing.

Exposure Approaches and Methodology Key Points (Section 0)

- The major routes of exposure considered were ingestion via mouthing, ingestion of suspended dust, ingestion of settled dust, inhalation, and dermal exposure.
- The exposure durations considered were acute, intermediate, and chronic.
- For inhalation and ingestion exposures, EPA used the Consumer Exposure Model (CEM) to estimate acute and chronic exposures to consumer users and bystanders (Section 2.2).
- Dermal exposures for both liquid products and solid articles were calculated in a spreadsheet outside of CEM using a flux dermal absorption approach (Section 2.3)

Exposure Dose Results Key Points (Section 3)

- The highest exposure dose for all lifestages (infant to adult) was for inhalation exposure from vinyl flooring.
- Dermal doses were generally higher than inhalation for all remaining scenarios, except for vinyl flooring.
- Ingestion has the overall lowest doses across scenarios except for vinyl flooring. Ingestion exposure from toys and furniture components considered mouthing in addition to ingestion of settled and suspended dust.

This technical support document (TSD) accompanies the TSCA *Draft Risk Evaluation for Diisobutyl Phthalate (DIBP)* (U.S. EPA, 2025e). It provides detailed descriptions of DIBP consumer and indoor exposure assessment. DIBP is a phthalate ester with CASRN 84-69-5 and chemical name, bis(2-methylpropyl) benzene-1,2-dicarboxylate (IUPAC), diisobutyl phthalate, 1,2-benzenedicarboxylic acid, among others. DIBP 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 DIBP tend to be specialized in their intended use. It is also added to support flexibility in products such as air beds and other plastics. This assessment considers human exposure to DIBP in consumer products resulting from COUs as defined under TSCA. The major routes of exposure considered were ingestion via mouthing, ingestion of suspended dust, ingestion of settled dust, inhalation, and dermal exposure. The exposure durations considered were acute, intermediate, and chronic. Acute exposures are for an exposure duration of 1 day, chronic exposures for 1 year, and intermediate for 30 days.

For inhalation and ingestion exposures, EPA used the 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. For each scenario, low-, medium-, and high-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, see Section 2.2 for CEM parameterization and input selection. Overall, confidence in the CEM inhalation and ingestion modeling estimates were robust and moderate depending on product or article scenario, see Section 5.1.

Briefly, CEM default scenarios were selected for mass of product used, duration of use, and frequency of use. Generally, when using CEM defaults EPA has robust confidence. When no CEM default was available or applicable for some products, manufacturer instructions and online retailers provided details on recommended use of the product (*e.g.*, mass of product used during product application), see Section 2.2.3.2. Overall confidence in most inhalation and ingestion product use patterns was robust, because the supporting evidence provided product specific information. For articles, key parameters that control DIBP emission rates from articles in CEM models are weight fraction of DIBP in the material, density of article material, article surface area, and surface layer thickness. For articles, that do not have default CEM inputs, EPA's *Exposure Factors Handbook* (also referred to as "the Handbook") (U.S. EPA, 2011c) or professional judgment was used to select the duration of use and article surface area for the low-, medium-, and high-exposure scenario levels for most articles. Most inhalation and ingestion article use patterns overall confidence was rated robust because the source of the information was either the Handbook, or when using professional judgment, EPA based selection of inputs on online article descriptions for article surface area (see Section 2.2.3.1). The Agency has a moderate confidence in ingestion via mouthing estimates due to uncertainties about professional judgment inputs regarding mouthing durations for synthetic leather furniture for children. In addition, the chemical migration rate input parameter has a moderate confidence due to the large variability in the empirical data used in this assessment and unknown correlation between chemical migration rate and DIBP concentration in articles.

Dermal exposures for both liquid products and solid articles were calculated in a spreadsheet outside of CEM, see *Draft Consumer Exposure Analysis for Diisobutyl Phthalate (DIBP)* (U.S. EPA, 2025a). CEM dermal modeling uses a dermal model approach that assumes infinite DIBP migration from product to skin without considering saturation, which 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 due to uncertainties associated with the dermal absorption literature. The flux-limited screening dermal absorption approaches for liquid and solid products and articles assumes a constant rate of absorption of DIBP in contact with the skin independent of DIBP concentration in the article/product. The flux-limited screening approach provides an upper bound of dermal absorption of DIBP and results in some overestimations, see Section 5.1 for detailed discussion on limitations, strengths, and confidence in dermal estimates. Briefly, inputs for duration of dermal contact were either from the *Exposure Factors Handbook* (U.S. EPA, 2011c) or professional judgment based on product and article manufacturer use descriptions. For products, manufacturer instructions provided details on recommended use of the product (*e.g.*, adhesives and sealants). However, for articles, typically such data is not available from manufactures. Sometimes inputs were found in the Handbook (*e.g.*, vinyl flooring contact duration), otherwise, professional judgment was used (*e.g.*, length of time an individual spends sitting on a couch per day for medium- and low-intensity use scenarios).

The highest exposure (dose) estimated for all lifestages infant to adult was for inhalation exposure from vinyl flooring, while dermal doses were generally higher than inhalation for the remaining scenarios. Inhalation doses of suspended dust from legacy and new children's toys differ by an order of magnitude with the only difference in these two scenarios being the weight fraction, which is a noteworthy pattern to remember when characterizing risks. Inhalation of DIBP-containing dust is an important contributor to indoor exposures. Dermal exposure differences among scenarios are driven by the exposure duration, frequency of contact, and exposed dermal surface area. For example, dermal dose values for air beds, children's clothing, and furniture textiles were higher because these scenarios used longer contact durations than the other dermal scenarios. Ingestion of DIBP has the overall lowest doses across scenarios except for vinyl flooring. Ingestion exposure from toys and furniture components considered mouthing in addition to ingestion of settled and suspended dust. However, mouthing tendencies decrease or cease entirely for children aged 6 to 10 years; thus, there is no mouthing influence in ingestion doses for ages above 6 years. For all ingestion doses, settled dust exposures were larger than ingestion doses from suspended dust and mouthing, supporting the observation that DIBP-containing dust is an important contributor to indoor exposures and overall DIBP consumer exposures.

1 INTRODUCTION

Diisobutyl phthalate (DIBP) is a phthalate ester with a CASRN 84-69-5 and properties used to support product flexibility and hydrophobicity. DIBP 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. These included PVC used in solid articles such as air beds, car mats, clothing, footwear, furniture components and textiles, vinyl flooring and carpeting tiles, wallpaper, shower curtains and children's toys; liquid products including adhesives, sealants, and paints; and coated textile products used in clothing. Under a final rule promulgated in response to the Consumer Product Safety Improvement Act (CPSIA), effective April 25, 2018, Congress permanently prohibited the sale of children's toys or childcare articles containing concentrations exceeding 0.1 percent DIBP. However, it is possible that some individuals may still have children's toys in the home that were produced before regulatory limitations. EPA further assembled reasonably available information from 2016 and 2020 data reported in the Chemical Data Reporting (CDR) database. EPA also consulted a variety of other sources including published literature, company websites, and government and commercial trade databases. All of these sources were used to identify products and articles under the defined conditions of use (COUs) of DIBP 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 DIBP in specific items were then gathered from a variety of sources, such as safety data sheets (SDS), databases, and literature reviewed publications. These data were used in this assessment in a tiered approach as described in Section 2.1.

The migration of DIBP 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 DIBP has not been well characterized. The identified uses can result in exposures to consumers and bystanders (non-product users that are incidentally exposed to the product). For all the DIBP 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 DIBP across COUs and various age groups.

Because PVC products are ubiquitous in modern indoor environments, and since DIBP is not chemically bound to many consumer products and articles in which it is incorporated, it can leach, migrate, or evaporate (to a lesser extent based on 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 of age.

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

Life Cycle Stage	Category	Subcategory of Use	Reference(s)
Consumer	Adhesives and sealants	Adhesives and sealants	(U.S. EPA, 2019a; Glue 360 Inc, 2018; Azon USA Inc, 2015; ITW Performance Polymers, 2015; Chemical Concepts Inc, 2014); EPA-HQ-OPPT-2018-0434-0007; EPA-HQ-OPPT-2019-0131-0022
	Fabric, textile, and leather products not covered elsewhere	Fabric, textile, and leather products not covered elsewhere (*e.g.*, textile (fabric) dyes)	(Dow Chemical, 2013)
	Floor coverings	Floor coverings	EPA-HQ-OPPT-2018-0434-0014; (Danish EPA, 2011, 2010)
	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	(U.S. EPA, 2019a, b, 2016); EPA-HQ-OPPT-2019-0131-0022
	Paints and coatings	Paints and coatings	(Aceto US LLC, 2022; LANXESS, 2021)
	Toys, playground, and sporting equipment	Toys, playground, and sporting equipment	(U.S. EPA, 2019b, 2016)
Disposal	Disposal	Disposal	

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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 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 judgment.
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 and articles containing DIBP were matched with TSCA COUs appropriate for the anticipated use of the item. 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. The qualitative analysis is fundamentally a discussion of exposure potential based on physical and chemical properties, and/or available monitoring data, if available. 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). All exposure estimates for tire crumb rubber were calculated using a computational framework implemented within a spreadsheet as described in Section 2.4 because CEM does not have capabilities to model exposure to chemicals in particulate matter other than indoor dust. Dermal exposure to DIBP-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. If only a range was reported, EPA 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 *Draft Risk Evaluation for Diisobutyl Phthalate (DIBP) - Supplemental Information File: Consumer Exposure Analysis* (U.S. EPA, 2025a). High-, medium-, and low-intensity use exposure scenarios serve as a two-pronged approach. First, it provides a sensitivity analysis with insight on the impact of the main modeling input parameters (*e.g.*, skin contact area, duration of contact, and frequency of contact) in the doses and risk estimates. And second, the high-intensity use exposure scenarios are used first to screen for potential risks at the upper-bound of possible

exposures, and to refine if needed.

Based on reasonably available information from the systematic review of consumer conditions of use and indoor dust studies, inhalation of DIBP is possible through DIBP emitted from products and articles and DIBP sorbed to indoor dust and particulate matter. A detailed discussion of indoor dust references, sources, and concentrations is available in Section 4. Due to DIBP's low volatility, there is expected to be negligible or very small gas-phase inhalation exposures. However, DIBP'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 DIBP in settled dust from indoor environments. Due to the presence of DIBP in indoor dust, inhalation and ingestion of suspended dust, and ingestion of settled dust, are both considered as exposure routes in this consumer assessment.

Based on reasonably available information from the systematic review of consumer conditions of use and indoor dust studies, oral exposure to DIBP 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 DIBP, 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 DIBP, 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 were 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 *Draft Risk Evaluation for Diisobutyl Phthalate (DIBP)* (U.S. EPA, 2024c). Similarly, solid articles not expected to be mouthed (*e.g.*, building materials, outdoor furniture, etc.) were not assessed for mouthing exposure. DIBP is a low volatility solid that is used primarily as a plasticizer in manufacturing, so potential take-home exposures are likely small in comparison to the scenarios considered in this assessment. Therefore, take-home exposures were not explored further.

EPA assessed acute, chronic, and intermediate exposures to DIBP from consumer COUs. For the acute dose rate calculations, an averaging time of one 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 one year. Professional judgment and product use descriptions were used to estimate number of events per day and per month for each product, 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 DIBP Content

Products are generally consumable liquids, aerosols, or semi-solids that are used a given number of times before they are exhausted. Articles are generally solids, polymers, foams, metals, or woods, which

are present within indoor environments for the duration of their useful life, which may be several years. The preferred data sources for DIBP content in U.S. consumer goods were SDSs for specific products or articles with reported DIBP content, peer-reviewed literature providing measurements of DIBP in consumer goods purchased in the United States, and government reports originating in the United States with manufacturer-reported concentrations. In instances where these data from preferred sources were not available, DIBP content in specific products and articles provided in peer-reviewed literature and government reports originating from Canada and the European Union were used. Manufacturing practices and regulations for DIBP 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. DIBP weight fractions reported in the CDR database were not used as 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, which will be added to other components during the manufacturing process of the finished good.

EPA further evaluated the products and articles identified to ensure that data was representative of items that may expose U.S. consumers to DIBP. Where possible, SDSs were cross-checked with company websites to ensure that each product could reasonably be purchased by consumers. 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 like as found in 16 CFR 1307.3 were considered when determining relevancy of data to the current U.S. consumer market. For solid articles with enacted limits on DIBP content (*e.g.*, children's toys and childcare items), it was considered reasonable that consumers might be exposed to older items with DIBP content higher than current limits via secondhand purchases or long-term use for these items. Exposure to legacy and new items were considered separately.

In addition to DIBP 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 needed to define exposure scenarios. The following sections provide a summary of specific products and articles with DIBP content identified for each item, and Table 2-1 provides a summary of TSCA COUs determined for each item and exposure pathways modeled.

2.1.1 Solid Articles

Although DIBP is known to be used in a large variety of solid articles, weight fraction data for solid articles containing DIBP and currently sold in the United States were limited. Consumer product data were obtained from two studies conducted by The Ecology Center, a nonprofit, on carpets (Changing Markets Foundation, 2018) and articles purchased from dollar stores (Ecology Center, 2015). Additionally, some information was obtained from the High Priority Chemicals Data System (HPCDS) (WSDE, 2020), a database compiling manufacturer reporting requirements from 2017 to 2024 per Washington and Oregon safe children's product regulations. Concentration ranges (*e.g.*, 100 to <500 ppm) based on test results or manufacturer knowledge are provided. Additionally, specific products or articles are not identified; only generic categories (*e.g.*, toys/games) are provided.

DIBP content in solid items not specific to children were lacking for U.S. consumer goods; data were also obtained from monitoring studies of phthalates in consumer goods conducted in European countries. In particular, a large amount of data was available for phthalates in consumer goods published across several studies carried out by the Danish EPA. For articles that did not have U.S. data, it is unclear if DIBP is present in similar U.S.-sold items or if these materials are not captured in U.S.

monitoring efforts. As such, EPA assessed these items under the assumption that the weight fractions reported by the Danish EPA are representative of DIBP content that could be present in items sold in the United States.

Given the high molecular weight (278.35 g/mol) and low vapor pressure (4.76×10^{-5} mmHg) of DIBP, partitioning into air and overlying dust from solid articles is expected to be limited. Consequently, inhalation and dust ingestion exposure for items with a small surface area of emissions (< 1 m^2) or those used outdoors are expected to be insignificant as compared to exposure by mouthing and dermal contact. As such, inhalation and dust ingestion were not assessed for these items. For articles assessed for dermal contact, the weight fraction data is used to confirm the presence of DIBP in the article, but these data are not used in the dermal modeling, see Section 2.3. Furthermore, dermal, and mouthing exposures assessments include high-, medium-, and low-intensity use scenarios for each article using a range of modeling input parameters described in the corresponding sections, such as dermal absorption related parameters and chemical migration rates (mouthing).

Air Beds

Air beds were assessed for DIBP exposure by inhalation, dust ingestion, and dermal pathways. Measurable DIBP was reported by the Danish EPA in one air bed at 1.1×10^{-5} w/w (Danish EPA, 2010). As data specific to the U.S. market is lacking, this weight fraction value was applied in low-, medium-, and high-exposure scenarios.

Car Mats

Car floor mats were assessed for DIBP exposure by inhalation, dust ingestion, and dermal pathways. The only available data for DIBP content in car mats were two car mat sets purchased from an internet vendor in Denmark, with reported DIBP weight fractions of 1×10^{-5} w/w and 3×10^{-5} w/w (Danish EPA, 2020). As data specific to the U.S. market is lacking, these values were used in low- and high- exposure scenarios and the average value of 2×10^{-5} w/w was used in the medium exposure scenario.

Children's Toys

Children's toys were assessed for DIBP exposure by inhalation, dust ingestion, dermal and mouthing routes of exposure. Under a final rule promulgated in response to the Consumer Product Safety Improvement Act (CPSIA), effective April 25, 2018, Congress permanently prohibited the sale of children's toys or childcare articles containing concentrations of more than 0.1 percent DIBP. However, it is possible that some individuals may still have children's toys in the home that were produced before regulatory limitations.

The HPCDS database contained test data for DIBP measurements in 64 toy/game items from 2017 to 2024. While there is some uncertainty about the materials these items are manufactured from, based on the limited descriptions in the database, EPA determined that these items are likely composed primarily of plastic and rubber components. For example, some of the descriptions provided for toys were dolls, dolls' furniture, action figures, puppets, board games, card games, developmental toys, scientific toys, and soft toys. DIBP content was reported to be <100 ppm (<0.0001 w/w) in 26 items, 100 to 500 ppm (0.0001 to 0.0005 w/w) in 33 items, 500 to 1,000 ppm (0.0005–0.001 w/w) in 2 items, 1,000 to 5,000 ppm (0.001–0.005 w/w) in 1 item, 5,000 to 10,000 ppm (0.005–0.01 w/w) in 1 item, and ≥10,000 ppm (0.01 w/w) in 1 item (WSDE, 2020).

EPA assessed exposure to DIBP 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 the regulatory limit (0.1%) and were therefore assessed with DIBP weight fraction of 0.001 w/w in low-, medium-, and high-exposure

scenarios. In the second scenario, legacy toys are assessed with weight fractions reported in the HPCDS database (WSDE, 2020). Based on the reported data, the weight fractions of DIBP used in low-, medium-, and high-exposure scenarios were 0.0001 w/w, 0.0003 w/w, and 0.01 w/w. The legacy toys scenario is also reflective of any new toys with weight fractions above the CPSIA regulatory limit.

Clothing

Clothing was assessed for DIBP exposure by dermal contact only, but a different approach was taken for adults and children based on anticipated contact with specific garments.

DIBP content was reported in two adult sized garments by the Danish EPA at 3×10^{-5} w/w in a raincoat (Solomon and Lutz, 1987) and 1.8×10^{-5} w/w in a jacket (Danish EPA, 2009). DIBP has also been reported in synthetic leather materials sampled from furniture items (see coated textiles description below). It is reasonable to assume that these materials may be used in synthetic leather clothing as well, which is expected to have a greater potential for dermal exposure as it may be worn more often than outerwear, has direct dermal contact, and may have a larger area of dermal contact. As such, synthetic leather clothing was chosen as the conservative representative clothing item for modeling dermal exposure to DIBP in adults and teens.

The HPCD database contained data for DIBP measurements in 12 children's clothing items including bodysuits, tops, bottoms, underwear, belts, and variety packs. DIBP content was reported to be <100 ppm (<0.0001 w/w) in nine items, 100 to 500 ppm (0.0001 to 0.0005 w/w) in one item, 500 to 1,000 ppm (0.0005 to 0.001 w/w) in one item, and 1,000 to 5,000 ppm (0.001 to 0.005 w/w) in one item. The maximum concentration of DIBP was reported in a clothing variety pack item. DIBP was associated with various components including inks/dyes/pigments, synthetic polymers, bio-based materials and textiles (WSDE, 2020). The weight fractions of DIBP are used to confirm DIBP presence in article and concentration range. The HPCD database specified that the targeted age groups for the identified examples were children under 12 years. As such, EPA assessed the exposure to children's clothing for young teens (11–15 years) age group and younger.

Coated Textiles

Coated textiles were assessed for DIBP exposure via inhalation, ingestion, and dermal uptake. The Danish EPA reported DIBP measurements for synthetic leather and oil cloth fabrics (Danish EPA, 2010). Reported DIBP weight fractions for synthetic leather furniture samples ranged from 8×10^{-6} to 0.01625 w/w and for oil cloth samples ranged from 8×10^{-6} to 5.6×10^{-5} mg/kg. Oil cloth material is not incorporated extensively in household items or clothing but may be used to manufacture tablecloths. Synthetic leather is expected to have many potential applications, including furniture, clothing, and accessory items such as belts and handbags. Exposure to coated textiles was assessed as two representative articles expected to capture a conservative and the highest exposure by inhalation, dermal uptake, and ingestion due to large surface area of emissions and long dermal contact times. To that end, consumer exposure to DIBP from coated textiles was modeled in scenarios for furniture and adult clothing. As oil cloth has lower reported weight fractions of DIBP and is expected to occur in smaller surface area items than furniture, exposure from these materials is expected to be less than that of synthetic leather furniture. The low-, medium-, and high-intensity use exposure scenarios for DIBP for synthetic leather correspond to the reported minimum, calculated average, and reported maximum weight fractions of 8×10^{-6}, 0.0014, and 0.016 w/w.

Flooring Materials

Carpet backing was assessed for DIBP 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. DIBP was reported in two carpet tile samples obtained from a U.S. retailer at weight fractions of 2.3×10^{-4} and 2.1×10^{-4} w/w (Changing Markets Foundation, 2018). Additionally, the Danish EPA reported DIBP weight fraction of 1.56×10^{-4} w/w in one carpet tile sample (Danish EPA, 2010). Based on the data reported in these studies, the weight fraction values used in low-, medium-, and high-exposure scenarios for carpet backing were 1.56×10^{-4}, 2×10^{-4}, and 2.3×10^{-4} w/w.

Vinyl flooring was assessed for DIBP exposure by inhalation, dust ingestion, and dermal exposure routes. In a Danish EPA study, DIBP was found in three vinyl flooring materials at weight fractions of 5.6×10^{-5}, 8.13×10^{-4}, and 0.074 w/w (Danish EPA, 2010). In an ECHA proposal for restriction report, DIBP was reported in three vinyl flooring materials at 0.0065, 0.0159, and 0.0571 w/w (Danish EPA, 2011). The weight fraction values used in low-, medium-, and high-exposure scenarios for vinyl flooring were the minimum, average and maximum values of 5.6×10^{-5}, 0.026, and 0.074 w/w.

Footwear

Footwear components were assessed for DIBP exposure by dermal contact only. DIBP content was reported by the Danish EPA in several footwear items including two flip flops at 1×10^{-5} and 0.0039 w/w, one sandal at 0.178 w/w (Danish EPA, 2020), and one rubber clog with 0.00067 w/w mg/kg (Danish EPA, 2009). DIBP content was also reported in the HPCDS database in four children's footwear items with DIBP content of 100 ppm (<0.0001 w/w). The weight fractions of DIBP are used to confirm DIBP in article and concentration range.

PVC Articles with Potential for Semi-Routine Dermal Exposure

DIBP has been measured in a variety of consumer goods that are not expected to be mouthed, are not expected to result in significant inhalation exposure due to their small size and/or outdoor only use and are not expected to result in significant dermal exposures due to short and/or infrequent dermal contact events. However, EPA recognizes that while dermal uptake of DIBP from contact with these individual items is not expected to be significant, given 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. It is likely that real world exposures to these types of items would occur as a result of dermal contact with articles belonging to multiple COUs. However, the contribution of individual COUs to exposure from these kinds of items is expected to vary at an individual level due to differences in lifestyle and habits. As such, although this scenario encompasses items from more than one COU, it may be viewed as an upper boundary for exposure to any of the COUs included. Weight fractions of DIBP are not used in dermal exposure calculations, they are provided below only to demonstrate the broad range of both product types, formulations, and DIBP contents that may be captured in this model scenario, see Section 2.3 for more dermal analysis and approaches details.

In a study conducted by The Ecology Center at dollar stores in the United States, DIBP was reported at 0.189 w/w in a headband, 0.123 w/w in a bath rub applique, and 0.002 w/w in a steering wheel cover (Ecology Center, 2015). In a 2020 study by the Danish EPA, DIBP content in a variety of consumer goods ordered from online retailers was measured. DIBP was reported at weight fractions of 8×10^{-5} w/w in diving goggles, 2.3×10^{-4} w/w in a phone charger, 0.0028 w/w in a garden hose, 1×10^{-5} and 4×10^{-5} w/w in pet chew toys, 4×10^{-5} w/w in a feeding mat, 5×10^{-5} to 0.002 w/w in hobby cutting boards,

1.2×10^{-4} to 0.014 w/w in tape, 3×10^{-5} w/w in a jump rope, 5×10^{-6} to 5×10^{-5} w/w in yoga mats, 9×10^{-5} to 3.4×10^{-4} w/w in footballs, and 0.418 to 0.445 w/w in yoga balls (Danish EPA, 2020). In an earlier study by the Danish EPA, DIBP concentrations in various fitness balls varied from 9.1×10^{-6} to 0.355 w/w (Carere et al., 2011). In a Finnish study, DIBP was reported in in two paper packaging products at 3.6×10^{-4} and 4.5×10^{-4} w/w and one folding boxboard at 3×10^{-5} w/w (Aurela et al., 1999).

Shower Curtains

Shower curtains were assessed for DIBP exposure by inhalation, dust ingestion, and dermal exposure routes. The Danish EPA reported DIBP in three shower curtain samples at weight fractions of 6.4×10^{-5}, 9.2×10^{-5}, and 1.7×10^{-4} w/w (Danish EPA, 2010). Based on these data, the weight fraction values used in low-, medium-, and high-exposure scenarios for PVC shower curtains were the minimum, average and maximum values of 6.4×10^{-5}, 1.1×10^{-4}, and 1.7×10^{-4} w/w, respectively.

Wallpaper

Wallpaper was assessed for DIBP exposure by inhalation, dust ingestion, and dermal exposure routes. The Danish EPA reported DIBP in nine wallpaper samples (Danish EPA, 2010). The minimum, mean, and maximum weight fractions of DIBP reported were 5×10^{-6}, 8.7×10^{-5}, and 6.3×10^{-4} w/w; these values were used to model the low-, medium-, and high-exposure scenarios.

2.1.2 Liquid and Paste Products

Liquid and paste products with DIBP content were identified using reasonably available information, largely via manufacturer safety data sheets (SDS). Products with similar DIBP content and expected use patterns were grouped together for modeling as described below. Note that for liquid and paste products assessed only for dermal exposure, DIBP content is provided here for context only as it is not used directly in exposure calculations for these routes (see Sections 2.3.3 and 2.3.4 for details).

Adhesives and Sealants for Home DIY Projects

One anchoring adhesive with DIBP was identified for sealing into concrete and masonry. The reported DIBP content was 0.2 to 0.3 w/w (Simpson Strong-Tie, 2014). As the anticipated use for this product was outdoors, inhalation exposure is expected to be negligeable, and it was modeled for dermal exposure only.

Two sealants for small home repairs were identified with DIBP content. A seaming adhesive had DIBP in the range of 0.15 to 0.4 w/w (Chemical Concepts Inc, 2014) and a fire caulk had DIBP in the range of 0.05 to 0.1 w/w (Abesco Fire LLC, 2015). Based on these data the weight fractions of DIBP used in low-, medium-, and high-exposure scenarios were 0.05, 0.175, and 0.4 w/w. These products were assessed for both inhalation and dermal exposure.

One wood flooring adhesive was identified with DIBP content in the range of 0.025 to 0.05 w/w (Jowat Corporation, 2016); these weight fractions were used in the low and high exposure scenarios, and the average value of 0.0375 w/w was used in the medium exposure scenario. This product was assessed for both inhalation and dermal exposure.

Paint

The manufacturer of a plasticizer with DIBP content includes paints in the suggested uses for the product listed in the technical specifications (LANXESS, 2015). EPA did not identify any liquid products available for consumer purchase in the United States. However, 16 items were reported in the HPCDS database with measurable DIBP in a component listed as “Surface coatings (paints, plating, waterproofing etc.).” The identified items were all children’s items including games or puzzles, puppets,

costume items, and arts and crafts supplies and weight fractions of DIBP ranged from 0.0001 to 0.0005. As no large items or items expected to have long term routine contact were identified, paints were assessed for dermal exposure only under the scenario Small Articles with Semi-Routine Contact.

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

Consumer Condition of Use Category	Consumer Condition of Use Subcategory	Product(s)/Article(s)	Exposure Scenario and Route	Evaluated Routes				
				Inhalation [a]	Dermal	Ingestion		
						Suspended Dust	Settled Dust	Mouthing
Adhesives and sealants	Adhesives and sealants	Wood flooring adhesive	Use of product in DIY large-scale home repair activities. Direct contact during use; inhalation of emissions during use	**QT**	**QT**	*QL*	*QL*	*QL*
Adhesives and sealants	Adhesives and sealants	Concrete and masonry adhesive adhesives for small repairs	Use of product in DIY small-scale home repair activities. Direct contact during use	*QL*	**QT**	*QL*	*QL*	*QL*
Adhesives and sealants	Adhesives and sealants	Small projects with seaming adhesive and a fire caulk	Use of product in DIY home repair activities. Direct contact during use; inhalation of emissions during use	**QT**	**QT**	*QL*	*QL*	*QL*
Fabric, textile, and leather products not covered elsewhere	Fabric, textile, and leather products not covered elsewhere (*e.g.*, textile (fabric) dyes)	Indoor furniture	Direct contact during use; inhalation of emissions / ingestion of airborne particulate; ingestion by mouthing	**QT** [b]	**QT**	**QT** [b]	**QT** [b]	**QT**
Fabric, textile, and leather products not covered elsewhere	Fabric, textile, and leather products not covered elsewhere (*e.g.*, textile (fabric) dyes)	Children's clothing	Direct contact during use	*QL*	**QT**	*QL*	*QL*	*QL*
Fabric, textile, and leather products not covered elsewhere	Fabric, textile, and leather products not covered elsewhere (*e.g.*, textile (fabric) dyes)	Clothing synthetic leather for teenagers and adults	Direct contact during use	*QL*	**QT**	*QL*	*QL*	*QL*
Fabric, textile, and leather products not covered elsewhere	Fabric, textile, and leather products not covered elsewhere (*e.g.*, textile (fabric) dyes)	Articles with semi-routine contact. Variety PVC articles: Bags, belts, headband accessories, and steering wheel cover	Direct contact during use	*QL*	**QT**	*QL*	*QL*	*QL*
Fabric, textile, and leather products not covered elsewhere	Fabric, textile, and leather products not covered elsewhere (*e.g.*, textile	Footwear components	Direct contact during use	*QL*	**QT**	*QL*	*QL*	*QL*

Consumer Condition of Use Category	Consumer Condition of Use Subcategory	Product(s)/Article(s)	Exposure Scenario and Route	Evaluated Routes				
				Inhalation [a]	Dermal	Ingestion		
						Suspended Dust	Settled Dust	Mouthing
	(fabric) dyes)							
Floor coverings	Floor coverings	Vinyl flooring	Direct contact, inhalation of emissions / ingestion of dust adsorbed chemical	**QT** [b]	**QT**	**QT** [b]	**QT** [b]	*QL*
Floor coverings	Floor coverings	Carpet tiles	Direct contact, inhalation of emissions / ingestion of dust adsorbed chemical	**QT** [b]	**QT**	**QT** [b]	**QT** [b]	*QL*
Paints and coatings	Paints and coatings	Articles with semi-routine contact. Paint	Direct contact during use	*QL*	**QT**	*QL*	*QL*	*QL*
Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Air beds	Direct contact during use, inhalation of emissions / ingestion of dust adsorbed chemical while in place	**QT** [b]	**QT**	**QT** [b]	**QT** [b]	*QL*
Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Car mats	Direct contact during use. See routine contact scenario inhalation of emissions / ingestion of dust adsorbed chemical	**QT** [b]	**QT**	**QT** [b]	**QT** [b]	*QL*
Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Wallpaper	Direct contact during installation (teenagers and adults) and while in place; inhalation of emissions / ingestion of dust adsorbed chemical	**QT** [b]	**QT**	**QT** [b]	**QT** [b]	*QL*
Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Shower curtain	Direct contact during use. See routine contact scenario inhalation of emissions / ingestion of dust adsorbed chemical while hanging in place	**QT** [b]	**QT**	**QT** [b]	**QT** [b]	*QL*
Other articles with routine direct contact during normal use including	Other articles with routine direct contact during normal use including rubber articles;	Articles with semi-routine contact. Tires and variety PVC articles: bathtub applique,	Direct contact during use	*QL*	**QT**	*QL*	*QL*	*QL*

Consumer Condition of Use Category	Consumer Condition of Use Subcategory	Product(s)/Article(s)	Exposure Scenario and Route	Evaluated Routes				
				Inhalation [a]	Dermal	Ingestion		
						Suspended Dust	Settled Dust	Mouthing
rubber articles; plastic articles (hard)	plastic articles (hard)	phone charger, garden hose, feeding mat, hobby cutting boards, tape, paper packaging products, folding boxboard						
Toys, playground, and sporting equipment	Toys, playground, and sporting equipment	Children's toys (legacy). Produced after CFR regulatory limitations, 0.1%.	Collection of toys. Direct contact during use; inhalation of emissions/ingestion of airborne particulate; ingestion by mouthing	**QT** [b]	**QT**	**QT** [b]	**QT** [b]	**QT**
Toys, playground, and sporting equipment	Toys, playground, and sporting equipment	Children's toys (new). Produced after CFR regulatory limitations, 0.1%.	Collection of toys. Direct contact during use; inhalation of emissions / ingestion of airborne PM; ingestion by mouthing	**QT** [b]	**QT**	**QT** [b]	**QT** [b]	**QT**
Toys, playground, and sporting equipment	Toys, playground, and sporting equipment	Tire crumb, artificial turf	Direct contact during use (particle ingestion via hand-to-mouth)	**QT**	**QT**	**QT** [c]		
Toys, playground, and sporting equipment	Toys, playground, and sporting equipment	Articles with semi-routine contact; variety PVC articles: diving goggles, exercise ball, yoga mats, pet chew toys, jump rope, footballs	Direct contact during use	*QL*	**QT**	*QL*	*QL*	*QL*
Disposal	Disposal	Down the drain products and articles	Down the drain and releases to environmental media	*QL*	*QL*	*QL*	*QL*	*QL*
Disposal	Disposal	Residential end-of-life disposal, product demolition for disposal	Product and article end-of-life disposal and product demolition for disposal	*QL*	*QL*	*QL*	*QL*	*QL*

CFR – Code of Federal Regulations [16 CFR 1307.3(b)]; DIY = do-it-yourself; *QL* = qualitative analysis; **QT** = quantitative analysis
In accordance with section 108(b)(3) of the Consumer Product Safety Improvement Act of 2008 (CPSIA), 16 CFR part 1307.3(b) prohibits any children's toy or childcare article that contains concentrations of more than 0.1 percent of DIBP. Section 108(b)(3) of the CPSIA 2008 requires the Consumer Product Safety Commission (CPSC) to promulgate a final rule regarding certain phthalates in children's toys and childcare articles. This rule must be issued within 180 days of receiving a final report from the Chronic Hazard Advisory Panel (CHAP), which was published in July 2014.
[a] Inhalation scenarios consider suspended dust and gas-phase emissions.
[b] These indoor dust articles scenarios consider the surface area from multiple articles such as toys, while furniture and flooring already have large surface areas. For

Consumer Condition of Use Category	Consumer Condition of Use Subcategory	Product(s)/Article(s)	Exposure Scenario and Route	Evaluated Routes				
						Ingestion		
				Inhalation [a]	Dermal	Suspended Dust	Settled Dust	Mouthing
these articles dust can deposit and contribute to significantly larger concentration of dust than single small articles [c] The tire crumb and artificial turf ingestion route assessment considers all three types of ingestions, settled dust, suspended dust, and mouthing altogether, but results cannot be provided separately has it was done for all other articles and products.								

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Qualitative Assessments

EPA performed 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	Qualitative 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	Qualitative 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 DIBP 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 DIBP. It is difficult for EPA to quantify these end-of-life and down-the-drain exposures due to limited information on source attribution of the consumer COUs. In previous assessments, the Agency has considered down-the-drain analyses for consumer product scenarios where it is reasonably foreseen that the consumer product would be discarded directly down-the-drain. For example, adhesives, sealants, paints, and coatings 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 DIBP releases to the environment via the cleaning and disposal of adhesives, sealants, paints, and coatings, the Agency did not quantitatively assess these products and instead provides a qualitative assessment. DIBP-containing products can be disposed when users no longer have use for them, or they have reached the product shelf life and are taken to landfills. 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, and paints and coatings. DIBP is expected to be persistent as it leaches from consumer products disposed of in landfills. Due to this, DIBP is likely to be present in landfill leachate up to its aqueous limit of solubility (6.2 mg/L). However, due to its affinity for organic carbon, DIBP is expected to be immobile in groundwater. And even in cases where landfill leachate containing DIBP were to migrate to groundwater, DIBP would likely partition from groundwater to organic carbon present in the subsurface (U.S. EPA, 2025d).

2.2 Inhalation and Ingestion Modeling Approaches

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 DIBP-containing consumer products. The advantages of using CEM to assess exposures to consumers and bystanders are as follows:

- The CEM model has been peer-reviewed (ERG, 2016);
- CEM accommodates the distinct inputs available for the products and articles containing DIBP, such as weight fractions, product density, room of use, and 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 DIBP).

CEM has capabilities to model exposure to DIBP 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, which are present within indoor environments for the duration of their useful life, which may be several years.

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 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 for the purposes of this evaluation 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 the *Exposure Factors Handbook* (U.S. EPA, 2011c). The default interzonal air flows are a function of the overall air exchange and volume of the building as well as the openness of the room, which is characterized in a regression approach for closed rooms and open rooms (U.S. EPA, 2023), 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. Like suspended and settled particulate, abraded particles 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. Thus, 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 DIBP 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 DIBP 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 1-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 DIBP consisted of both products and articles. The embedded models within CEM 3.2 that were used for DIBP 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; thus, 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 DIBP sorbed to dust/PM and were therefore not modeled for these routes (A_ING1, A_ING3). Note that products and articles not assessed in CEM (concrete adhesives, clothing and footwear components, tire crumb, and small articles with potential for semi routine contact) are not listed in this table; modeling for these items was performed outside of CEM as described in Sections 2.3 and 2.5.

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

Consumer COU	Sub COU	Product/Article	Emission Model and Exposure Pathway(s)	CEM Saved Analysis
Adhesives and sealants	Adhesives and sealants	Wood flooring adhesive	E1; P_INH2 (Near-field)	Glue and adhesives (large scale)
Adhesives and sealants	Adhesives and sealants	Small projects with seaming adhesive and a fire caulk	E1; P_INH2 (Near-field)	Caulk (Sealant)
Fabric, textile, and leather products not covered elsewhere	Fabric, textile, and leather products not covered elsewhere (*e.g.,* textile [fabric] dyes)	Indoor furniture	E6; A_INH1, A_ING1, A_ING2, A_ING3	Leather Furniture
Floor coverings	Floor coverings	Vinyl flooring	E6; A_INH1, A_ING1, A_ING3	Plastic articles: vinyl flooring
Floor coverings	Floor coverings	Carpet tiles	E6; A_INH1, A_ING1, A_ING3	Plastic articles: vinyl flooring

Consumer COU	Sub COU	Product/Article	Emission Model and Exposure Pathway(s)	CEM Saved Analysis
Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Air beds	E6; A_INH1, A_ING1, A_ING3	Plastic articles: other objects with potential for routine contact (toys, foam blocks, tents)
Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Car mats	E6; A_INH1, A_ING1, A_ING3	Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)
Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Wallpaper	E6; A_INH1, A_ING1, A_ING3	Fabrics: curtains, rugs, wall coverings
Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Shower curtain	E6; A_INH1, A_ING1, A_ING3	Plastic articles: other objects with potential for routine contact (toys, foam blocks, tents)

In total, the specific products representing 6 COUs for DIBP 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 Section 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 DIBP in air and dust result in increased exposure. This may occur due to article specific characteristics that allow for higher emissions of DIBP to air, and/or environment specific characteristics such as smaller room volume and lower ventilation rates. Key parameters that control DIBP emission rates from articles in CEM 3.2 models are weight fraction of DIBP 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 DIBP. 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 in CEM (clothing, footwear components, tire crumb rubber, and small articles with potential for semi-routine dermal contact) are not described here or included in the table. However, tire crumb rubber was assessed for inhalation exposure outside of CEM to accommodate use of empirical data for concentrations of DIBP in air; details of this approach are provided in Section 2.4.

Weight fractions of DIBP 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. 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.

Due to the high variability and uncertainty inherent to 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.

Air Beds

To identify the estimates for the surface area of air beds, an informal survey was conducted to identify common dimensions sold by various internet retailers. Twin, queen, and king-sized airbeds are commonly sold, and commonly observed dimensions for these products were used to develop estimates for surface area for the low-, medium-, and high-exposure scenarios. The dimensions used are as follows: a twin airbed is 75" × 39" × 9", a queen airbed is 80" × 60" × 9", and a king airbed is 80" × 76" × 9". The general approach involved calculating the total surface area by summing the areas of the top and four side surfaces, excluding the bottom surface, which is not expected to emit to air. The total surface areas used in low-, medium-, and high-exposure scenarios were 3.9, 5.9, and 7.4 m^2, respectively.

It should be noted that the exposure to all products and articles, including air beds, was estimated by lifestage (also known as age groups), including for infants under 1 year of age. According to the Consumer Product Safety Commission (CPSC), airbeds should not be marketed or used by infants (CPSC, 2012). A review of air bed consumer labeling also highlighted that air beds are not intended for use by infants between the ages of 0 to 15 months due to a risk of suffocation during sleep (ASTM F2755 − 22).

Building Materials

To estimate surface areas for flooring materials (vinyl flooring and carpet tiles), 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.

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 the *Exposure Factors Handbook* Table 9-13 (U.S. EPA, 2011c). This value was scaled to 200 and 50 m^2 for the high and low exposure levels based on professional judgment.

Car Mats

Based on a survey of car mat sets available on manufacturers' websites, there was little variability in surface area. 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 modelled was 1.29 m^2. As there was little observed variation in dimensions, this value was used in the low, medium, and high scenarios.

Furniture

For textile furniture components, 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", 60" × 36" × 30", and 72" × 42" × 35" for a loveseat. The measurements were compiled from furniture retail stores' descriptions. EPA added the lowest values of surface area for a couch and a loveseat together to estimate a total surface area for smaller furniture in the low-end scenario, and similarly for the medium and high estimates. EPA assumes the bottom side of the furniture item is not covered with the same material.

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 × 1.78 m) 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.

Children's Toys

Children's toys 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 DIBP content. As such, surface area for these items was estimated by assuming that a home has several of these items rather than one. The surface area of new and legacy toys was varied for the low-, medium-, and high-exposures based on EPA's professional judgment of the number and size of toys and size of toys collected in a bedroom. Low, medium, and high estimates, respectively, were based on 5 small toys measuring 15 cm × 10 cm × 5 cm, 20 medium toys measuring 20 cm × 15 cm × 8 cm, or 30 large toys measuring 30 cm × 25 cm × 15 cm.

Table 2-5. Summary of Key Parameters for Inhalation and Dust Ingestion Exposure to DIBP 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]	Volume (m^3) [d]	Interzone Ventilation Rate (m^3/h) [d]
Air beds	High	0.000011	1.4	7.2	0.01	Bedroom	36.0	107.01
	Medium	0.000011		5.9				
	Low	0.000011		3.9				
Car mats	High	0.00003	1.4	1.29	0.01	Automobile	2.4	9.5
	Medium	0.00002						
	Low	0.00001						
Carpet tiles	High	0.000011	1.4	202	0.01	Whole house	492.0	1.E−30
	Medium	0.000011		101				
	Low	0.000011		50.5				
Children's toys (legacy) [f]	High	0.01	1.4	9.45	0.01	Bedroom	36.0	107.01
	Medium	0.0003		2.32				
	Low	0.0001		0.28				
Children's toys (new) [g]	High	0.001	1.4	9.45	0.01	Bedroom	36.0	107.01
	Medium	0.001		2.32				
	Low	0.010		0.28				
Furniture components (textile)	High	0.01625	1.4	17	0.01	Living room	50.0	108.98
	Medium	0.001425		12				
	Low	0.000008		7.9				
Shower curtains	High	0.000173	1.4	6.5	0.01	Bathroom	15.0	107.01
	Medium	0.00011						
	Low	0.000064						
Vinyl flooring	High	0.074	1.4	202	0.01	Whole house	492.0	1.E−30
	Medium	0.026		101				
	Low	0.000056		50.5				

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]	Volume (m^3) [d]	Interzone Ventilation Rate (m^3/h) [d]
Wallpaper (in place)	High	0.000626	1.4	200	0.01	Whole house	492.0	1.E−30
	Medium	0.000088		100				
	Low	0.000005		50				

[a] See Section 2.1.1 for weight fraction sources and discussion.
[b] Used density of PVC from various sources, see *DIBP Draft Consumer Exposure Analysis Spreadsheet* (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 may be older than the 2017 CSPC phthalate rule, 16 CFR part 1307.
[g] New toys scenarios consider application of the U.S. Consumer Product Safety Commission (CSPC) final phthalates rule established in 2017 (16 CFR 1307.3(b)) that bans children's toys and childcare articles from containing more than 0.1% of five phthalates, including DIBP. The identified weight fractions in the legacy toys scenario were not limited to 0.1%.

Environmental Parameters

The room of use selected for modeling affects the time occupants spend in the environment while products are actively emitting DIBP, the total volume of air in the room, and ventilation rates. Default values are provided in CEM for use environment and ventilation rates in each room, which may be modified by the user. Time spent in each use environment is defined by activity patterns as described in Section 2.2. For the articles assessed EPA used CEM defaults.

PVC Solid Article to Air Partitioning Coefficient

EPA considers refinement of exposure scenarios (*e.g.*, refinement of input parameters or modelling approach) if potential risk is identified with the screening approach. Potential risk is identified when the Margin of Exposure (MOE) calculated for the screening risk estimates are lower than the benchmark MOE. See Appendix B for results and discussion of the screening and refined approaches. The screening approach relies on CEM using physical chemical properties and kinetic equations to estimate partitioning among surfaces in the use environment, gas phase, and the particle phase that are applicable to most SVOCs with a K_{OW} less than 13. However, when available, empirical, and modeling inputs that are chemical and surface specific are considered less conservative. EPA used DIBP specific empirical date to refine the solid article to air partitioning coefficient. EPA used Gilliam (2022) empirical correlations for the diffusion coefficient and partition coefficient of phthalates in PVC materials. The partition coefficient correlation was tested using di-octyl terephthalate (DOTP) in a PVC-based automotive sealant, which is cured before testing and serves as a proxy for all PVC solid articles within this assessment.

Gilliam (2022) used data from several experimental studies on the equilibrium air concentration for phthalates in PVC-based flooring in a linear regression analysis. For each individual study, data obtained in the temperature range that is representative of indoor environments where the articles are in use were included (Cao et al., 2016a; Cao et al., 2016b; Liang and Xu, 2015, 2014; Xu and Little, 2006). The weight fraction percent concentration of phthalate ranged from 0.1 to 23 percent, and the temperatures in the studies ranged from 15 to 32 °C. With one exception, the partition coefficients were calculated from the data in the studies by applying Equation 2-1, assuming a constant and uniform concentration in the solid. The study by Xu (2006) reported the calculated partition coefficient. For the studies that did not report the concentration of phthalate in the solid material (Cao et al., 2016a; Cao et al., 2016b; Liang and Xu, 2015), it was calculated from the reported percent of phthalate assuming a solid PVC density of 1.38

g/cm^3 (BPF, 2025).

Equation 2-1. Partition Coefficient Formula

$$K = \frac{C(L,t)}{y_0(t)}$$

The data, phthalate concentration in the gas phase at the surface at time *t* and concentration of phthalate in the article at time *t* (µg/m^3), are used to determine the constants in Equation 2-2 where X and Y are estimated based on linear regression of existing data and Vp is vapor pressure in Pa units.

Equation 2-2. Linear Regression Model to Estimate Partition Coefficients

$$ln(K) = X + Y\ ln(V_P)$$

The combined data showed good agreement for the partition coefficient with a coefficient of determination (R^2) value of 0.93. Equation 2-2was used to estimate *K* for four phthalate compounds with *X = 15.11* and *Y = -0.9182*. In experimental validation, *K* of DoTP was calculated to be 1.43×10^{10}, in which its natural log is within the 95 percent confidence interval of the regression equation. Using Equation 2-2 , $K_{PVC\text{-}Air}$ for DIBP can be calculated as follows:

$$ln(K_{PVC-Air}) = 15.11 - 0.9182 \times ln(0.00634)$$
$$ln(K_{PVC-Air}) = 3.8 \times 10^8$$

Mouthing Exposure: For mouthing exposure, key parameters include the rate of chemical migration from the article to saliva (µg/cm^2/hour), surface area mouthed (cm^2), 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, etc.), 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.

Very little data were available for migration rates of DIBP from solid articles to saliva, and no data were found with weight fractions of DIBP similar to those reported for the articles assessed here (< 2 percent DIBP by weight). As such, chemical migration rates of DIBP were modeled with a theoretical framework based on physical and chemical properties of DIBP, and the solid matrix material was employed to estimate this parameter. The model chosen for use was developed based on a regression model and validated against chemical migration rates for a wide range of chemical classes in several materials. This model estimates chemical-material specific chemical migration rates based on physical and chemical properties of DIBP and parameters that can be estimated based on the solid matrix material (Aurisano et al., 2022). The regression-based model takes the form in Equation 2-3.

Equation 2-3. Regression Model for Chemical Migration Rate from Aurisano, (2022)

$$log_{10}R_{mgr} = 3.23 + 0.73log_{10}D_P + 0.92log_{10}C_0 - 0.0610log_{10}K_{OW}$$

Where R_{mgr} is the rate of chemical migration (µg/10 cm^2/min), D_p is the solid phase diffusion coefficient

(cm^2/s), C_0 is the initial concentration of DIBP in the solid matrix ($\mu g/cm^2$), and K_{OW} is the octanol-water partitioning coefficient.

Chemical material-specific values for the solid phase diffusion coefficient were estimated with a quantitative property-property relationship (QPPR) developed to predict diffusion coefficients for a wide range of organic chemicals and materials based on temperature, material type, and molecular weight of the chemical (Huang et al., 2017). This model was internally and externally validated against measured diffusion coefficients and shown to have good predictive capability for chemicals with molecular weights between 30 and ,1178 g/mol at temperatures between 4 and 180 °C. The value calculated and used to assess mouthing exposure was 5.98×10^{-12} m^2/hour.

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 cm^2 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 cm^2 was therefore chosen for all mouthing exposure models for children.

Mouthing Duration: Mouthing durations were obtained from the *Exposure Factors Handbook*, Table 4-23 (U.S. EPA, 2011c), which provides mean mouthing durations for children between 1 month and 5 years of age, broken down by age groups expected to have similar behaviors. 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.*, synthetic leather furniture). The data provided in the 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 Table 4-23 of the *Exposure Factors Handbook* (U.S. EPA, 2011c) 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 Handbook) was used in the medium exposure scenario as shown in Table 2-6.

Table 2-6. Mouthing Durations for Children for Toys and Other Objects

	Estimated Mean Daily Mouthing Duration Values (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]**	**Medium 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 [b]**	**Medium Exposure Scenario [c]**	**Low Exposure Scenario [d]**
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 Year**	**4 Years**	**5 Years**	**High Exposure Scenario [b]**	**Medium Exposure Scenario [c]**	**Low Exposure Scenario [d]**
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 the *Exposure Factors Handbook* (U.S. EPA, 2011c)
[b] High exposure scenario value was the largest of the reported mouthing durations for each age group.
[c] 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 inhalation, while dermal exposures were modeled outside of CEM, see Section 2.3. Higher concentrations of DIBP in air result in increased inhalation exposure. This may occur due to product formulation or use patterns that allow for higher emissions of DIBP to air, and/or environment specific characteristics such as smaller room volume and lower ventilation rates. Key parameters that control DIBP emission rates from products in CEM 3.2 models are weight fraction of DIBP 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.

Sealants for small home repair products, assessed for dermal contact only (see Table 2-1), were not modeled with CEM. For dermal exposure modeling, the weight fraction data are used to confirm the presence of DIBP 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, and frequency of the contact.

Flooring adhesives 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 2-7.

CEM default values for key parameters for exposure modeling including product mass used, duration of

use, and frequency of use were not available for the specific products identified with DIBP content. As such, values for these parameters were based on professional judgment that incorporated information from product labels and technical specifications as well as information obtained from an informal survey of customer reviews on e-commerce sites. Product densities were taken from product specific technical specifications and SDS sheets when possible. In instances where no data were available for a product type, a density obtained for a similar product was used as a proxy. A detailed description of derivations of 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 2-7. Note that articles not modeled for inhalation exposure are not included in the table.

Mass of Product Used

All of the products identified are primarily used for DIY home improvement and repair projects, see Section 2.1.2. In all cases, the mass of product applied in each scenario was based on the reasonable assumption that the volume in which products are sold is adequate for the tasks they are intended for. Mass of product used inputs was based on a survey of consumer available products fitting the COU description on manufacturers websites, see DIBP Product Review tab (links and products available) in *Draft Risk Evaluation for Diisobutyl Phthalate (DIBP) - Supplemental Information File: Consumer Exposure Analysis* (U.S. EPA, 2025a). This section summarizes the identified information for each product. For flooring adhesives, a single product was identified that was sold in a 5 gallon can. The high exposure scenario for this product assumed that the entire mass of the product container is used, reflecting scenarios where a large project or extensive application is undertaken. Medium exposure scenario 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 caulking products, two products were identified in different size containers. For these products, the high exposure scenario assumed that the entire container with the larger volume is used, low scenario assumed that the entire container with the smaller volume is used, and medium exposure scenario used the average of these values.

Duration of Use

Duration of use inputs was based on a survey of consumer available products fitting the COU description on manufacturers websites, see DIBP Product Review tab (links and products available) in *Draft Risk Evaluation for Diisobutyl Phthalate (DIBP) - Supplemental Information File: Consumer Exposure Analysis* (U.S. EPA, 2025a) and professional judgment. For flooring adhesives products, large projects 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. Caulking products 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.

Frequency of Use

The frequency of use input is used in the calculation of acute and chronic exposure durations. Acute exposures are for an exposure duration of 1 day and chronic exposures are for an exposure duration of one year. For flooring adhesives, given the significant work required to prepare and clean up after use as well as the relatively niche use of this product, use is not anticipated to be routine for consumers. The product is assumed to be used for a single project each year, which may take 2 days to complete. For caulking products, daily use was not considered likely, but the product could reasonably be used weekly

during a period of extensive home renovations. Therefore, this product was modeled using conservative assumptions at a use frequency of 52 times per year. For all liquid and paste products, acute frequency was modeled as one use per day.

Environmental Parameters

The room of use selected for modeling affects the time occupants spend in the environment while products are actively emitting DIBP, the total volume of air in the room, and ventilation rates. Default values are provided in CEM for use environment and ventilation rates in each room, which may be modified by the user. Time spent in each use environment is defined by activity patterns as described in Section 2.2 and cannot be modified for individual environments within CEM. As such, it is sometimes required to select an environment of use based on the activity pattern required and modify the environmental parameters to reflect conditions in the home area in which a product is expected to be used.

In this assessment, the majority of the products modeled used CEM defaults for all parameters in the specified room of use. However, for indoor floor refinishing products, the garage environment was selected as CEM activity patterns do not include any time in this room. This was chosen to reflect the fact that occupants are not expected to spend time in rooms with recently refinished floors outside of time spent actively applying the products. For this model, room volume and ventilation rates were changed from CEM default values for garage to CEM default values for living room as shown in Table 2-7.

Table 2-7. Summary of Key Parameters for Products Modeled in CEM 3.2

Product	Exposure Scenario Level [a]	Weight Fraction [b]	Density (g/cm^3) [c]	Duration of Use (min) [d e]	Product Mass Used (g) [d e]	Chronic Freq. of Use (year^{-1}) [d e]	Acute Freq. of Use (day^{-1}) [d e]	Use Environ.; Volume (m^3) [d g]	Air Exchange Rate, Zone 1 and Zone 2 (h^{-1}) [f]	Interzone Ventilation Rate (m^3/h) [g]
Sealants for small home repairs	H	0.4	4.9	120	2,062.5	2	1	Kitchen; 24	0.45	108.978
	M	0.175		60	1,285.878					
	L	0.05		30	509.2557					
Flooring adhesive	H	0.05	1.1	480	19,873.4	2	1	Whole House; 492	0.45	1E−30
	M	0.0375		240	5,712.948					
	L	0.025		120	406.6356					

[a] See Section 2.1.2. High-intensity use value is the maximum of the reported range, the low-intensity use value is the minimum of the reported range, and the medium-intensity use value is the mean of the reported maximum and minimum.
[b] Weight fraction in decimal, information is available in Section. 2.1.2.
[c] Used product SDS reported density value, for flooring adhesive Simpson Strong-Tie Company Inc (2014) and for sealants for small home repairs Chemical Concepts Inc (2014); Abesco Fire LLC (2015); and Jowat Corporation (2016).
[d] From product use information provided by manufacturers, available in DIBP Product Review tab in U.S. EPA (2025a).
[e] Based on product use descriptions, available in DIBP Product Review tab in U.S. EPA (2025a).
[f] 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.
[g] CEM default.

2.3 Dermal Modeling Approach

This section summarizes the available dermal absorption data related to DIBP, the interpretation of the dermal absorption data, dermal absorption modeling efforts, and uncertainties associated with dermal absorption estimation in Section2.3. 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 below. Dermal exposures to vapors are not expected to be significant due to the extremely low volatility of DIBP, and therefore, are not included in the dermal exposure assessment of DIBP.

EPA assumes that the rate of transport of DIBP across the dermal barrier is considered flux limited, rather than delivery limited. Briefly, the physical and chemical properties of DIBP (high molecular weight, large size, and low solubility in water) impede its ability to cross the dermal barrier, limiting the rate of flux independent of the concentration on the skin. CEM does not have built in models appropriate for flux limited dermal uptake, so dermal exposure modeling was done outside of CEM for both liquid and solid products.

2.3.1 Dermal Absorption Data

Dermal absorption data related to DIBP are limited. Specifically, EPA identified only one study directly related to the dermal absorption of DIBP (Elsisi et al., 1989), which was an *in vivo* absorption study using male F344 rats. For each *in vivo* dermal absorption experiment, neat DIBP was applied to a freshly shaven area of 1.3 cm^2 in doses ranging from 5 to 8 mg/cm^2 and the site of application was covered with a perforated cap. Urine and feces were collected and analyzed every 24 hours for a duration of 7 days, and at the end of the seventh day, each rat was killed and all remaining contents (tissues, organs, *etc.*) were analyzed. Results of the study showed 52 percent absorption of DIBP over the 7-day period. EPA calculated the maximum flux of neat DIBP in rats equal to 2.48×10^{-2} $mg/cm^2/h$. Elsisi et al. (1989) also measured dermal absorption for dibutyl phthalate (DBP), and results show 64.8 percent absorption of DIBP over the 7-day period. EPA calculated the maximum flux of neat DBP in rats equal to 3.08×10^{-2} $mg/cm^2/h$.

There was also one study identified that measured the *in vitro* dermal absorption of dibutyl phthalate (DBP) using human skin (Scott et al., 1987). Specifically, the study used dermal doses of approximately 0.5 mL of DBP, applied over 3 cm diameter skin samples, and then the steady-state absorption of DBP in both rat and human skin was measured. The study results show the absorption of DBP through rat skin as 9.33×10^{-3} $mg/cm^2/h$ and absorption of DBP through human skin as 7.0×10^{-5} $mg/cm^2/h$, which indicates that DBP may penetrate rat skin over 100 times more rapidly than human skin.

The dermal absorption study by Elsisi et al. (1989) reports the dermal absorption of both DBP and DIBP in live rats, with the maximum rates of dermal absorption equal to 3.08×10^{-2} $mg/cm^2/h$ and 2.48×10^{-2} $mg/cm^2/h$, respectively. The study by Elsisi et al. (1989) shows that the rates of dermal absorption measured in live rats are quite similar between the two chemicals. However, dermal absorption rates measured from rat skin may overestimate dermal absorption rates applicable to human skin. Specifically, the study by Scott et al. (1987) shows that rat skin is over 100 times more permeable than human skin with respect to absorption of DBP. Since DIBP and DBP are isomers, and the two isomers share very similar physical-chemical properties (*i.e.*, identical molecular weights and very similar octanol-water partition coefficients), it is expected that the difference in permeability between rat skin and human skin exhibited by DBP is also relevant for DIBP. Because absorption data from live rats likely overestimate dermal absorption of DIBP in humans, and due to the similar physical and chemical properties between DBP and DIBP. EPA prefers the use of surrogate dermal absorption data for DBP in human skin samples over dermal absorption data for DIBP in live rats to estimate the potential rate of

dermal absorption of DIBP in humans.

For tire crumb rubber, the method described below was not used as surface area in contact with the material could not be estimated with confidence based on available data. A detailed description of dermal uptake modeling for DIBP from tire crumb rubber is described in Section 2.5.

2.3.2 Dermal Absorption Modeling

Because DIBP exhibits relatively low water solubility (*i.e.*, 6.2 mg/L) and a relatively high octanol-water partition coefficient (*i.e.*, log K_{OW} = 4.34), it is expected that aqueous solubility limits the rate of DIBP absorption. Therefore, EPA has modeled the rate of absorption of DIBP through aqueous media as outlined below.

The first step in modeling 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 DIBP as 0.016 cm/h. Next, EPA relied on Equation 3.2 from the *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual, (Part E: Supplemental Guidance for Dermal Risk Assessment)* (U.S. EPA, 2004) which characterizes dermal uptake (through and into skin) for aqueous organic compounds. Specifically, Equation 3.2 from U.S. EPA (2004), also shown in Equation 2-4 below, was used to estimate the dermally absorbed dose (DA_{event}, mg/cm^2) for an absorption event occurring over a defined duration (t_{abs}).

Equation 2-4. Dermal Absorption Dose During Absorption Event

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

Where:

DA_{event}	=	Dermally absorbed dose during absorption event t_{abs} (mg/cm^2)
FA	=	*Effect of stratum corneum on quantity absorbed = 0.9 [see value for DIBP* in the supplemental spreadsheet of U.S. EPA (2004)] "Organic Chemicals in Water"]
K_p	=	Permeability coefficient = 0.016 cm/hour (calculated using CEM (U.S. EPA, 2023))
S_w	=	Water solubility = 6.2 mg/L [see (U.S. EPA, 2024b)]
t_{lag}	=	$0.105 \times 10^{0.0056MW} = 0.105 \times 10^{0.0056 \times 278.35}$ = 3.8 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. The dermal consumer exposure assessment scenarios consider a range of exposure durations described for each COU and product/article scenario in Section 2.3.4. Figure 2-1 illustrates the relationship between the average absorptive flux and the absorption time for DIBP.

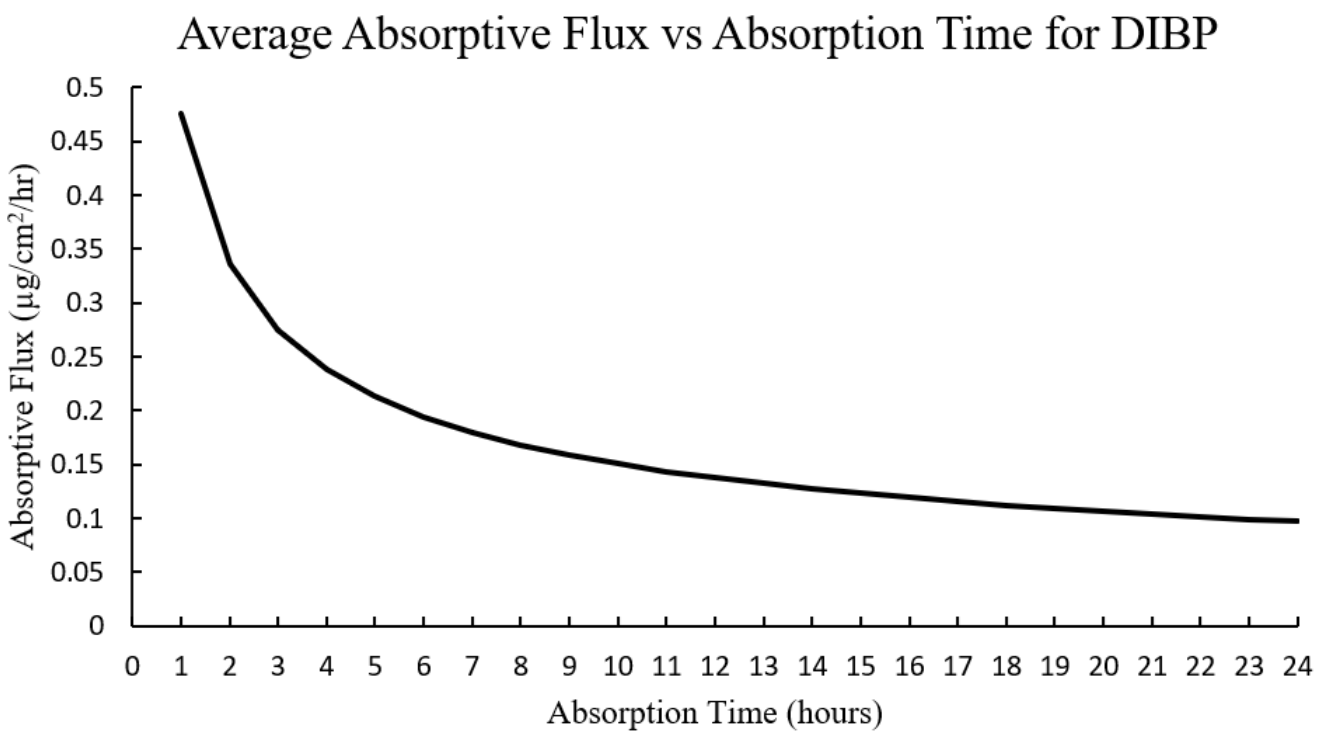

Figure 2-1. DIBP Average Absorptive Flux vs. Absorption Time

Figure 2-1 shows that the average absorptive flux for DIBP is expected to vary between 0.47 and 0.1 µg/cm^2/h for durations between 1 and 24 hours, respectively. The range of modeled flux values are two orders of magnitude lower than measured by the *in vivo* rat absorption data presented by Elsisi et al. (1989), and rather, the modeled values of absorption of DIBP more directly align with the surrogate dermal absorption data of DBP measured with *in vitro* human skin samples by Scott et al. (1987).

2.3.3 Flux-Limited Dermal Absorption for Liquids and Solids

In agreement with the results presented by Scott et al. (1987), dermal absorption modeling of DIBP, as shown in Section 2.3.2, also suggests that absorption of DIBP through human skin is likely much lower than predicted by the *in vivo* rat absorption testing by Elsisi et al. (1989). Further, there is reasonable comparison between the modeled rate of absorption of DIBP (*i.e.*, 1.7×10^{-4} mg/cm^2/h) and the surrogate rate of absorption measured for DBP in human skin (*i.e.*, 7.0×10^{-5} mg/cm^2/h). As mentioned in Section 2.3.1, EPA prefers the use of surrogate dermal absorption data for DBP in human skin samples over dermal absorption data for DIBP in live rats to estimate the potential rate of dermal absorption of DIBP in humans. Also, the Agency prefers the use of measured data over modeled data for estimating exposure. The rate of dermal absorption of DBP in human skin samples was measured as 7.0×10^{-5} mg/cm^2/h by Scott et al. (1987), and EPA has determined that this rate of absorption is the most reasonable data to characterize the rate of dermal absorption of DIBP in humans. Using the DBP Scott et al. (1987) rate of dermal absorption is more representative of dermal exposures to liquid products since the experiments were performed using liquid neat chemical. In the dermal exposure to solid articles approach, EPA assumes DIBP first migrates from the solid matrix to a thin layer of moisture on the skin surface. Hence, using the Scott et al. (1987) rate of dermal absorption for solids is considered an upper bound estimate.

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 2-8. For contact area, professional judgment, based on product use descriptions from manufacturers and an article's 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 *Draft Risk Evaluation for Diisobutyl Phthalate (DIBP)* (U.S. EPA, 2025e). For items which were considered to have a high level of uncertainty or potential variability, different surface areas were assumed in high, medium, and low scenarios. The subsections under Table 2-8 provide details on assumptions used to derive other key parameters. Calculations, sources, input parameters and results are also available in *Draft Risk Evaluation for Diisobutyl Phthalate (DIBP) - Supplemental Information File: Consumer Exposure Analysis* (U.S. EPA, 2025a). Acute and chronic dose calculations and equations are summarized in AppendixA.4.

Table 2-8. Key Parameters Used in Dermal Models

Product	Scenario	Duration of Contact (minutes)	Chronic Frequency of Contact (year^{-1})	Acute Frequency of Contact (day^{-1})	Dermal Flux (mg/cm^2/hour) [g]	Contact Area
Air beds	High	857 [b]	36	1	7.0E−05	25% of face, hands, and arms
	Medium	480 [c]				
	Low	120 [c]				
Car mats	High	60 [d]	52	1	7.0E−05	10% of hands (some fingers)
	Medium	30 [d]				
	Low	15 [d]				
Carpet tiles	High	120 [e]	365	1	7.0E−05	Inside of 2 hands (palms, fingers)
	Medium	60 [e]				
	Low	30 [e]				
Children's toys (legacy)	High	137 [f]	365	1	7.0E−05	Inside of 2 hands (palms, fingers)
	Medium	88 [f]				
	Low	24 [f]				
Children's toys (new)	High	137 [f]	365	1	7.0E−05	Inside of 2 hands (palms, fingers)
	Medium	88 [f]				
	Low	24 [f]				
Clothing (synthetic leather)	High [a]	480 [c]	52	1	7.0E−05	50% of entire body surface area
	Medium	240 [c]				25% of face, hands, and arms
	Low	120 [c]				Inside of 2 hands (palms, fingers)
Clothing (children's)	High	480 [c]	365	1	7.0E−05	50% of entire body surface area
	Medium	240 [c]				25% of face, hands, and arms
	Low	120 [c]				Inside of 2 hands (palms, fingers)
Concrete adhesive	High	120 [d]	2	1	7.0E−05	10% of hands (some fingers)
	Medium	60 [d]				
	Low	30 [d]				
Flooring adhesive	High	480	2	1	7.0E−05	10% of hands (some fingers)
	Medium	240				
	Low	120				
	High	480 [c]	365	1	7.0E−05	Inside of 1 hand (palms, fingers)

Product	Scenario	Duration of Contact (minutes)	Chronic Frequency of Contact (year $^{-1}$)	Acute Frequency of Contact (day^{-1})	Dermal Flux (mg/cm^2/hour) [g]	Contact Area
Footwear components	Medium	240 [c]				
	Low	120 [c]				
Furniture components (textile)	High	480 [c]	365	1	7.0E−05	50% of entire body surface area
	Medium	240 [c]				25% of face, hands, and arms
	Low	120 [c]				Inside of 2 hands (palms, fingers)
Sealants for small home repairs	High	120 [d]	2	1	7.0E−05	Inside of 2 hands (palms, fingers)
	Medium	60 [d]				Inside of 1 hand (palms, fingers)
	Low	30 [d]				10% of hands (some fingers)
Shower curtains	High	60 [c]	365	1	7.0E−05	Inside of 1 hand (palms, fingers)
	Medium	30 [c]				
	Low	15 [c]				
Small articles with potential for semi-routine contact	High	120 [c]	365	1	7.0E−05	Both hands (entire surface area)
	Medium	60 [c]				Inside of 2 hands (palms, fingers)
	Low	30 [c]				10% of hands (some fingers)
Vinyl flooring	High	120 [e]	365	1	7.0E−05	Inside of 1 hand (palms, fingers)
	Medium	60 [e]				
	Low	30 [e]				
Wallpaper (in place)	High	60 [c]	365	1	7.0E−05	Inside of 1 hand (palms, fingers)
	Medium	30 [c]				
	Low	15 [c]				
Wallpaper (installation)	High	480 [c]	1	1	7.0E−05	Inside of 2 hands (palms, fingers)
	Medium	240 [c]				
	Low	120 [c]				

[a] High-intensity use exposure scenario is a hypothetical for items of clothing like tops and bottoms. EPA did not identify evidence that this is an actual use. Scenario was not used for risk characterization.
[b] Value corresponds to the sleep times for 1- to 4-year-olds presented in the *Exposure Factors Handbook* Table 16-26 (U.S. EPA, 2011c).
[c] Professional judgement assumption based on product and article use description.
[d] From CEM input for same product for inhalation and ingestion scenarios.
[e] Based on EPA's Standard Operating Procedures for Residential Pesticide Exposure Assessment for the high-exposure level (2 hours; time spent on floor surfaces) (U.S. EPA, 2012), ConsExpo for the medium-exposure level (1 hour; time a child spends crawling on treated floor), and professional judgment for the low exposure level (0.5 hour)
[f] From EPA's *Exposure Factors Handbook*.
[g] See Sections 2.3.1 and 2.3.3.

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 as described in Section 2.2.3.2. For products not modeled in CEM (concrete adhesive) consumer reviews indicated that the product was used for outdoor projects of moderate size as well as small repairs. As

such, duration of use was assumed to be 120, 60, and 30 minutes for large, medium, and small projects.

For articles for which default input values for duration of use are not available in CEM, professional judgment was used to select the duration of use/article contact for the low-, medium-, and high-exposure scenario levels. For flooring products (carpet tiles and vinyl flooring), 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) (U.S. EPA, 2012), ConsExpo for the medium exposure level (1 hour; time a child spends crawling on treated floor), and professional judgment for the low exposure level (0.5 hour) . For articles used in large home DIY projects (wallpaper 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, footwear, 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 the high-, medium-, and low-intensity use exposure scenarios, respectively. Additionally, for children's clothing EPA assumes changes of clothing to other items not necessarily containing DIBP, specially for young children still using diapers or needing more changes during the day.

For synthetic leather clothing EPA did not use the high-intensity use scenario for further risk characterization. This is because the identified clothing item examples were jackets and raincoats which are not commonly used for 8 hours and are 50 percent of the entire body surface in contact with the item of clothing. The high-intensity use scenario is for hypothetical synthetic leather clothing such as pants and shirts, for which EPA did not identified support that it is an actual use. For furniture high-intensity use exposure scenario it was assumed that 8 hours of contact (50% of entire body, partially dressed person) simulate sleeping on a cough for people 11 years of age and older, but younger children (infants, toddlers, and preschoolers) are unlikely to sleep on furniture for that long. It was assumed that infants and toddlers (1–2 years) sleeping on furniture for 8 hours was a misuse. However, toddlers may sit and nap, not continuously, for 4 and 2 hours on furniture in a day. Contact durations of 60, 30, and 15 minutes were assigned to articles anticipated to have low durations of contact (car mats, shower curtain, and routine (in-place) contact with wallpaper and specialty wall coverings).

For air beds, contact durations of 857, 480, and 120 minutes and 25 percent of face, arms and hands were applied. The 857-minute values correspond to the sleep times for 1- to 4-year-olds presented in Table 16-26 of the *Exposure Factors Handbook* (U.S. EPA, 2011c), which were used for the high-intensity use exposure scenario. The 480- and 120-minute contact durations were used for the medium- and low-intensity use scenarios, respectively. EPA used professional judgment for using 480 minutes to represent an average nighttime sleeping pattern, and 120 minutes to represent an average nap time. The surface area of skin in contact was selected to simulate long sleepwear commonly used while camping or sleepover activities. To estimate contact time with children's toys, data were obtained from the Handbook, Table 16-26. Reported values for playtime for children under 15 ranged from 24 mins/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 years was also used for children 16 to 20 years due to lack of playtime duration information for this age range and as a conservative assumption that can be further refined should risk be identified in the risk characterization stage of this assessment, see Section 4 of the *Draft Risk Evaluation for Diisobutyl Phthalate (DIBP)* (U.S. EPA, 2025e).

In addition to the scenarios for dermal exposure to DIBP from specific articles, a scenario was modeled in which consumers may have semi-routine contact with one or more small items containing DIBP. 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 DIBP 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.

Range for 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 products used in potentially large outdoor DIY projects (concrete adhesives), due to significant work required to prepare and clean-up afterwards it was assumed that these projects were carried out over a 2-day period once per year.

For articles, assumptions about frequency of use were made based on professional judgment based on one contact per event duration as a conservative approach, further refinement is considered at the risk calculation stage, see Section 4 of the *Draft Risk Evaluation for Diisobutyl Phthalate (DIBP)* (U.S. EPA, 2025e). For articles which are expected to be used on a routine basis, such as children's toys, furniture, and shower curtains, use was assumed to be once per day every day. Similarly, for routine contact with household building materials (carpet tiles, vinyl flooring, and wallpaper), contact was assumed to occur on a daily basis. For articles used in large home DIY projects (wallpaper installation), due to significant work required to prepare and clean-up afterwards it was assumed that installation was carried out over a single day once per year. DIBP is expected to be present in PU leather garments. 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. However, children's clothing items reported in the HPCDS database did not provide adequate descriptive data to draw conclusions about the garment type or specific component measured. As such, both footwear components and children's clothing were modeled with daily contact. Car mats were modeled as a single contact event each week, to represent an individual who does a weekly car cleaning. Air beds were modeled to be used sporadically for overnight trips and camping for an average of three nights once a month, or 36 events in 1 year.

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 2-5 for inhalation and Table 2-8 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 A.3.

Table 2-9. Short-Term Event per Month and Day Inputs

Product	Events Per Day[a]	Events Per Month[a]
Concrete adhesive	1	2
Flooring adhesive	1	2
[a] Events per day and month values determined using professional judgment based on manufacturer product description use.		

2.5 Tire Crumb Rubber Modeling

Tire crumb rubber was modeled using a similar approach to a previously published exposure characterization for the material (U.S. EPA, 2024d). This approach models exposure to tire crumb via inhalation, ingestion, and dermal contact. It was peer reviewed at the time of publication and allows for an estimate of dose with the limited data available.

The exposure characterization provides concentrations of SVOCs in air samples obtained from both outdoor (number of samples = 25) and indoor playing fields (number of samples = 15) and a separate document published in conjunction provided measurements of DIBP content in tire particles retrieved from the same locations (U.S. EPA, 2019b). Concentrations of DIBP in air were not reported in the exposure characterization report. However, DIBP concentrations in the tire particles themselves were reported in the associated tire particle characterization document and were very similar to the reported content of DBP. Physical and chemical properties expected to significantly impact chemical transport including molecular weight, octanol air partitioning coefficient, and solubility in water are similar between DIBP and DBP; thus, it is reasonable to assume that air concentrations of DBP may provide a reasonable proxy for DIBP. These data were used to develop estimates for exposure to DIBP during sporting events on tire crumb fields as described below. All calculations are provided in *Draft Consumer Exposure Analysis for Diisobutyl Phthalate (DIBP)* (U.S. EPA, 2025a).

2.5.1 Tire Crumb Inhalation Exposure

Air samples were collected for semi-volatile organic compound (SVOC) analysis without a size-selective particle inlet to allow both vapor- and particle-phase SVOCs to be collected simultaneously. Separate particle- and gas-phase air concentrations were not measured. However, as previously discussed DIBP is more likely to be present in the particulate rather than gaseous phase. As such, it is unlikely that inhaled DIBP will be fully absorbed after inhalation and the fraction absorbed was estimated to be 0.7. This was the recommended value in the exposure characterization (U.S. EPA, 2024d) and likely represents a health protective estimate given the slow rate of diffusion through solid media for DIBP and low solubility in aqueous fluids which would limit partitioning to lung fluids. The inhaled dose per event is defined below in Equation 2-5:

Equation 2-5. Inhalation Dose Per Exposure Event

$$Inhalation\ Event\ Dose = (C_{air}\ x\ R_{inh}\ x\ ET\ x\ ABS)/BW$$

Where:

- C_{air} = Concentration of DIBP in air (mg/m^3)
- R_{inh} = Inhalation rate (m^3/hour)
- ET = Exposure time (hours)
- ABS = Fraction absorbed (0.7)
- BW = Body weight (kg)

Age stratified inhalation rates during high-intensity activity were taken from the *Exposure Factors Handbook*, Table 6-2 (U.S. EPA, 2011c). Body weight values were the same as those used in CEM. Exposure time was assumed to be 1 hour for children aged less than 11 years, 3 hours for teens aged 11 to 16 years, and 2 hours for older teens and adults.

2.5.2 Tire Crumb Dermal Exposure

Dermal exposure to tire crumb was assessed under the assumption of dermal adherence during play and subsequent absorption; The 10th, 50th, and 90th percentile measurements of DIBP in tire crumb samples

were used in low-, medium-, and high-exposure scenarios. The fraction of DIBP absorbed from each event was assumed to be 10 percent as recommended in the exposure characterization (U.S. EPA, 2024d). It is likely that this value somewhat overestimates exposure given that uptake of DIBP is expected to be flux limited. However, a flux-based value could not be calculated as there were no data available to estimate total contact area of the particulate matter adhered to skin and the assumption of 10 percent absorption is expected to provide a reasonable, health protective estimate. Dermal dose per exposure event was defined as:

Equation 2-6. Inhalation Dose Per Exposure Event

$$Dermal\ Event\ Dose = (C_{solid}\ x\ ADH\ x\ SA\ x\ ABS)/BW$$

Where:

C_{solid}	=	Concentration of DIBP in crumb rubber (mg/g)
ADH	=	Solids adherence on skin (g/cm^2 -day)
SA	=	Skin surface area available for contact (cm^2)
ABS	=	Fraction absorbed (0.1)
BW	=	Body weight (kg)

Age-specific adherence factors were calculated by estimating the percentage of a skin surface area exposed while wearing a typical sports uniform during the summer, multiplying those percentages by the total surface area per body part found in EPA's *Exposure Factors Handbook* (U.S. EPA, 2011b), summing the products and then dividing by the total exposed body surface area of the body parts to get a weighted adherence factor (Equation 5-4); this equation can be found in Chapter 7 of the Handbook (U.S. EPA, 2011b). Body part percentages were assumed to be 100 percent of the face, 72.5 percent of the arms, 40 percent of the legs (to account for socks and short pants), and 100 percent of the hands. These values were recommended in the exposure characterization based on empirical observations.

Values for dermal adherence to skin were obtained from Kissel et al. (1996b). Only values for adherence of solids to skin after playing sporting events on tire crumb fields was used in this assessment; the upper and lower boundaries of the 95 percent confidence interval were used in high- and low-exposure scenarios, respectively. The geometric mean reported value was used in the medium-exposure scenario.

2.5.3 Tire Crumb Ingestion Exposure

The same values of DIBP content in solid particles described in Section 2.5.1 were used to estimate exposure by inadvertent ingestion during play. The absorption fraction of 50 percent recommended in the exposure characterization was used (U.S. EPA, 2024d). Ingestion dose per exposure event was then calculated as:

Equation 2-7. Ingestion Dose Per Exposure Event

$$Ingestion\ Event\ Dose = (C_{solid}\ x\ R_{ing}\ x\ ET\ x\ ABS)/BW$$

Where:

C_{solid}	=	Concentration of DIBP in crumb rubber (mg/g)
R_{ing}	=	Ingestion rate (g/day)
ET	=	Exposure time (day)
ABS	=	Fraction absorbed (0.5)
BW	=	Body weight (kg)

Age stratified ingestion rates were taken from the *Exposure Factors Handbook*, Table 5-1 (U.S. EPA, 2011c).

2.5.4 Tire Crumb Acute and Chronic Dose Calculation

For all exposure routes, acute and chronic doses were calculated as follows:

Equation 2-8. Chronic Average Daily Dose (CADD)

$$CADD = (Event\ Dose\ x\ Events\ x\ \ EF)/T_A$$

Where:

EF = Exposure Frequency (days/year)
Events = Number of exposure events per day (days^{-1})
T_A = Averaging Time (years)

Equation 2-9. Acute Dose Rate (ADR)

$$ADR = (Event\ Dose\ x\ Events\ x\ EF)/T_A$$

Where:

EF = Exposure Frequency (days^{-1})
Events = Number of exposure events per day (days^{-1})
T_A = Averaging Time (days)

For all exposure scenarios, the number of exposure events per day was assumed to be one. For chronic dose calculations, the averaging time was assumed to be 1 year for all scenarios and the exposure frequency assigned was 78 days per year for children under 11, 138 days per year for older children and teens under 16, and 138 days per year for older teens and adults. These values were recommended in the exposure characterization document based on empirical observations (U.S. EPA, 2024d).

3 CONSUMER EXPOSURE MODELING RESULTS

This section summarizes the dose estimates from inhalation, ingestion, and dermal exposure to DIBP in consumer products and articles. Exposure via the inhalation route occurs from inhalation of DBP gas-phase emissions or when DBP partitions to suspended particulate from installation of solid 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 DIBP 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

DIBP Draft Consumer Risk Calculator (U.S. EPA, 2025b) summarizes all the high, medium, and low acute dose rate results from modeling in CEM and outside of CEM (dermal only) for all exposure routes and all lifestages. Products and articles marked with a dash (-) did not have dose results because the product or article was not targeted for that lifestage or exposure route. Dose results applicable to bystanders are highlighted. Bystanders are people that are not in direct use or application of a product but can be exposed to DIBP 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 scenario inputs were selected as proximity to the product during use would result in larger exposure doses. The main purpose of *DIBP Draft 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 which results are used for bystanders. Data patterns are illustrated in figures and summary descriptions of the patterns by exposure route and population or lifestage are summarized in this section.

Figure 3-1 through Figure 3-7 show acute dose rate data for all products and articles modeled in all lifestages assessed. The figures show ADR estimated from exposure via inhalation, ingestion (aggregate of mouthing, suspended dust ingestion, and settled dust ingestion), and dermal contact. Among the younger lifestages, there was no clear pattern which showed a single exposure pathway most likely to drive exposure. However, for teens and adults, dermal contact was a strong driver of exposure to DIBP, 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 and articles covers a larger range than others primarily due to a wider distribution of DIBP weight fraction values and behavioral factors such as duration of use or contact time and mass of product used as described in Section.2.2. Key differences in exposures among lifestages include designation as product user or bystander; behavioral differences such as mouthing durations, hand to mouth contact times, and time spent on the floor; and dermal contact expected from touching specific articles which may not be appropriate for some lifestages. Figures and observations specific to each lifestage are below.

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

Figure 3-1 show all exposure routes for infants less than a year old and toddlers 1 to 2 years and Figure 3-2 show all exposure routes for preschoolers ages 3 to 5 and middle childhood children ages 6 to 10 years. Exposure patterns were very similar for products or articles and routes of exposure across these four lifestages. Ingestion route acute dose results in the figures show the sum of all ingestion scenarios, mouthing, suspended dust, and surface dust when applicable for that scenario, see Table 2-1. Inhalation

exposures consider suspended dust that has been in direct contact with the article and is then resuspended or gas phase emissions that partition to suspended dust.

The acute dose values of DIBP from exposure to consumer products and articles are driven primarily by dermal and inhalation exposures, except for vinyl flooring where the range of ingestion doses from medium- to high-intensity use are higher than dermal doses. Dermal ADR values are sometimes higher, for example, air beds, furniture textiles, and children's clothing, and in other scenarios inhalation is higher like vinyl flooring, wallpaper in-place, and legacy children's toys.

Inhalation is the highest exposure dose followed by dermal and then ingestion for products used in small amounts, such as adhesives and sealants. For articles, dermal doses can be higher than the other routes, like clothing, carpet tiles, furniture components, shower curtains, and new and legacy children's toys or lower than inhalation like vinyl flooring and air beds. In the case of vinyl flooring the higher inhalation dose is due to larger DIBP weight fractions than in other articles. Dermal exposure differences among scenarios are driven mainly by the exposure duration, frequency of the contact, and exposed dermal surface area. Air beds, children's clothing, and furniture textiles dermal dose values were higher mainly because these scenarios used contact durations longer than the other dermal scenarios, 2 to 14 hours per event for air beds and 2 to 8 hours per event for furniture textiles and clothing for low- to high-intensity use scenarios and significantly larger surface area of skin exposed than for other products and articles, like wallpaper, flooring, small articles, footwear that may have similar contact durations, but less contact skin surface area.

The highest acute dose for these age groups is from inhalation of suspended dust and gas-phase emissions from vinyl flooring followed by adhesives, furniture components, children's toys, in-place wallpaper, carpet tiles, shower curtains, air beds, and car mats. Inhalation doses of adhesives and sealants for these lifestages represent bystander exposures, which is a person in the proximity of someone else using such products. These products inhalation doses are higher than certain articles, like carpet tiles, air beds, children's toys, and in-place wallpaper, and lower for vinyl flooring and furniture textiles doses. The differences are driven by DIBP weight fractions and total surface area of articles and indoor presence, for example, vinyl flooring and furniture surfaces are much larger than those covered by toys, shower curtains, and smaller or less numerous articles, in addition to having larger weight fractions as well.

Ingestion of DIBP has the overall lowest doses across scenarios except for vinyl flooring. For articles assessed for mouthing, such as toys, and furniture textiles exposure from mouthing is expected to have a larger impact in the overall ingestion dose because is a direct exposure; however, that is not the case, ingestion of settled dust had a larger impact in the overall ingestion doses, see Figure 3-3 and Figure 3-4. Mouthing tendencies decrease or cease entirely for children aged 6 to 10 years; thus, there is no mouthing influences in ingestion doses for ages above 6 years. 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.

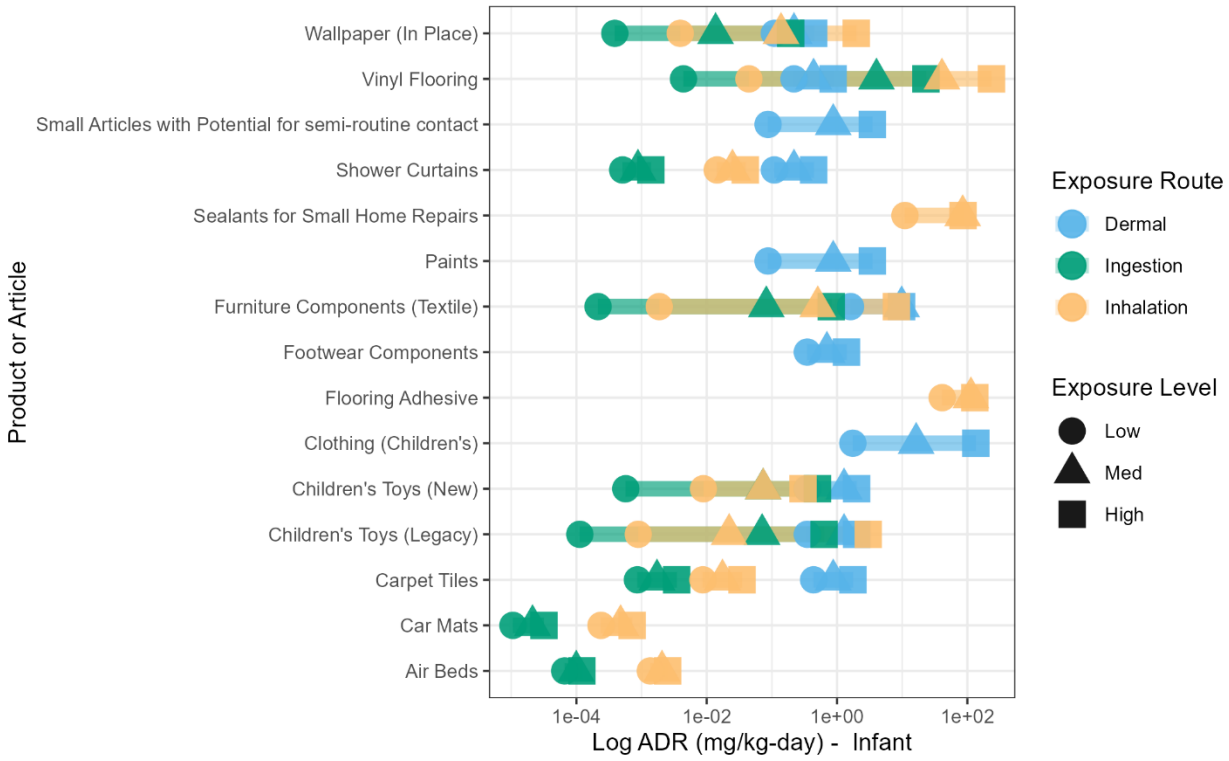

Figure 3-1. Acute Dose Rate for DIBP from Ingestion, Inhalation, Dermal Exposure Routes in Infants Aged <1 Year and Toddlers Aged 1–2 Years

Note: Horizontal axis label is for infants and toddlers.

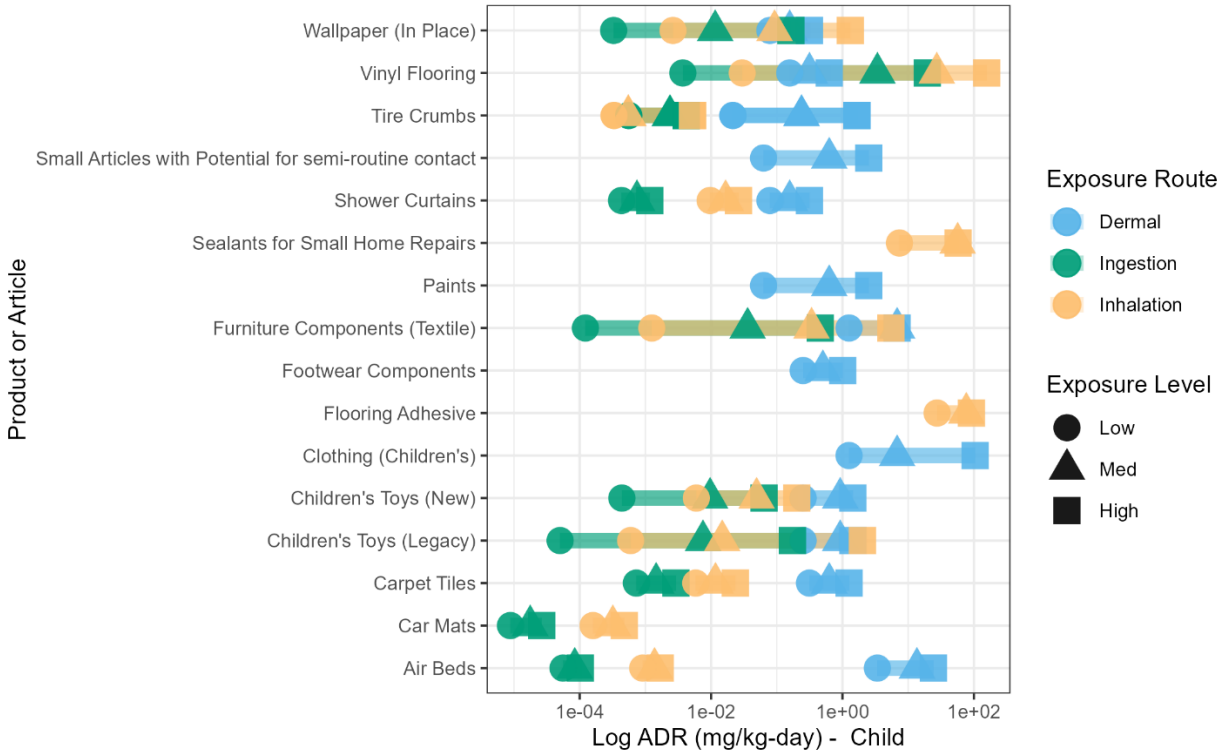

Figure 3-2. Acute Dose Rate of DIBP from Ingestion, Inhalation, and Dermal Exposure Routes for Preschoolers Aged 3–5 Years and Middle Childhood Aged 6–10 Years

Note: Horizontal axis label is for preschoolers and middle childhood.

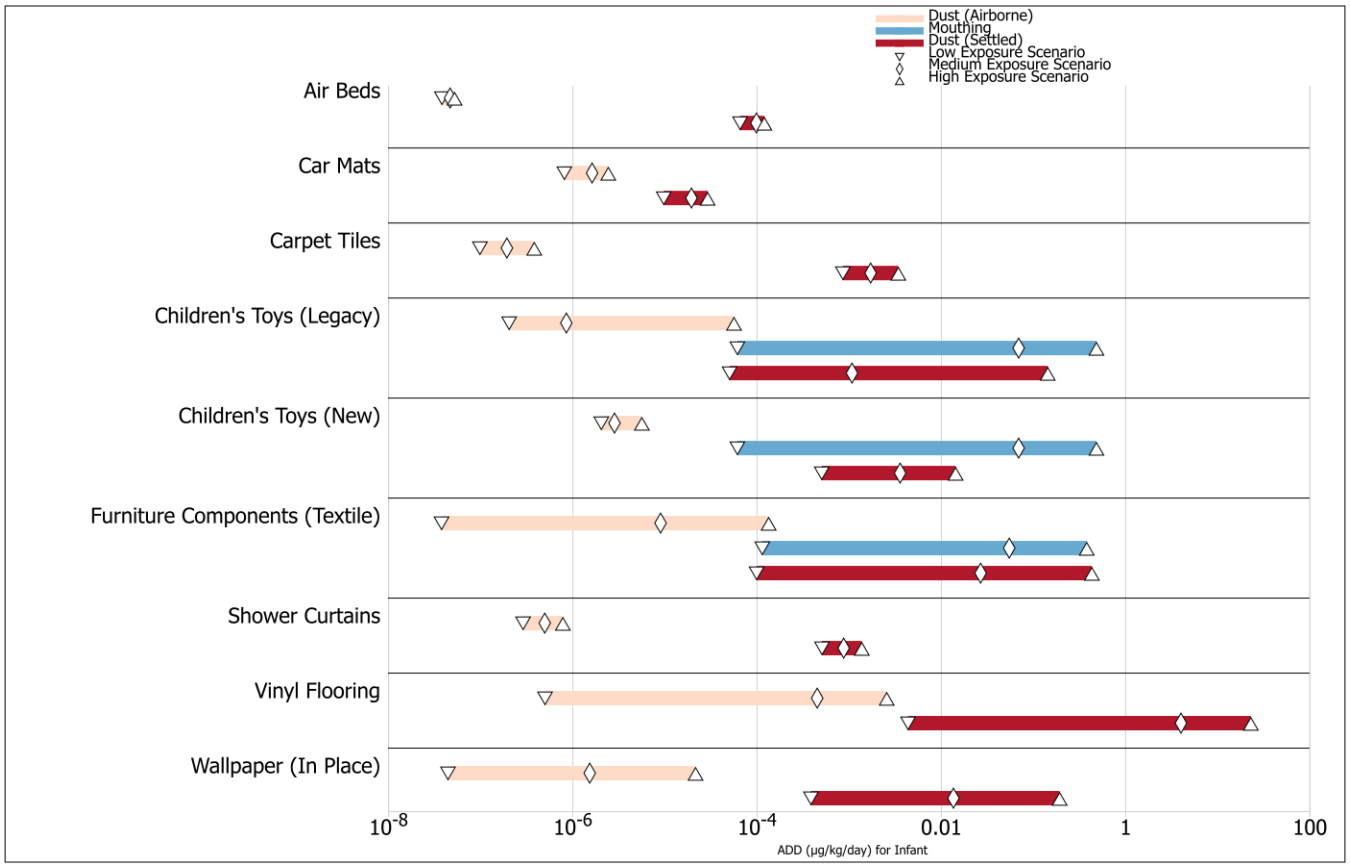

Figure 3-3. Acute Dose Rate of DIBP from Suspended and Settled Dust Ingestion and Mouthing for Infants Aged <1 Year

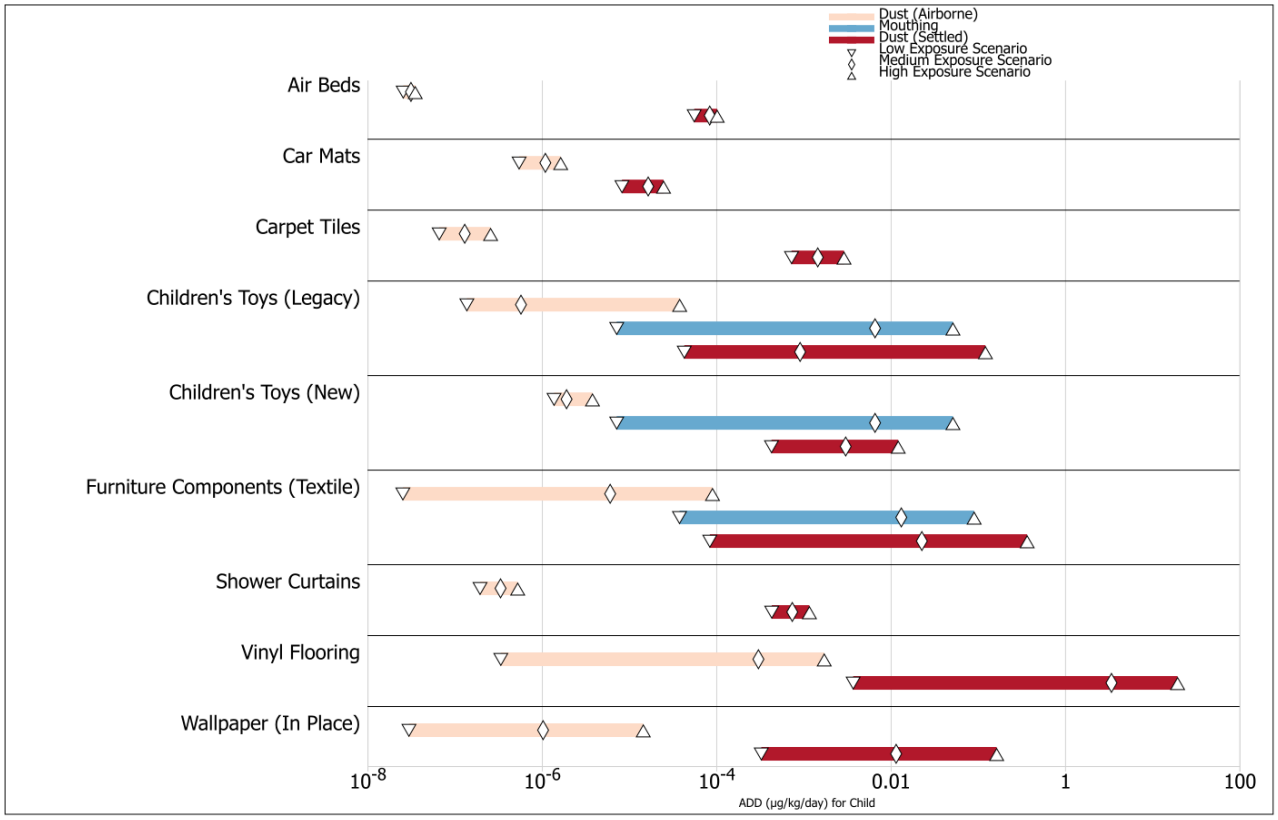

Figure 3-4. Acute Dose Rate of DIBP from Suspended and Settled Dust Ingestion and Mouthing for Preschoolers Aged 3–5 Years

Young Teens, Teenagers, Young Adults, and Adults (11–21 Years and 21+ Years)

Figure 3-5 show all exposure routes for young teens (11–15 years) and teenagers and young adults (16–20 years) combined. Figure 3-6 show all exposure routes for adults above 21 years old. Exposure patterns were very similar for all products and articles and routes of exposure in these three lifestages. The acute dose rate for some products and articles covers a larger range than others primarily due to a wider distribution of weight fraction values, like for toys, furniture components, vinyl flooring, and wallpaper. Inhalation exposure as a bystander for these lifestages were not targeted for adhesives and sealants. Teenagers and young adults (16- to 20-year-olds) can use adhesives and sealants products in similar capacity as adults during DIY projects; thus, 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 except for vinyl flooring inhalation doses which were higher than all doses across scenarios.

For articles considered in the indoor assessment, dermal doses were generally higher than inhalation and ingestion of suspended and settled dust. For example, air beds, car mats, carpet tile, new children's toys, furniture components, shower curtains, and tire crumb had higher dermal doses, while for vinyl flooring, in-place wallpaper, and legacy children's toys inhalation doses were higher than dermal and ingestion. The scenarios with higher inhalation doses are driven by larger weight fractions in comparison to other articles.

Ingestion via mouthing is not considered for these lifestages which is expected due to a decrease in or ceasing of mouthing behavior. Ingestion of settled dust is the highest ingestion pathway for products and articles, see Figure 3-7, which suggests that indoor dust ingestion can be an important contributor to DIBP exposures.

Figure 3-5. Acute Dose Rate of DIBP from Ingestion, Inhalation, and Dermal Exposure Routes for Young Teens Aged 11–15 Years and for Teenagers and Young Adults Aged 16–20 Years

Note: Horizontal axis label is for young teens, teenagers, and young adults.

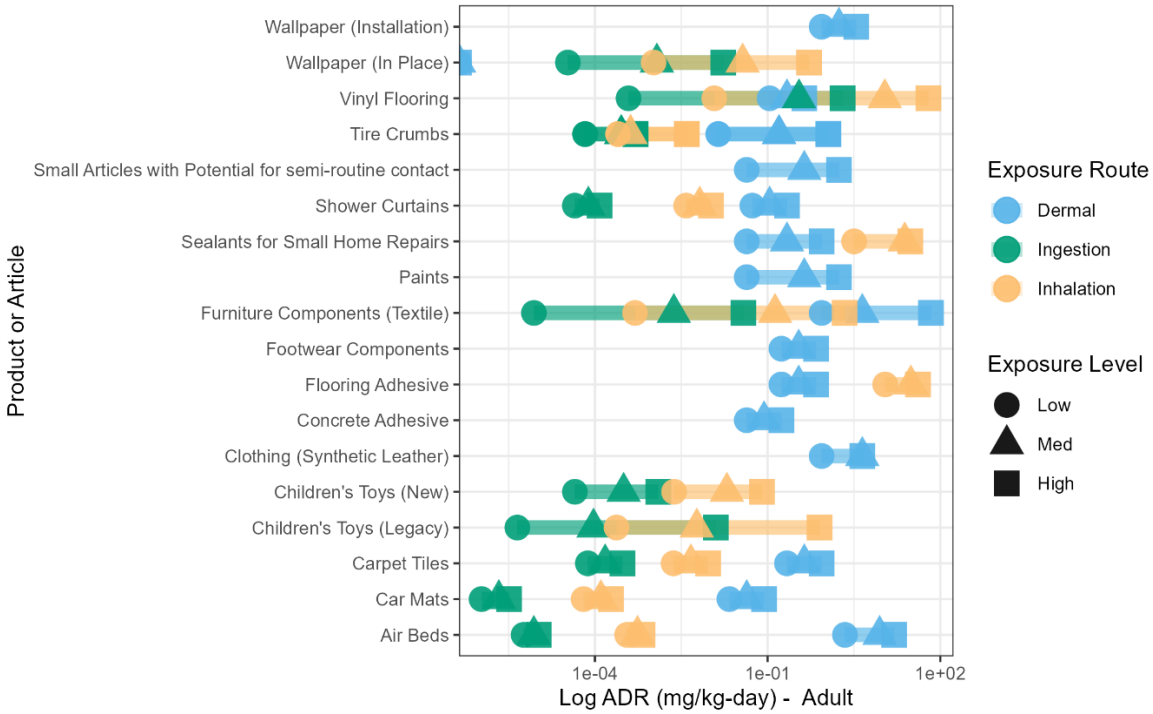

Figure 3-6. Acute Dose Rate of DIBP from Ingestion, Inhalation, and Dermal Exposure Routes in Adults Aged 21+ Years

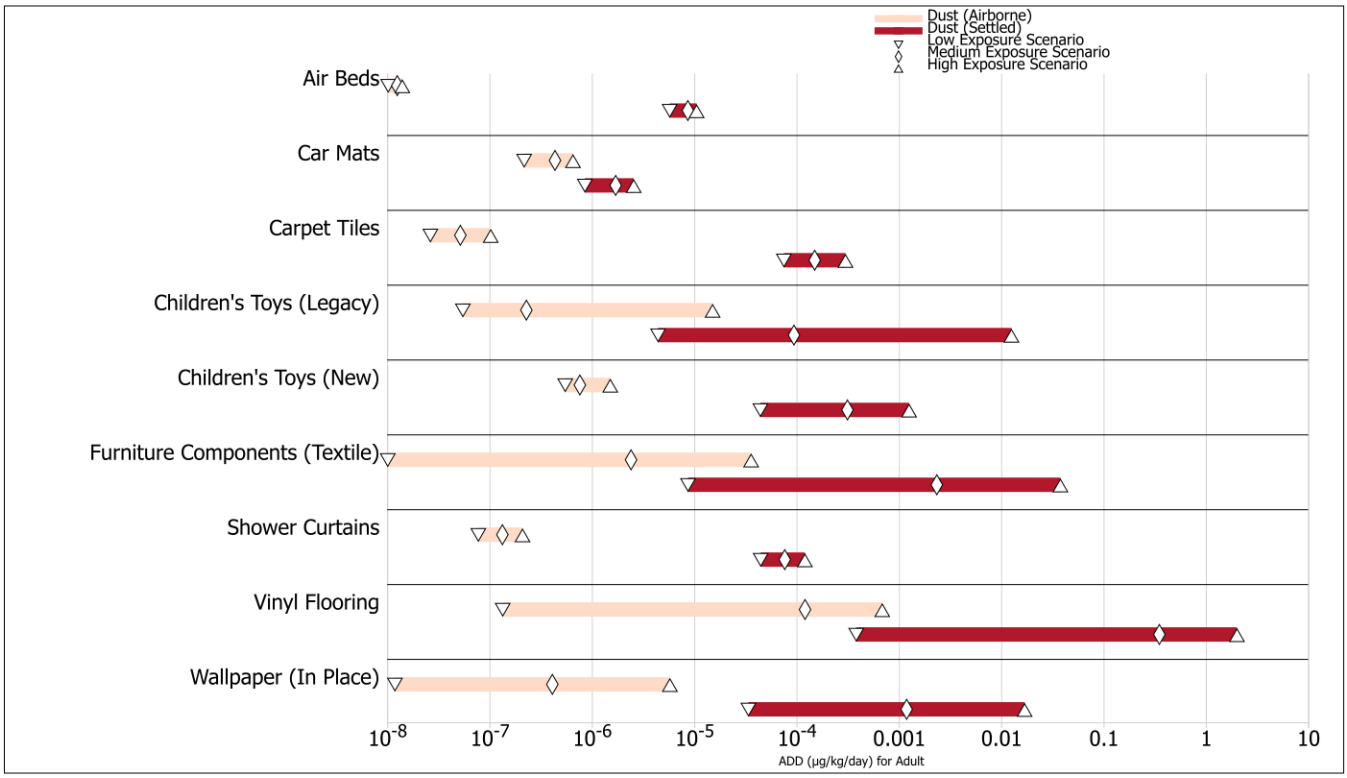

Figure 3-7. Acute Dose Rate of DIBP from Suspended and Settled Dust Ingestion Exposure Routes for Young Teens Aged 11 Years to Adults Aged 21+ Years

Note: Horizontal axis label is for adults. Figure will be corrected during finalization.

3.2 Intermediate Average Daily Dose Conclusions and Data Patterns

DIBP Draft Consumer Risk Calculator (U.S. EPA, 2025b) summarizes the high- (H), medium- (M), and low (L)-intensity use intermediate dose results from modeling in CEM and outside of CEM (dermal only) for all exposure routes and all lifestages. Only two product examples under the *Adhesives and Sealants* COU were candidates for intermediate exposure scenarios. Intermediate exposure durations assess product use in a 30-day period (≈1 month). Some products did not have dose results because the product examples were not targeted for that lifestage for that exposure route.

Only concrete adhesive and flooring adhesive qualified to be used in intermediate scenarios. Based on manufacturer use description and professional judgment/assumption, these products may be used repeatedly within a 30-day period depending on the project. Infant 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 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 3-8 to Figure 3-11 for intermediate dose visual representation. A noteworthy pattern is that bystander flooring adhesives inhalation doses for children younger than 10 years are similar to dose values to users that are directly using or applying the product.

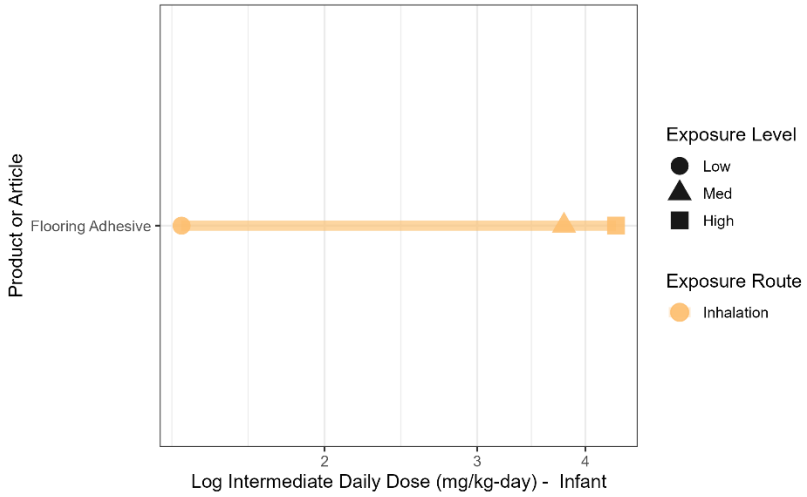

Figure 3-8. Intermediate Dose Rate for DIBP from Inhalation Exposure Route in Infants Aged <1 Year and Toddlers Aged 1–2 Years

Note: Horizontal axis label is for infants and toddlers.

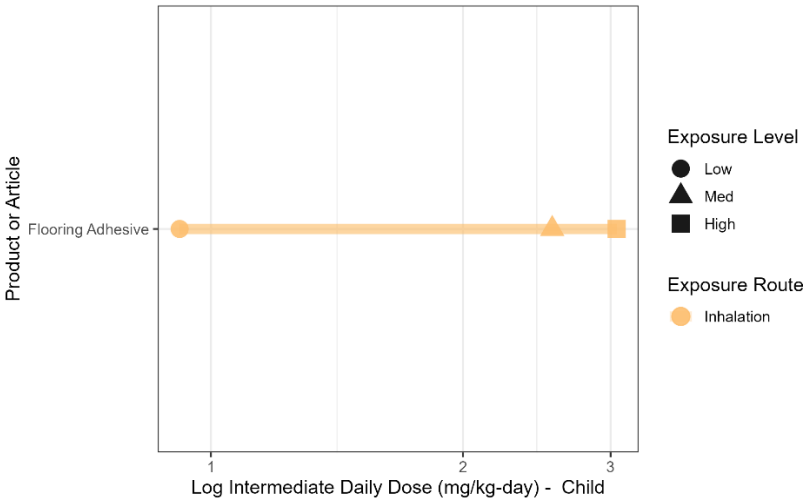

Figure 3-9. Intermediate Dose Rate for DIBP from Inhalation Exposure Route in Preschoolers Aged 3–5 Years and Middle Childhood Aged 6–10 Years

Note: Horizontal axis label is for preschoolers and middle childhood.

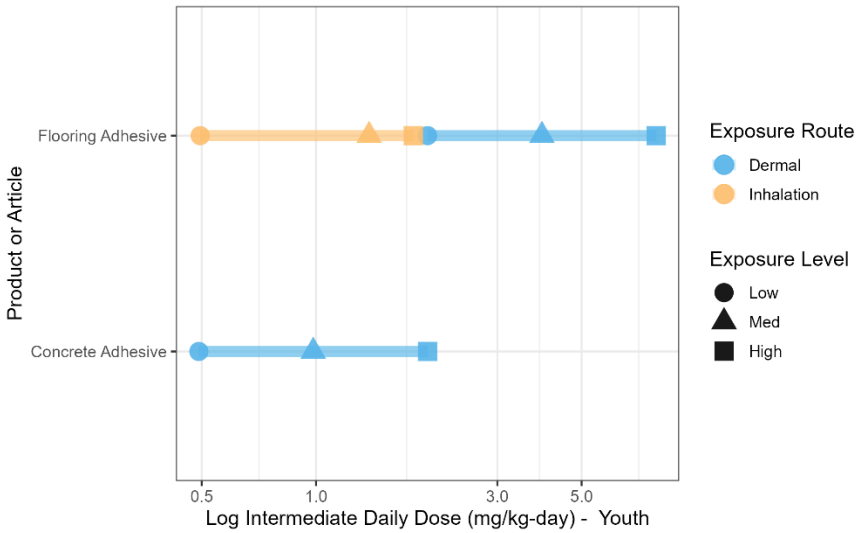

Figure 3-10. Intermediate Dose Rate of DIBP from Inhalation, and Dermal Exposure Routes for Young Teens Aged 11–15 Years and for Teenagers and Young Adults Aged 16–20 Years

Note: Horizontal axis label is for young teens and teenagers and young adults.

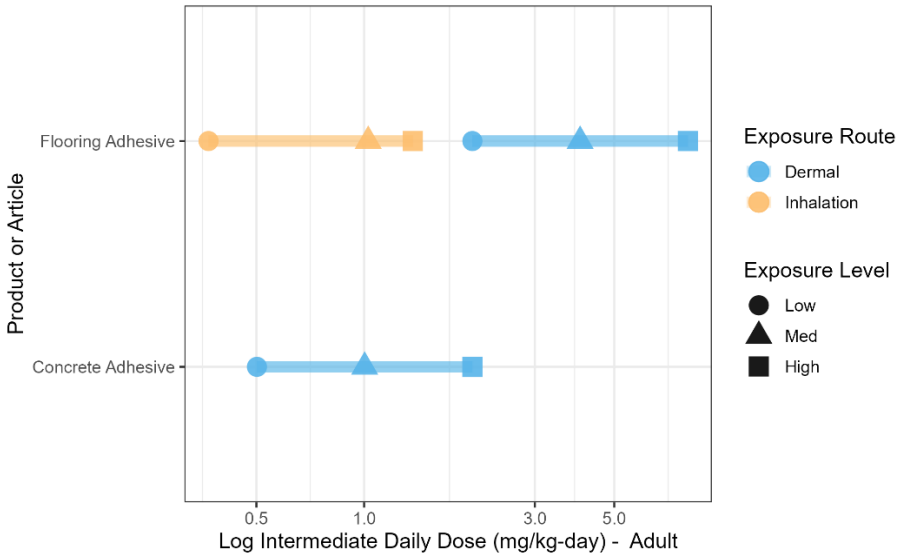

Figure 3-11. Intermediate Dose Rate of DIBP from Inhalation, and Dermal Exposure Routes for Adults Aged 21+ Years

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

DIBP Draft Consumer Risk Calculator (U.S. EPA, 2025b) summarizes the high- (H), medium- (M), and low (L)-intensity use chronic daily dose results from modeling in CEM and outside of CEM (dermal only) for all exposure routes and all lifestages. Some products and articles did not have dose results because the product or article was not targeted for that lifestage or exposure route. Bystanders are people that are not in direct use or application of the product but can be exposed to DIBP by proximity to the use of the product via inhalation of gas-phase emissions or suspended dust. Some product scenarios, adhesives and sealants, were assessed for bystanders for children under 10 years and as users for older than 11 years because the products were not targeted for very young children (<10 yrs). People older than 11 yrs can also be bystanders; however, the user scenarios utilize inputs that would result in larger

exposure doses. The main purpose of *DIBP Draft 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. which includes summary descriptions of the patterns by exposure route and lifestage. The following set of figures (Figure 3-12 to Figure 3-15) show chronic average daily dose data for all products and articles modeled in all lifestages. For each lifestage, figures are provided which show CADD estimated from exposure via inhalation, ingestion (aggregate of mouthing, suspended dust ingestion, and settled dust ingestion), and dermal contact.

The CADD figures resulted in similar overall data patterns as the acute doses with some differences driven by the chronic exposure durations. For example, dermal doses for all articles were generally higher than inhalation and ingestion doses, except for vinyl flooring and in-place wallpaper for which inhalation doses were higher. The higher inhalation doses for vinyl flooring and in-place wallpaper are likely due to the larger surface area presence and weight fractions in comparison to other articles.

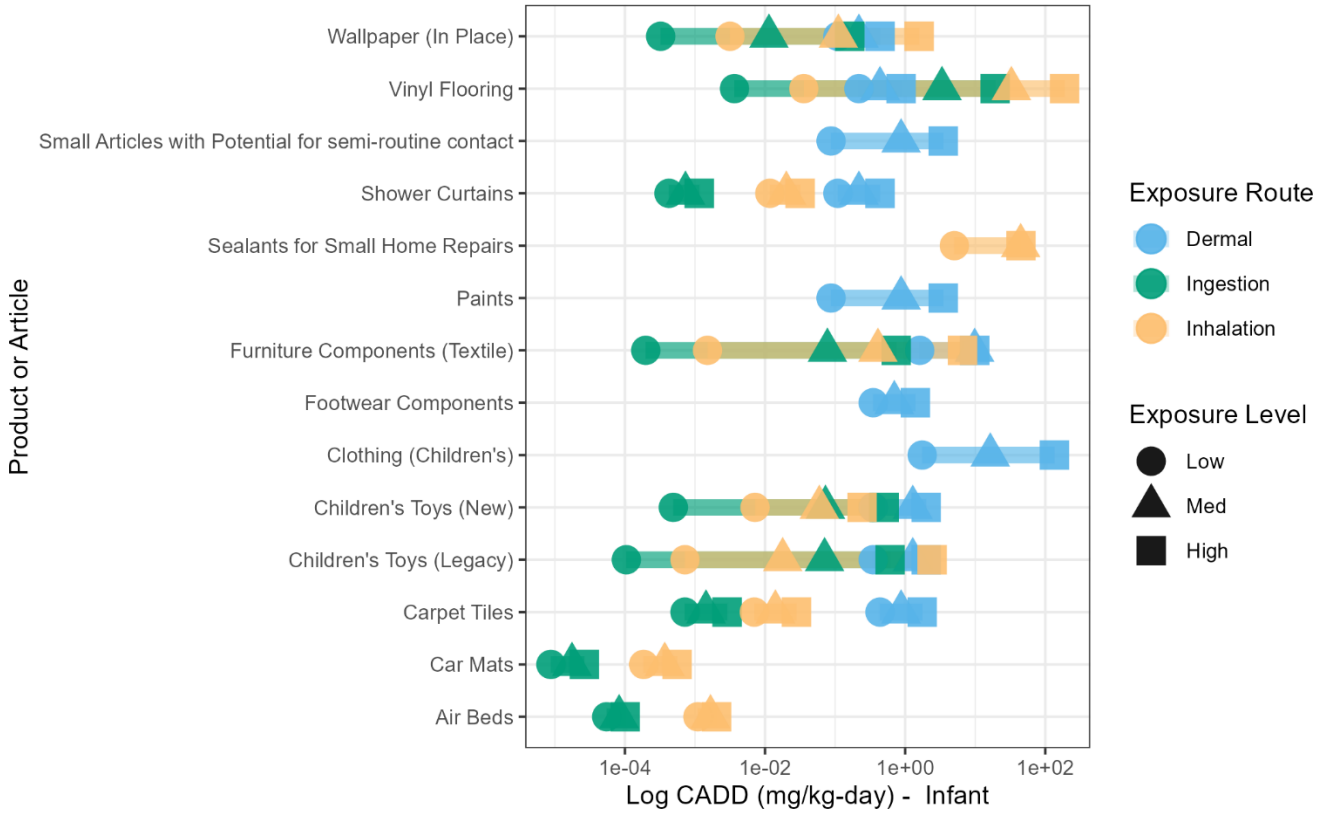

Figure 3-12. Chronic Dose Rate for DIBP from Ingestion, Inhalation, Dermal Exposure Routes in Infants Aged <1 Year and Toddlers Aged 1–2 Years

Note: Horizontal axis label is for infants and toddlers.

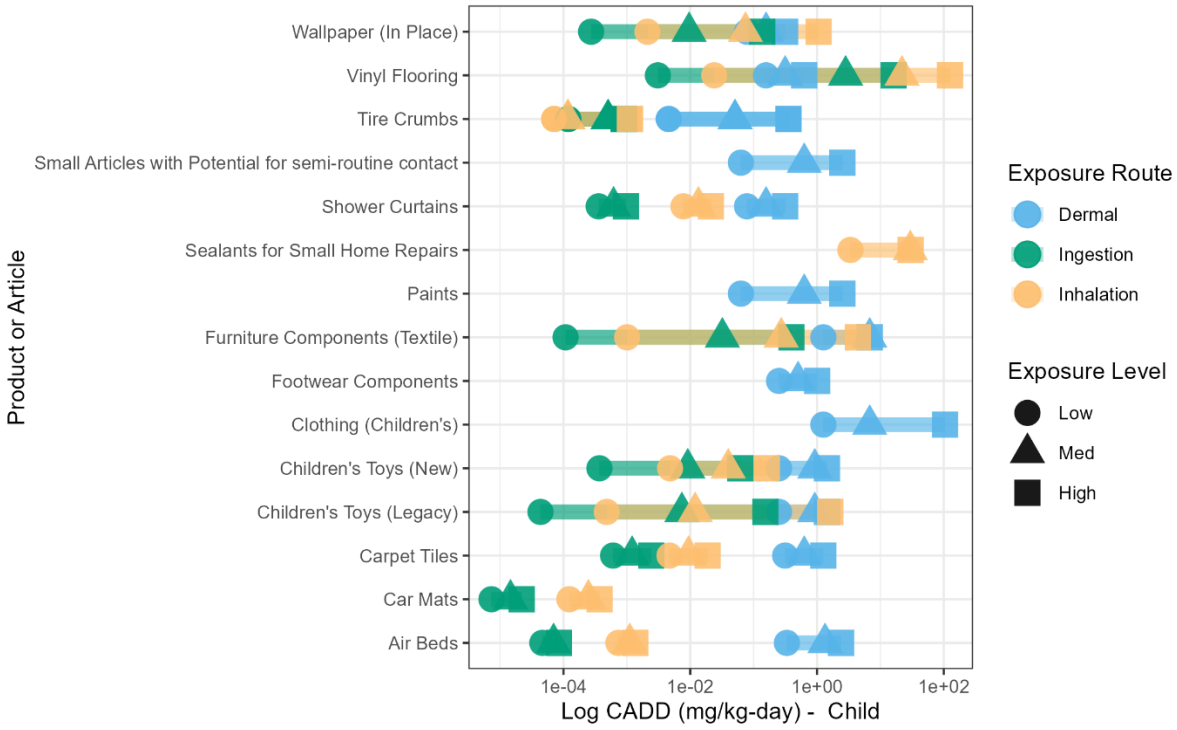

Figure 3-13. Chronic Dose Rate of DIBP from Ingestion, Inhalation, and Dermal Exposure Routes for Preschoolers Aged 3–5 Years and Middle Childhood Aged 6–10 Years

Note: Horizontal axis label is for preschoolers and middle childhood.

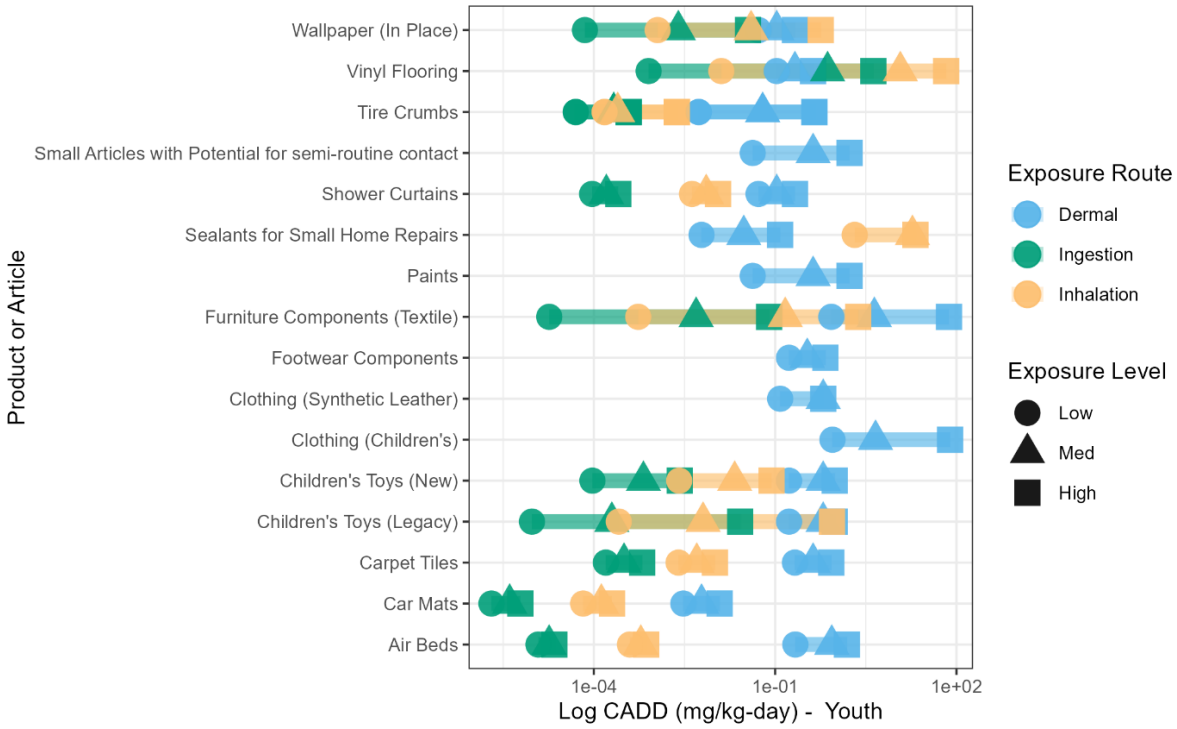

Figure 3-14. Chronic Dose Rate of DIBP from Ingestion, Inhalation, and Dermal Exposure Routes for Young Teens Aged 11–15 Years and for Teenagers and Young Adults Aged 16–20 Years

Note: Horizontal axis label is for young teens, teenagers, and young adults.

Figure 3-15. Chronic Dose Rate of DIBP from Ingestion, Inhalation, and Dermal Exposure Routes in Adults Aged 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 DIBP in dust and obtain COU and product specific exposure estimates for ingestion and inhalation of dust. Exposure to DIBP 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 the following:

- Furniture components (textiles),
- Vinyl flooring,
- Carpet tiles,
- Air beds,
- Car mats,
- In-place wallpaper,
- Shower curtains,
- Children's toys, both legacy and new, and
- Tire crumb.

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 *DIBP Consumer Risk Calculator* (U.S. EPA, 2024a) 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 DIBP concentrations were compared to evaluate consistency among data sets. EPA used two U.S. monitoring studies to generate an estimate of overall DIBP 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

Studies that measured DIBP dust concentrations in non-residential buildings such as offices, schools, businesses, and day cares, and/or were not conducted in the United States were not used in the comparison with modeling data. Data from other countries were not included in the comparison because of the expected difference in use patterns, behaviors, and residential characteristics as compared to the U.S. population. Forty-three studies were identified during systematic review as containing measured DIBP concentrations in indoor dust. Of the 43 studies, 4 were identified as containing U.S. data on measured DIBP concentrations in dust in homes, offices, and other indoor environments. Out of the four studies, two were selected because they collected settled indoor dust, which is used in the comparison to indoor dust ingestion modeling data (Section 4.3).4.3). 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).

In Bi et al. (2015), 43 settled dust samples were collected from multiple indoor environments in Delaware during 2013. These included 7 apartments, 3 gyms, 4 commercial stores, 5 college student

dormitories, 7 offices, 3 house garages, 10 houses, and 5 daycare centers.

Hammel, 2019, 5532853@@author-year} measured DIBP concentrations in residential dust that was not focused on a subpopulation (*i.e.*, specific socioeconomical or educational background status) . 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.

Table 4-1 reports summary statistics for DIBP content in dust from indoor environments. EPA compiled data from multiple indoor environments such as homes, retail, offices, daycares, and gyms. The studies reported various indoor environments the results statistics combined and by environment, see Table 4-1. Statistics (*e.g.*, mean, median, etc.) were directly taken from each study, and when individual data were provided EPA calculated the summary statistics. Sampling methods that use wipes and vacuums to collect samples from hands or other surfaces are categorized as settled dust and were used in the assessment of dust ingestion route in this indoor dust exposure assessment. Combined refers to the total concentration from all sampled indoor environments.

Table 4-1. Detection and Quantification of DIBP in House Dust from Various Studies

Study	Indoor Environment	N	Mean (µg/g)	Median (µg/g)	Min (µg/g) [d]	Max (µg/g)	SD (µg/g)	95th Percentile (µg/g)	Detection Frequency (%)
Bi et al. (2015) [c]	Combined [a]	43	17	12	1.1	89	17	NR [b]	100
	Apartment	7	9.7 [c]	9.6	5.4	14	3.2	NR [b]	100
	Home	10	16 [c]	12	3.3	43	14	NR [b]	100
	Home garage	3	1.6	1.6	0.8	2	0.66	NR [b]	100
	Student dormitory	5	17	17	12	22	4.4	NR [b]	100
	Gym	3	51	51	13	89	38	NR [b]	100
	Office	7	19	14	6.4	55	17	NR [b]	100
	Commercial stores	4	10	12	4.7	13	3.8	NR [b]	100
	Daycare center	5	17	13	5.4	37	13	NR [b]	100
Hammel et al. (2019)	Home	188	NR [b]	4.367 [c]	ND [d]	NR [b]	NR	33.898 [c]	100

[a] Combined refers to multiple indoor environments including household living areas, attic, basement, and an office building.
[b] NR, not reported
[c] Used in dust ingestion calculations for central tendency (mean) and high-end tendency (95th percentile), Equation 4-2.
[d] ND, not detected.

Although the number of studies and sampled states is low, two studies and states, the number of samples between the studies provides a moderate level of confidence in these data adequately representing the U.S. population. Additionally, the study with the largest number of samples, Hammel et al. (2019), provided generic descriptions of the articles that may be sources of DIBP in the indoor environment sampled. A comparison between modeled and monitoring data can provide some insight in the distribution and variability within monitoring and modeling estimates. However, it is noteworthy that the monitoring data is an aggregate of all indoor TSCA and non-TSCA sources of DIBP in dust and a comparison with only TSCA sources modeling results can be challenging to characterize.

4.2 Indoor Dust Monitoring Approach and Results

To estimate DIBP dust ingestion, the central tendency ingestion weighted average is first calculated from the reported means and medians of measured concentrations for residential (homes and apartments) in Table 4-1 (footnote "C"). Studies that did not report means were not used in the calculation and only residential settled dust concentration values were used to compare to modeling results (Section 4.3).4.3). The same equation was used to calculate the high-end tendency using the reported maximums and 95th percentile. The central tendency ingestion weighted average concentration is calculated using Equation 4-1.

Equation 4-1. Ingestion Weighted Average Concentration Calculation

$$DIBP\ Ingestion\ Weighted\ Average\ (\mu g/g\ DIBP) = \frac{Mean\ Ingestion\ Set\ 1\left(\frac{\mu g}{g}\ DIBP\right) \times Number\ in\ Set\ 1 \ldots + Mean\ Ingestion\ Set\ N\left(\frac{\mu g}{g}\ DIBP\right) \times Number\ in\ Set\ N}{Number\ in\ Set\ 1 \ldots + Number\ in\ Set\ N}$$

EPA used recent U.S. sources for dust ingestion rate and body weights from Özkaynak et al. (2022). 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 due to pacifier and blanket use, increased hand-to-surface contact, and increased rates of hand-to-mouth activity. Geometric mean and 95th percentile dust ingestion rates for ages 0 to 21 years were taken from Özkaynak et al. (2022) to estimate DIBP ingestion doses in dust (Table 4-2). The geometric mean (GM) was used as the measure of central tendency because the distribution of doses is skewed as dust ingestion doses in young children (3 months to 2 years) are higher vs. older children and adults.

Body weights representative of the U.S. population were taken from Table 8-1 in the *Exposure Factors Handbook* (U.S. EPA, 2011b). DIBP ingestion was calculated according to Equation 4-2 for two scenarios: central tendency (geometric mean (GM) dust ingestion, median DIBP concentration in dust) and high end (dust ingestion, 95th percentile DIBP concentration in dust).

Equation 4-2. Calculation of DIBP Settled Dust Ingestion Dose

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

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 (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 Handbook, estimates were calculated for DIBP ingestion dose for ages 21 to exceeding 80 years (Table 4-3). Estimates of DIBP ingestion in indoor dust per day based on monitoring data are presented in Table 4-2 and Table 4-3.

Table 4-2. Estimates of DIBP Settled Dust Ingestion Per Day from Monitoring, Ages 0–21 Years

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
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
DIBP Ingestion (µg/kg-day)	Central tendency (5.1 µg DIBP/g dust)	2.0E−02	1.8E−02	1.6E−02	1.4E−02	1.0E−02	5.2E−03	4.1E−03	2.1E−03	7.9E−04	2.5E−04
	High-end (33.7 µg DIBP/g dust)	1.3E−01	1.2E−01	1.0E−01	9.5E−02	6.8E−02	3.4E−02	2.7E−02	1.4E−02	5.2E−03	1.6E−03

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

Table 4-3. Estimates of DIBP Settled Dust Ingestion Per Day from Monitoring, Ages 21-80+ 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
DIBP Ingestion (µg/kg-day)	Central tendency (5.1 µg DIBP/g dust)	2.3E−04	2.2E−04	2.1E−04	2.1E−04	2.2E−04	2.3E−04	2.6E−04
	High-end (33.7 µg DIBP/g dust)	1.5E−03	1.5E−03	1.4E−03	1.4E−03	1.4E−03	1.5E−03	1.7E−03

[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. EPA only considered TSCA COU related articles that are present in residences and homes for comparison with monitoring data. Car mats and tire crumb although are present in indoor environments like vehicles, are not used in homes and therefore inclusion would not be appropriate.

Table 4-4 Comparison Between Modeled and Monitored Daily Dust Dose Estimates for DIBP

Lifestage (years)	Daily DIBP Dose Estimate from Dust, µg/kg-day, Modeled Exposure [a]	Daily DIBP Dose Estimate from Dust, µg/kg-day, Monitoring Exposure [b]	Margin of Error (Modeled ÷ Monitoring)
Infant (<1)	3.0	0.017 [c]	176
Toddler (1–2)	3.7	0.0078	483
Preschooler (3–5)	4.2	0.0041	1,026
Middle Childhood (6–10)	1.5	0.0021	710
Young Teen (11–15)	0.83	0.00079	1,049
Teenager (16–20)	0.66	0.00025	2,638
Adult (21+)	0.30	0.00023 [d]	1,299

[a] Sum of chronic doses for indoor dust ingestion for the "medium" dose 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 DIBP doses from dust in CEM modeled scenarios were considerably higher than those predicted by the monitoring approach, see Table 4-4. These discrepancies partially stem from differences in the exposure assumptions of the CEM model vs. the assumptions made when estimating daily dust doses in Özkaynak et al. (2022). Dust doses 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 dose, 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 used in the monitoring comparison. It is likely that individual residences have varying assortments and amounts of the products and articles that are sources of DIBP, resulting in lower and higher exposures. Additionally, sources of differences between modeling and monitoring indoor dust ingestion exposures is that the modeling approaches used conservative assumptions and input parameters that may have contributed to the large differences. For example, the modeling scenario that is driving the large difference is vinyl flooring. This modeling scenario may be using a larger surface area presence than in U.S. homes included in the monitoring studies used in the comparison. Modeling doses for furniture components (textiles) and in-place wallpaper are slightly larger than the monitoring dose, 1 to 17 margin of error, see *Draft Diisobutyl Phthalate (DIBP) Consumer Risk Calculator* (U.S. EPA, 2025b). The other articles used in this comparison, carpet tiles, air beds, shower curtains, and children's toys both legacy and new, are all lower than the monitoring dose estimated. Also, the monitoring data is an aggregate of all indoor

TSCA and non-TSCA sources of DIBP in dust and a comparison with only TSCA sources modeling results can be challenging to compare.

In the indoor dust modeling assessment, EPA reconstructed the scenario using consumer articles as the source of DIBP 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, but in some scenarios the inputs may be more conservative than in others. CEM calculates DIBP 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 DIBP 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 DIBP-containing dust.

5 WEIGHT OF SCIENTIFIC EVIDENCE

5.1 Consumer Exposure Analysis Weight of the Scientific Evidence

This section describes the sources of variability and uncertainty, the strengths and weaknesses, and the overall confidence in the modeled consumer and indoor dust exposure analysis. 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 DIBP in consumer goods and strategies to address those uncertainties are described in this section.

Generally, a 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 there is an absence of complete information and there are additional uncertainties that may need to be considered. The designation of slight to moderate confidence suggests that some aspects of the analysis are reasonably adequate but other aspects are not adequate or well understood to characterize the exposure. 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. However, EPA reduced uncertainty by using reported concentrations from product specific SDS. EPA obtained DIBP weight fractions in various products and articles from material safety data sheets, data bases, and existing literature (Section 2.1). A large amount of data was available for DIBP in consumer goods published across several studies carried out by the Danish EPA, see Section 2.1. EPA used the Danish EPA information under the assumption that the weight fractions reported by the Danish EPA are representative of DIBP content that could be present in items sold in the United States. 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 multiple sources but insufficient description on how the concentrations were obtained, *robust* for products/articles with more than one source, and *slight* for articles with only one source with unconfirmed content or little understanding on how the information was produced.

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 Use Patterns

For inhalation and ingestion exposures to articles, the high-, medium-, and low-intensity use scenario default values from CEM 3.2's prepopulated scenarios were selected for indoor use environment/room volume, interzone ventilation, and surface layer thickness. For dermal exposures, article use patterns such as frequency of use and skin contact area are expected to have a range of low to high use intensities. For articles, which do not use duration of use as an input in CEM, professional judgment was used to select the duration of use/article contact duration for the low-, medium-, and high-exposure scenario levels for most articles except for carpet tiles and vinyl flooring. Carpet tiles and vinyl flooring contact duration values were taken from EPA's Standard Operating Procedures for Residential Pesticide Exposure Assessment for the high exposure level (2 hours; time spent on floor surfaces) (U.S. EPA, 2012). ConsExpo (U.S. EPA, 2012) for the medium exposure level (1 hour; time a child spends crawling on treated floors), and professional judgment for the low exposure level (0.5 hour). There are more uncertainties in the assumptions and professional judgment for contact duration inputs for articles, and therefore EPA has *moderate* confidence in those inputs.

Article Surface Area

The surface area of an article directly affects the potential for DIBP emissions to the environment. For each article modeled for inhalation exposure, low, medium, and high estimates for surface area were calculated (Section 2.1). This approach relied on manufacturer-provided dimensions where possible, or values from the *Exposure Factors Handbook* (U.S. EPA, 2011c) for floor and wall coverings. For small items which might be expected to be present in a home in significant quantities, such as children's toys, aggregate values were calculated for the cumulative surface area for each type of article in the indoor environment. 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 the Consolidated Human Activity Database (CHAD). For all products and articles modeled, the stay-at-home activity pattern was chosen as it is the most protective assumption.

Mouthing durations are a source of uncertainty in human behavior. The data used in this assessment are based on a study in which parents observed children (n = 236) ages 1 month to 5 years for 15 minutes per sessions and 20 sessions in total (Smith and Norris, 2003). There was considerable variability in the data due to behavioral differences among children of the same lifestage. For instance, while children aged 6 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 this was 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 DIBP. EPA assigned a *moderate* confidence associated with mouthing estimates duration of activity because the magnitude of the overestimation is not well characterized. All other human behavior parameters are well defined and understood, or the ranges used capture use patterns representative of various lifestages, which results in a *robust* confidence in use patterns.

Inhalation and Ingestion 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. The model used, CEM 3.2, has been peer-reviewed (ERG, 2016), is publicly available, and has been applied in the manner intended by estimating exposures associated with uses of household products 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 of DIBP Exposure for Liquids and Solids

Experimental dermal data was identified via the systematic review process to characterize consumer dermal exposures to liquids or mixtures and formulations containing DIBP, see Sections 2.3.1 and 2.3.3. EPA has moderate understanding of the scientific evidence and the uncertainties. The determination of uncertainties supporting scientific evidence is reasonably adequate to characterize exposure estimates for liquid products. The confidence in the dermal exposure to liquid products model used in this assessment is *moderate*. The determination of uncertainties supporting scientific evidence for some aspects of the analysis are reasonably adequate but other aspects are not adequate or well understood to characterize the exposure for solid articles. The confidence in the dermal exposure to solid articles model used in this assessment is *slight to moderate*.

EPA identified only one set of experimental data related to the dermal absorption of neat DIBP Elsisi (1989). This dermal absorption study was conducted *in vivo* using male F344 rats. There have been additional studies conducted to determine the difference in dermal absorption between rat skin and human skin. Specifically, Scott (1987) examined the difference in dermal absorption between rat skin and human skin for four different phthalates (*i.e.*, dimethyl phthalate [DMP], diethyl phthalate [DEP], dibutyl phthalate [DBP], and DIBP) 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. Because there is uncertainty regarding the magnitude of difference between dermal

absorption through rat skin vs. human skin for DIBP, based on DIBP physical and chemical properties (size, solubility), EPA is confident that the *in vitro* human dermal absorption data from Scott et al. (1987) provides an upper-bound and likely overestimation (slight to moderate confidence) of dermal absorption of DIBP for solid articles and a representative (moderate confidence) dermal absorption for liquid products based on the findings of Scott (1987).

Differences in skin structure and metabolism between rats and humans may limit the direct applicability of rat data to human scenarios. The flux of other phthalates across rat skin has been shown to be about 2 to 10 times higher than the flux across human skin for the same chemical. Additionally, the permeation characteristics of neat chemicals may differ from those of saturated solutions of phthalates. Because DIBP is strongly hydrophobic, dermal flux of neat chemical is expected to be lower than that of saturated solutions, introducing a potential underestimation of dermal flux when extrapolating from neat DIBP to aqueous solutions.

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

Ingestion via Mouthing

Very little data were available for migration rates of DIBP from solid articles to saliva, and no data were found with weight fractions of DIBP similar to those reported for the articles assessed here (< 2 percent DIBP by weight). The weight fraction range used in this assessment for the articles evaluated for mouthing, specifically the two children's toys' scenarios, are significantly below the range considered for the empirical chemical migration data for other phthalates. A theoretical framework based on physical and chemical properties of DIBP and the solid matrix material was used to estimate chemical migration rates, in the absence of adequate empirical data. This model was internally and externally validated against measured diffusion coefficients and shown to have good predictive capability for chemicals with molecular weights between 30 and 1,178 g/mol at temperatures between 4 and 180 °C (Aurisano et al., 2022), which are well within DIBP properties and temperatures during product use. Major limitations of the chemical migration rate estimate calculation approach are that there is no understanding of the correlation between concentration of DIBP in consumer products and the calculated chemical migration rate, and there is no available data to compare the estimated chemical rate value. These limitations result in a significant level of uncertainty for the estimated chemical migration rate, as the value may also differ among similar items due to variations in chemical makeup and polymer structure. Thus, it is unclear whether the migration rate value is applicable to consumer goods with low weight fractions of DIBP. EPA has a *slight* confidence in the chemical migration rate value in the context of this assessment consumer product considerations and a *slight* confidence in the overall

modeling approach even when considering the moderate confidence in the mouthing durations and other modeling inputs. Note that overall confidence in ingestion exposures considers the aggregation of ingestion of suspended dust, settled dust, and if applicable to the scenario—ingestion via mouthing. Confidence in dust ingestion was *moderate*.

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

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
Adhesives and sealants; Adhesives and sealants	Three different scenarios were assessed under this COU for three product types with differing use patterns: wood flooring adhesives, concrete and masonry adhesives for small repairs, and small projects with seaming adhesive and a fire caulk. Of these three scenarios, concrete and masonry adhesives were assessed for dermal exposures only because these products are used outdoors where the potential for inhalation and ingestion exposure is low. The overall confidence in this COU's inhalation exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use. See Section 2.1.2 for number of products, product examples, and weight fraction data. For dermal exposure EPA used a dermal flux approach, which was estimated based on DIBP *in vitro* dermal absorption in humans. The flux-limited approach likely results in an overestimation of dose due to the assumption about constant rate of absorption of DIBP in contact with skin. An overall moderate confidence in dermal assessment of adhesives was assigned. EPA is confident that the *in vitro* human dermal absorption data from Scott et al. (1987) provides a representative dermal absorption for liquid products. Other parameters, such as frequency and duration of use and surface area in contact, are well understood and representative, resulting in a moderate overall confidence.	Inhalation– Robust Dermal – Moderate
Fabric, textile, and leather products not covered elsewhere; Fabric, textile, and leather products not covered elsewhere (*e.g.*, textile [fabric] dyes)	Five different scenarios were assessed under this COU for articles with differing use patterns: indoor furniture and textiles, children's clothing, synthetic leather clothing for teenagers and adults, variety of PVC articles with routine contact, and footwear components. Indoor furniture articles were assessed for all exposure routes (inhalation, ingestion (suspended and settled dust, and mouthing), and dermal) as part of the indoor exposure assessment, while the other scenarios were only assessed for dermal contact since the articles were too small to result in significant inhalation and ingestion exposures. The overall confidence in this COU's inhalation exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use. See Section 2.1.2 for number of products, product examples, and weight fraction data. The indoor furniture ingestion exposure estimate overall confidence is moderate due to uncertainties in the parameters used for chemical migration to saliva. For example, unknown correlation between chemical concentration in articles and chemical migration rates, and no reasonably available data to compare and confirm selected rate parameters to understand uncertainties. However, the ingestion modeling approach was validated against measured diffusion coefficients and shown to have good predictive capabilities for chemicals with DIBP's molecular weight. The dermal absorption estimate assumes that dermal absorption of DIBP from solid objects would be limited by the aqueous solubility of DIBP. EPA has slight to moderate confidence in the exposure estimate for solid articles because of the high uncertainty in the assumption of partitioning from solid to liquid, and because subsequent dermal absorption is not well characterized. Additionally, there are uncertainties associated with the flux-limited approach that likely result in an overestimation of dose due to the assumption about constant rate of absorption	Inhalation – Robust Ingestion – Moderate Dermal – Slight to moderate

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
	of DIBP in contact with skin. EPA is confident that the *in vitro* human dermal absorption data from Scott et al. (1987) provides an upper-bound of dermal absorption of DIBP for solid articles. Other parameters such as frequency and duration of use, and surface area in contact, are well understood and representative, resulting in an overall confidence of slight to moderate.	
Floor coverings; Floor coverings	Two different scenarios were assessed under this COU for articles with differing use patterns—vinyl flooring and carpet tiles. Both scenarios were part of the indoor assessment and evaluated for all exposure routes except mouthing. The overall confidence in this COU's inhalation exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use. See Section 2.1.2 for number of products, product examples, and weight fraction data. Ingestion exposure estimate overall confidence is moderate due to uncertainties in the parameters used for chemical migration to saliva. For example, unknown correlation between chemical concentration in articles and chemical migration rates, and no reasonably available data to compare and confirm selected rate parameters to understand uncertainties. However, the ingestion modeling approach was validated against measured diffusion coefficients and shown to have good predictive capabilities for chemicals with DIBP's molecular weight. The dermal absorption estimate assumes that dermal absorption of DIBP from solid objects would be limited by the aqueous solubility of DIBP. EPA has slight to moderate confidence in the exposure estimate for solid articles because of the high uncertainty in the assumption of partitioning from solid to liquid, and because subsequent dermal absorption is not well characterized. Additionally, there are uncertainties associated with the flux-limited approach, which likely results in an overestimation of dose due to the assumption about constant rate of absorption of DIBP in contact with skin. EPA is confident that the *in vitro* human dermal absorption data from Scott et al. (1987) provides an upper-bound of dermal absorption of DIBP for solid articles. Other parameters such as frequency and duration of use, and surface area in contact, are well understood and representative, resulting in an overall confidence of slight to moderate.	Inhalation – Robust Dust Ingestion – Moderate Dermal – Slight to moderate
Paints and coatings; Paints and coatings	One scenario was assessed for this COU, paints. The scenario was assessed for dermal exposures during application and direct dermal contact because inhalation and ingestion exposures were determined to be minimal due to small amount of product used and potential small surface area to release DIBP. For dermal exposure EPA used a dermal flux approach, which was estimated based on DIBP *in vitro* dermal absorption in rats. The flux-limited approach likely results in an overestimation of dose due to the assumption about constant rate of absorption of DIBP in contact with skin. An overall moderate confidence in dermal assessment of adhesives was assigned. Uncertainties about the difference between human and rat skin absorption increase uncertainty. EPA is confident that the *in vitro* human dermal absorption data from Scott et al. (1987) provides a representative dermal absorption for liquid products. Other parameters such as frequency and	Dermal – Moderate

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
	duration of use, and surface area in contact, are well understood and representative, resulting in a moderate overall confidence.	
Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard); Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Seven different scenarios were assessed under this COU for articles with differing use patterns: air beds, car mats, in-place wallpaper, wallpaper installation, shower curtains, tire crumb and artificial turf, and variety PVC articles with routine contact (multiple examples). Air beds, car mats, in-place wallpaper, and shower curtains scenarios were considered in the indoor assessment for all exposure routes except mouthing, while wallpaper installation was assessed for dermal and inhalation for age groups above 10 years and just inhalation for age groups under 10 years as bystanders of the installation process. The overall confidence in this COU's inhalation exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use. See Section 2.1.2 for number of products, product examples, and weight fraction data. Ingestion exposure estimate overall confidence is moderate due to uncertainties in the parameters used for chemical migration to saliva. For example, unknown correlation between chemical concentration in articles and chemical migration rates, and no reasonably available data to compare and confirm selected rate parameters to understand uncertainties. However, the ingestion modeling approach was validated against measured diffusion coefficients and shown to have good predictive capabilities for chemicals with DIBP's molecular weight. The dermal absorption estimate assumes that dermal absorption of DIBP from solid objects would be limited by the aqueous solubility of DIBP. EPA has slight to moderate confidence in the exposure estimate for solid articles because of the high uncertainty in the assumption of partitioning from solid to liquid, and because subsequent dermal absorption is not well characterized. Additionally, there are uncertainties associated with the flux-limited approach, which likely results in an overestimation of dose due to the assumption about constant rate of absorption of DIBP in contact with skin. EPA is confident that the *in vitro* human dermal absorption data from Scott et al. (1987) provides an upper-bound of dermal absorption of DIBP for solid articles. Other parameters such as frequency and duration of use, and surface area in contact, are well understood and representative, resulting in an overall confidence of slight to moderate.	Inhalation – Robust Ingestion – Moderate Dermal – Slight to moderate
Toys, playground, and sporting equipment; Toys, playground, and sporting equipment	Four different scenarios were assessed under this COU for various articles with differing use patterns: legacy children's toys, new children's toys, tire crumb and artificial turf, and a variety of PVC articles with potential for routine contact. Toy scenarios were included in the indoor assessment for all exposure routes (inhalation, dust ingestion, mouthing, and dermal) with varying use patterns and inputs. Tire crumb was also part of the indoor assessment for all exposure routes except mouthing. Articles of semi-routine contact were only assessed for dermal exposures since they are too small to result in impactful inhalation or ingestion exposures. The high-, medium-, and low-intensity scenarios capture variability and provide a range of representative use patterns. The overall confidence in this COU's inhalation exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use. See Section 2.1.2 for location of use, number of products,	CEM Inhalation – Robust Ingestion, Tire Crumb Inhalation, – Moderate Dermal – Slight to moderate

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
	product examples, and weight fraction data. Tire crumb inhalation confidence is moderate due to higher uncertainty in using surrogate chemical air concentrations, while all other parameters are well understood and representative of use patterns by the various age groups. The overall confidence in this COU's mouthing and dermal exposure assessment is moderate. 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 rate value is DIBP specific, and the main sources of uncertainty are related to article formulation and chemical migration dynamics. Migration of the chemical to saliva may not be very well characterized, but by assessing high-, medium-, and low-intensity use exposure scenarios EPA increases confidence in the estimates by using representative scenarios. The dermal absorption estimate assumes that dermal absorption of DIBP from solid objects would be limited by the aqueous solubility of DIBP. EPA has slight to moderate confidence in the exposure estimate for solid articles because of the high uncertainty in the assumption of partitioning from solid to liquid, and because subsequent dermal absorption is not well characterized. Additionally, there are uncertainties associated to the flux-limited approach, which likely results in overestimations due to the assumption about constant rate of absorption of DIBP in contact with skin. EPA is confident that the *in vitro* human dermal absorption data from Scott et al. (1987) provides an upper-bound of dermal absorption of DIBP for solid articles. Other parameters such as frequency and duration of use, and surface area in contact, are well understood and representative, resulting in an overall confidence of slight to moderate.	

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5.2 Indoor Dust Monitoring Weight of the Scientific Evidence

The weight of scientific evidence (WOSE) for the indoor dust exposure assessment of DIBP (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 DIBP, two studies were identified as containing data on dust from indoor environments in the United States and were selected for use in the indoor dust monitoring assessment as described in Section 4.1, Bi et al. (2015), and Hammel et al. (2019). The systematic review study rating per the exposure systematic review criteria is listed in Table 5-2. The systematic review ratings for the studies are high indicating good reporting and description of the monitoring from the authors. However, the use of these studies' data in this risk assessment to represent the U.S. population is a factor considered in the designation of overall confidence in Table 5-2. The number of studies and sampled states is low, two studies and states, however the number of samples between the studies provides a moderate level of confidence in these data adequately representing the U.S. population. Additionally, the study with the largest number of samples (190), Hammel et al. (2019) provided generic descriptions of the articles that may be sources of DIBP in the indoor environment sampled.

Table 5-2. Weight of the Scientific Evidence Conclusions for Indoor Dust Ingestion Exposure

Studies Used in Monitoring Indoor Analysis	Systematic Review Rating	Confidence in Data Used	Confidence in Model Inputs		Weight of Scientific Evidence Conclusion
			Body Weight [a]	Dust Ingestion Rate [b]	
Bi et al. (2015)	High	Moderate	Robust	Moderate	Moderate
Hammel et al. (2019)	High	Moderate			Moderate

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

Table 5-2 presents the level of confidence in the data quality of the input data sets for estimating dust ingestion from monitoring data, including the DIBP dust monitoring (Confidence in Data Used column in Table 5-2), 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 EPA has determined 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 there is an 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 professional judgment (see Table 5-2).

Monitoring data collected in the United States were identified for DIBP, from the Toddlers' Exposure to SVOCs in the Indoor Environment (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 which began in 2005 and recruited pregnant women who received services at Duke obstetrics facilities. Although these facilities are

associated with a teaching hospital and university, services are not restricted to students, and the demographic characteristics of the TIESIE study population match those of the Durham community (see Table 1 in Hammel et al. (2019)). Because this 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 represent consumer practices of the broader U.S. public, EPA has assigned moderate confidence to our use of this model input due to uncertainties from the lack of geographic diversity.

In Bi et al. (2015) (systematic review rating was high), monitoring data was collected from Dover, Delaware, for DBP in 2013. This study sampled 10 houses, with the floor material being made of carpet, hardwood or a combination of both. The study also indicated that the houses did not have a custodian for daily cleaning. EPA believes the residential samples from this study, along with Hammel et al. (2019) (systematic review rating was high) residential samples, can serve as a proxy of the broader U.S. population as the samples were collected in various houses containing differing DIBP source materials. Due to lack of geographic diversity, EPA has assigned moderate confidence to our use of these inputs.

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 Handbook is generally considered the gold standard input for body weight, and because the underlying body weight data were derived from the U.S. nationally representative NHANES dataset, EPA has assigned robust confidence to Agency use of this model input.

Total daily dust dose 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 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 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 Handbook, EPA has assigned moderate confidence to this model input.

Taken as a whole, with moderate Bi et al. (2015) and robust Hammel et al. (2019) confidence in the DIBP concentration monitoring data in indoor residential dust, robust confidence in body weight data from the *Exposure Factors Handbook* U.S. EPA (2011b), and moderate confidence in dust dose data from Özkaynak et al. (2022), EPA has assigned a weight of scientific evidence rating of moderate confidence in our estimates of daily DIBP dose rates from ingestion of indoor dust in residences due to concerns about adequate U.S. representation.

5.2.1 Assumptions in Estimating Doses from Indoor Dust Monitoring

5.2.1.1 Assumptions for Monitored DIBP Concentrations in Indoor Dust

The DIBP concentrations in indoor dust were derived from two studies, Bi et al. (2015) and Hammel et

al. (2019). Two of the studies were rated robust and one was rated modera te in the confidence in data used. For the studies rated moderate, there are concerns when determining the data's representativeness of a typical U.S. household, though the robust studies were assumed to be representative. Samples were either taken from the living room or children's room, where the children's room was identified as the room in which the child(ren) residing in the home spent the most time. 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 EPA's *Exposure Factors Handbook* (U.S. EPA, 2011b), in which they were derived from the NHANES 1999 to 2006 data set. The NHANES studies were designed to obtain a nationally representative data set for the United States and include weight adjustment for oversampling of certain groups (children, adolescents ages 12 to 19 years, persons 60+ years, 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 dose of DIBP in residential indoor dust, a daily rate of dust ingestion is required. EPA used rates from Özkaynak et al. (2022) which modeled to estimate dust and soil doses for children from birth to 21 years. 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 Dose Model

Variable	Description	Units	Source(s)
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/hour	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)

Variable	Description	Units	Source(s)
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
F_blanket [b]	Protective barrier factor of blanket when used	(–)	Professional judgment
Pacifier_size [b]	Area of pacifier surface	cm^2	Özkaynak et al. (2022)
Pacifier_frac_hard [b]	Fraction of pacifier drops onto hard surface	(–)	Professional judgment
Pacifier_frac_soft [b]	Fraction of pacifier drops onto soft surface	(–)	Professional judgment
Pacifier_transfer [b]	Fraction of dust transferred from floor to pacifier	(–)	Extrapolated from Rodes et al. (2001), Beamer et al. (2009), and Hubal et al. (2008)
Pacifier_washing [b]	Composite of the probability of cleaning the pacifier after it falls and efficiency of cleaning	(–)	Conservative assumption (zero cleaning is assumed)
Pacifier_drop [b]	Frequency of pacifier dropping	(–)	Tsou et al. (2015)
P_pacifier [b]	Probability of pacifier use	(–)	Tsou et al. (2015)

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

5.2.2 Uncertainties in Estimating Doses from Monitoring Data

5.2.2.1 Uncertainties for Monitored DIBP Concentrations in Indoor Dust

For the two studies, there is uncertainty for sampling biases which can include choice of study location, include only households that contain children and by differences among the households that chose to participate in the study. For example, Hammel et al. (2019) sampled residential house dust in 190 households in Durham, North Carolina, from a population selected from an existing pregnancy cohort study. In addition, differences in consumer behaviors, housing type and quality, tidiness, and other variables that affect DIBP concentrations in household dust are possible between participating households and the general population. Uncertainties arise from the low number of localities within the monitoring studies used to represent the U.S. population.

5.2.2.2 Uncertainties for Body Weights

Body weights were obtained from the *Exposure Factors Handbook* (U.S. EPA, 2011c), which contains data from the 1999 to 2006 NHANES. Body weights were aggregated across lifestages and averaged by

sex. In general, body weights have increased in the United States since 2006 (CDC, 2013) which may lead to an underestimate of body weight in this analysis. This would lead to an overestimate of DIBP dose per unit body weight, because actual body weights in the US population may be larger than those assumed in this analysis.

5.2.2.3 Uncertainties for Dust Ingestion Rates

Dust ingestion rates were obtained from Özkaynak et al. (2022) which uses mechanistic methods (the SHEDS model) to estimate dust ingestion using a range of parameters (Table 5-3). 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 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
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 dose for an 11-year-old based on EPA's *Exposure Factors Handbook* (U.S. EPA, 2017) is 30 mg/day. The age ranges do not align between the 2 sources in this instance.

The Özkaynak et al. (2022) dust dose estimates for children above 1 year old are substantially lower than those in the *Exposure Factors Handbook* (U.S. EPA, 2011c), while the estimate for children between 1 month and 1 year of age are slightly higher. The authors of the Özkaynak et al. (2022) study offer some justification for the discrepancy by noting that the Handbook recommendations are a synthesis of several types of study, including tracer studies that "[suffer] from various sources of uncertainty that could lead to considerable study-to-study variations." Biokinetic and activity pattern studies, such as Von Lindern et al. 2016 and Wilson et al. 2013 respectively, achieve results that are closer to the Özkaynak et al. (2022) results (see Fig. 4, Özkaynak et al. (2022).

5.2.2.4 Uncertainties in Interpretation of Monitored DIBP Dose Estimates

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

- Number of samples and locations used to represent the U.S. population.
- 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 DIBP that included non-TSCA COUs.
- None of the identified monitoring data contained source apportionment information that could be used to determine the fraction of DIBP in dust samples that resulted from a particular TSCA or non-TSCA COU. Therefore, these monitoring data represent background concentrations of DIBP 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.

6 CONCLUSIONS AND STEPS TOWARD RISK CHARACTERIZATION

Indoor Dust

For the indoor exposure assessment, EPA considered reasonably available modeling and monitoring data. Monitoring data is expected to represent aggregate exposure to DIBP 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 environments. The indoor dust assessment used consumer products and articles commonly present in indoor spaces inhalation exposure from toys, flooring, synthetic leather furniture, wallpaper, and wire insulation include a consideration of dust collected on the surface of a relatively large area, like flooring, furniture, and wallpaper, but also multiple toys and wires collecting dust with DIBP and subsequent inhalation and ingestion.

Given the wide discrepancies between monitoring and modeling of DIBP 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. Due the moderate confidence evaluation of the monitoring assessment, a risk estimate based on these data was not derived. Instead, they were used as a comparator to show that the modeled DIBP exposure estimates were health protective relative to residential monitored exposures (Table 4-4). This comparison was a key input to the Agency's robust confidence in the overall health protectiveness of our exposure assessment for ingestion of DIBP 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 *DIBP Draft Consumer Risk Calculator* (U.S. EPA, 2025b) have a moderate to robust confidence and therefore can be used for risk estimate calculations and to determine risk to the various lifestages. The consumer assessment has low-, medium-, and high-exposure scenarios which 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 DIBP from products/articles to sweat and skin. Low and medium exposure scenarios represent less intensity in use patterns, mouthing behaviors, and conditions that promote DIBP 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 (accessed July 23, 2025).

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 DIBP in air (mg/m^3)
Inh	=	Inhalation rate (m^3/hour)
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 minutes/hour)

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 to 24, 2 to 25, etc.) and then reports the highest of these computed values as the ADR.

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

Equation_Apx A-2. Acute Dose Rate for Inhalation from Article Placed in Environment

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

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

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

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)
$DIBPRP_{air\_max}$	=	Maximum DIBP 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/hour)
CF_1	=	Conversion factor (24 hours/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

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

Where:

ADR_{IAI}	=	Acute Dose Rate from Ingestion and Inhalation (mg/kg-day)
$DIBPRP_{air\_max}$	=	Maximum DIBP in respirable particles (RP) concentration, air (µg/mg)
RP_{air_max}	=	Maximum RP concentration, air (mg/m^3)
IF_{TSP}	=	RP ingestion fraction (unitless)
$DIBPDust_{air\_max}$	=	Maximum DIBP in dust concentration, air (µg/mg)
$Dust_{air\_max}$	=	Maximum dust concentration, air (mg/m^3)
IF_{Dust}	=	Dust ingestion fraction (unitless)
$DIBPAbr_{air\_avg}$	=	Maximum DIBP 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/hour)
CF_1	=	Conversion factor (24 hours/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/hour)
CA	=	Contact area of mouthing (cm^2)
D_m	=	Duration of mouthing (min/hour)
ED_{ac}	=	Exposure duration, acute (days)
CF_1	=	Conversion factor (24 hours/day)
BW	=	Body weight (kg)
AT_{ac}	=	Averaging time, acute (days)
CF_2	=	Conversion factor (60 minutes/hour)

See Section 2.2.1 for migration rate inputs and determination of these values.

Acute dose rate for incidental ingestion of dust (CEM A_ING3 model) was calculated as described below.

The article model named E6 in CEM calculates DIBP concentration in small particles, termed respirable particles (RP), and large particles, termed dust, that are settled on the floor or surfaces. The model assumes the particles bound to DIBP 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 DIBP-containing dust. The model uses a weighted dust concentration, shown in Equation_Apx A-6.

Equation_Apx A-7. Acute Dust Concentration

$$Dust_{ac\_wgt} = \frac{\left(RP_{floor\_max} \times DIBPRP_{floor\_max}\right) + \left(Dust_{floor\_max} \times DIBPDust_{floor\_max}\right) + \left(AbArt_{floor\_max} \times DIBPAbArt_{floor\_max}\right)}{\left(TSP_{floor\_max} + Dust_{floor\_max} + AbArt_{floor\_max}\right)}$$

Where:

$Dust_{ac\_wgt}$	=	Acute weighted dust concentration (µg/mg)
RP_{floor_max}	=	Maximum RP mass, floor (mg)
$DIBPRP_{floor\_max}$	=	Maximum DIBP in RP concentration, floor (µg/mg)
$Dust_{floor\_max}$	=	Maximum dust mass, floor (mg)
$DIBPDust_{floor\_max}$	=	Maximum DIBP in dust concentration, floor (µg/mg)
$AbArt_{floor\_max}$	=	Maximum abraded particles mass, floor (mg)
$DIBPAbArt_{floor\_max}$	=	Maximum floor dust DIBP 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 DIBP can volatilize from the DIBP-containing article to the air and then partition to dust. Alternately, DIBP 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 DIBP 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 DIBP in Dust

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

Where:

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

Once DIBP 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 DIBP 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/hour)
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 minutes/hour)

CEM uses two default inhalation rates which trace to the *Exposure Factors Handbook* (U.S. EPA, 2011c) (see Table_Apx A-1 footnote), one when the person is using the product and another after the use has ended. Table_Apx A-1 shows the inhalation rates by receptor age category for during and after product use.

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

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

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

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)
$DIBPRP_{air\_avg}$	=	Average DIBP 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 hours/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 DIBP 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 DIBP 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

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

Where:

$CADD_{IAI}$	=	Chronic Average Daily Dose from ingestion after inhalation (mg/kg-day)
$DIBPRP_{air\_avg}$	=	Average DIBP in RP concentration, air (µg/mg)
RP_{air_avg}	=	Average RP concentration, air (mg/m^3)
IF_{RP}	=	RP ingestion fraction (unitless)
$DIBPDust_{air\_avg}$	=	Average DIBP dust concentration, air (µg/mg)
$Dust_{air\_avg}$	=	Average dust concentration, air (mg/m^3)
IF_{Dust}	=	Dust ingestion fraction (unitless)
$DIBPAbr_{air\_avg}$	=	Average DIBP 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 hours/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 2.2.1 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 hours/day)
AT_{cr}	=	Averaging time, chronic (years)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (60 minutes/hour)

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

The article model in CEM E6 calculates DIBP 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 particles, bound to DIBP, 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 DIBP-containing dust. The model uses a weighted dust concentration, shown in Equation_Apx A-18.

Equation_Apx A-18. Chronic Dust Concentration

$$Dust_{cr\_wgt} = \frac{\left(RP_{floor\_avg} \times DIBPRP_{floor\_avg}\right) + \left(Dust_{floor\_avg} \times DIBPDust_{floor\_avg}\right) + \left(AbArt_{floor\_avg} \times DIBPAbArt_{floor\_avg}\right)}{\left(RP_{floor\_avg} + Dust_{floor\_avg} + AbArt_{floor\_avg}\right)}$$

Where:

$Dust_{cr\_wgt}$	=	Chronic weighted dust concentration (µg/mg)
RP_{floor_avg}	=	Average RP mass, floor (mg)
$DIBPRP_{floor\_avg}$	=	Average DIBP in RP concentration, floor (µg/mg)
$Dust_{floor\_avg}$	=	Average dust mass, floor (mg)
$DIBPDust_{floor\_avg}$	=	Average DIBP in dust concentration, floor (µg/mg)
$AbArt_{floor\_avg}$	=	Average abraded particles mass, floor (mg)
$DIBPAbArt_{floor\_avg}$	=	Average floor dust DIBP 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 DIBP can volatilize from the DIBP-containing article to the air and then partition to dust. Alternately, DIBP 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 DIBP 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 2-5 for inhalation and Table 2-8 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_Apx A-2
$Event\ per\ Day$	=	Events per day, day^{-1}, see Table_Apx A-2

Table_Apx A-2. Short-Term Event per Month and Day Inputs

Product	Events Per Day	Events Per Month
Concrete adhesive	1	2
Flooring adhesive	1	2

A.4 Dermal Absorption Dose Modeling for Acute and Chronic Exposures

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

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

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

Appendix B SOLID ARTICLE TO AIR PARTITIONING COEFFICIENT REFINEMENT

This appendix summarizes the screening approach doses and risk estimate results for inhalation and ingestion exposures to vinyl flooring. Potential risk is first identified when comparing the risk estimates to a benchmark. The benchmark margin of exposure (MOE) of 30 was estimated as described in *DIBP Draft Non-Cancer Human Health Hazard Technical Support Document* (U.S. EPA, 2025c). Because potential risk was identified in the inhalation exposure screening approach for all lifestages for the vinyl flooring high- and medium-intensity use scenarios, and there were available empirical data to refine the solid article to air partitioning coefficient, EPA refined inhalation exposure from vinyl flooring for all lifestages. See Section 2.2.3.1 for refinement approach description. Table_Apx B-1 summarizes the screening approach doses and risk estimates while highlighting those that pose potential risks. Table_Apx B-2 summarizes the refined approach doses and risk estimates.

Table_Apx B-1. Screening Approach Vinyl Flooring Inhalation Dose and Risk Estimate Results

Exposure Level	Exposure Duration	Dose µg/kg bw day – By Individual Age Group							Risk Estimate Margin of Exposure						
		Infant	Toddler	Preschooler	Middle Childhood	Young Teen	Teenager	Adult	Infant	Toddler	Preschooler	Middle Childhood	Young Teen	Teenager	Adult
High	Acute	5,072	4,778	3,884	2,705	1,908	1,634	1,312	1	1	1	2	3	3	4
Med	Acute	884	833	677	471	332	285	229	6	7	8	12	17	20	25
Low	Acute	9.6E−01	9.1E−01	7.4E−01	5.1E−01	3.6E−01	3.1E−01	2.5E−01	5,912	6,276	7,720	11,087	15,717	18,356	22,863
High	Chronic	560	528	429	299	211	180	145	10	11	13	19	27	32	39
Med	Chronic	98	92	75	52	37	31	25	58	62	76	109	155	181	226
Low	Chronic	1.1E−01	1.0E−01	8.2E−02	5.7E−02	4.0E−02	3.4E−02	2.8E−02	53,511	56,804	69,877	100,353	142,259	166,141	206,935

Table_Apx B-2. Refined Approach Vinyl Flooring Inhalation Dose and Risk Estimate Results

Exposure Level	Exposure Duration	Dose µg/kg bw day – By Individual Age Group							Risk Estimate, Margin of Exposure						
		Infant	Toddler	Preschooler	Middle Childhood	Young Teen	Teenager	Adult	Infant	Toddler	Preschooler	Middle Childhood	Young Teen	Teenager	Adult
High	Acute	241	227	184	128	91	78	62	24	25	31	44	63	74	92
Med	Acute	42	40	32	22	16	14	11	140	140	180	250	360	420	530
Low	Acute	4.6E−02	4.3E−02	3.5E−02	2.4E−02	1.7E−02	1.5E−02	1.2E−02	120,000	130,000	160,000	230,000	330,000	390,000	480,000
High	Chronic	194	182	148	103	73	62	50	29	31	38	55	78	91	110
Med	Chronic	34	32	26	18	13	11	8.7	170	180	220	320	450	520	650
Low	Chronic	3.7E−02	3.5E−02	2.8E−02	2.0E−02	1.4E−02	1.2E−02	9.5E−03	150,000	160,000	200,000	290,000	410,000	480,000	600,000