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Non-food products: How to assess children's exposure?

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Abstract

Guidance for child specific exposure assessment of non-food products

The risk assessment of children can be substantially improved by refining the exposure assessment. Children's exposure to chemical compounds will differ according to behaviour, physiological function or exposure pattern during the use of chemical products. An exposure assessment specifically designed for children is therefore necessary. This report provides guidance for the exposure assessment of consumer products ("non-food"). Different exposure aspects of child-specific activities at different ages (0 to18 years) are outlined here. Furthermore, the report illustrates how children can be exposed to all the different product types within a specific group of chemicals, the biocides. In addition, the report provides information on how the models from the RIVM's ConsExpo 4.0 software package can be used to calculate exposure.

Keywords: exposure assessment, children, consumer products, biocides, ConsExpo

Rapport in ‘t kort

Handreiking voor kinderspecifieke blootstellingschatting voor consumentenproducten

De risicoschatting voor kinderen kan aanzienlijk worden verbeterd door blootstellingsscenario’s specifiek voor kinderen op te stellen. Kinderen vertonen een ander gedragspatroon, zijn fysiologisch gezien verschillend van volwassen en worden tijdens gebruik van consumentenproducten op een andere wijze blootgesteld.
Het huidige rapport biedt een handreiking voor het opstellen van kinderspecifieke scenario’s voor de blootstelling aan consumentenproducten (voeding uitgezonderd). Het geeft een overzicht van een aantal kinderspecifieke activiteiten voor kinderen in verschillende leeftijdscategorieën (0-18 jaar). Daarnaast wordt ingegaan op de blootstelling aan een diverse groep van chemische stoffen, de biociden. Ook wordt aangegeven welke modellen van het RIVM softwareprogramma ConsExpo 4.0 gebruikt kunnen worden voor de berekening van de blootstelling.

Trefwoorden: blootstelling, kinderen, consumentenproducten, biociden, ConsExpo

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Samenvatting

In de risicoschatting voor chemische stoffen, gaat de laatste jaren veel aandacht uit naar kinderen als een gevoelige groep. Er wordt met name onderzoek verricht naar effecten door blootstelling tijdens zogenaamde ‘sensitive windows’, gevoelige perioden in de ontwikkeling van kinderen, maar dit is moeizaam en zal nog geruime tijd in beslag nemen. Het gebruik van specifieke blootstellingsscenarios voor kinderen is relatief eenvoudig, en levert een belangrijke bijdrage aan een verbeterde risicoschatting voor kinderen.

Kinderen vertonen een ander gedragspatroon, hebben een andere constitutie dan volwassenen, en worden tijdens gebruik van consumentenproducten op een andere wijze blootgesteld. Derhalve vormen kinderen vanuit blootstellingsoptiek een relevante groep, en dient er bij een risicoschatting een separate blootstellingsschatting voor kinderen te worden opgesteld. Wanneer er een blootstellingsscenario voor kinderen wordt opgesteld moet er rekening gehouden worden met de micro-omgeving, de karakteristieken van de chemische stof, de leeftijdsgerelateerde activiteiten van een kind, de relevante blootstellingsroutes en de aannames betreffende de opname van de chemische stof via deze blootstellingsroutes.
Het huidige rapport biedt een handreiking voor blootstellingsschatters op het gebied van blootstellingsschatting aan consumenten producten (voeding uitgezonderd). Het geeft een overzicht van een aantal kinder-specifieke activiteiten, voor kinderen in verschillende leeftijdscategorieën (0-18 jaar).

Daarnaast wordt voor een specifieke groep van chemische stoffen, de biociden, aangegeven op welke wijze kinderen aan deze producten kunnen worden blootgesteld. Daarnaast wordt ook aangegeven welke modellen van het RIVM softwareprogramma ConsExpo 4.0 gebruikt kunnen worden voor de berekening van de blootstelling.

Summary

During the last few years, considerable attention is given to children as a sensitive sub-population in chemical risk assessment. The focus of this discussion is mainly on sensitive windows in development and specific toxicological endpoints. However, knowledge on the exposure part of the risk assessment is equally important, but scarce. A child's exposure pattern to a non-food consumer product can be very different from that of an adult, due to distinct child-specific behaviours and activities. For this reason, an exposure assessment for a child requires incorporation of these child-specific behaviours and activities when defining exposure scenarios.

This report aims to provide guidance for child-specific exposure assessments for non-food consumer products. Characteristics of children may influence exposure due to their different behavior, physiology and activities. Children can be categorized in different age groups based on age-related activities. These activities in turn can be associated with several exposure aspects.

While defining an appropriate exposure scenario for children, aspects to consider in include the micro-environment, the characteristics of the chemical, the age related activities of the child, the resulting exposure pathways, and assumptions on the uptake of the chemical via these pathways.

When performing a risk assessment for a specific type of chemicals, the biocides, it is important to include a child-specific exposure assessment. The exposure of children to the different product types, as defined in the Biocide Directive (98/8/EC) may vary from that of adults. Models from the RIVM's ConsExpo 4.0 software package can be used to calculate exposure levels.

1 Introduction and purpose of the report

At present, risk assessments targeted specifically at children are subject to much discussion. The discussion focuses mainly on sensitive windows of development and specific toxicological endpoints. The research on toxicological effects is very difficult and progresses slowly. Hence, a spin-off for improvement of risk assessment cannot be expected on a short-term basis. However, knowledge of the exposure part of the risk assessment is equally important. Children's exposure to chemicals will be different due to different behaviour, dietary pattern, physiological characteristics or exposure pattern during use. For instance, adults generally will use consumer products, while children are only present as bystander. For these reasons, children form a relevant group with regard to risk assessment of chemicals and a separate exposure and risk assessment should be performed for children.
Refinement of the exposure assessment can be carried out relatively easy and contributes substantially to a more adequate risk assessment.
The aim of this report is two-fold. Firstly, it provides general guidance for the factors to be considered in children exposure assessment. Secondly, this report aims to guide the exposure assessment of biocides in relation to child exposure. For all product types, as defined in the Biocide Directive (98/8/EC), it is reported what are the typical exposure scenarios for children and which model from the ConsExpo 4.0 software package can be used to calculate this exposure.

2 General guidance for exposure assessment of children

The present chapter provides guidance on the factors to be considered in exposure assessment for children. The following issues are considered:

- why should children be considered separately in an exposure assessment?
- how do children's characteristics influence exposure?
- what are the exposure aspects of child-specific activities?
- what are the elements of an exposure scenario?
- which exposure model can be used for a particular exposure route?

2.1 Considering children separately in an exposure assessment

Exposure of children to compounds may differ from exposure of adults due to differences in behaviour, diet and physiology.
Children show a different activity pattern compared to adults. Depending on age, they spend more time crawling, sleeping, and mouthing on objects compared to adults. They spend more time in the same room or area, are in closer contact with a contaminated surface, for instance during crawling. They also display less hygienic behaviour such as mouthing of hands and objects and pica behaviour. They consume more food and drinks per kg body weight and their dietary pattern is different and less varied. Moreover, children have a high inhalation rate and a high body surface relative to body weight (US-EPA, 1997).
These factors generally cause children to be exposed to higher levels of contaminants from food, drinks, air and surface areas (e.g. floor, soil). With increasing age, higher exposure levels gradually decline to adult levels.

Not only the level of exposure of a child to a chemical may differ from that of adults; also the route of exposure may be different. For instance, treating a room or surface with a substance by using a spray-can may lead primarily to inhalation exposure in adults during application of the spray. However, due to their behaviour, children that are 0.5-2 years of age may be significantly exposed through the dermal and oral route by crawling and mouthing. Like in adults, the route of exposure may affect the level of exposure due to different levels of absorption and the presence or absence of a first pass effect. Related to this, the route of exposure also potentially affects the toxic effects of a chemical. Therefore, differences in the

expected routes of exposure between children and adults substantiate the need for a separate risk assessment for children.

The following points should be considered when performing an exposure assessment for children:

- Is the source of exposure accessible to children? For example, is the substance present in soil and dust in and around residences, schools or play areas?
- Do child-specific activities such as crawling, cuddling and mouthing indicate a possible route of exposure to the chemical, which may not be relevant for adults?

2.2 Age categories: factors influencing exposure

Not only may exposure of children differ from exposure of adults, but the exposure between children of different ages may also differ considerably. Although a child's development is a continuous process, age categories can be identified based on physiology, behaviour and physical activities. Using these factors, Armstrong et al. (2000) have proposed a classification of age categories that represent a group of children for which the highest exposure potential is expected (table 1)

Table 1: Age categories (Armstrong et al., 2000)

Age category	**Age**
Baby	0 - 6 months
Infant	6 months - 2 yr.
Toddler	2 - 5 years
Schoolchild	5 - 12 years
Adolescent	> 13 years

To determine which age group is relevant for the exposure assessment of a chemical, it is important to assess which type of behaviour is relevant for the product and/or chemical under study. For instance, in the exposure assessment of an insecticide used to treat a carpet, crawling infants will be the group to focus on, since they will come in close contact with the insecticide. It has to be stressed that the age group that is most exposed is not necessarily most at risk, since the sensitivity to the adverse effects of the substance may also vary between

children of different ages. It is therefore recommended to estimate exposure levels in children of several age categories.
The physiology, behaviour, and physical activity that determine the differences in exposure between children of different age are described in the following paragraphs.

2.2.1 Physiological characteristics

A number of physiological characteristics of children influence the level of exposure to a chemical.
Firstly, to provide energy for their growth and development and to maintain body temperature, children have a high metabolic rate, reflected by a high breathing rate and food consumption rate on a mg/kg bw basis. The high breathing rate and the growing surface area of the alveoli in the lungs may lead to a higher absorption of air contaminants as a child grows. Furthermore, the high food consumption rate will influence the exposure to environmental contaminants in food (Wolterink et al., 2002; Cohen-Hubal et al., 2000).
Secondly, to meet nutritional requirements varying with age, the body regulates absorption and permeability in the gut. For example, the same mechanism used to actively absorb calcium can inadvertently enhance the absorption of comparable ions such as lead (Hubal et al., 2000). Lead exposure may occur when infants and toddlers ingest contaminated soil or dust via hand-mouth contact.
Thirdly, the diet between children of different ages varies considerably. Shortly after birth the variation in the diet is very limited, i.e. predominantly breast milk or powdered milk. Gradually other food products such as fruit and cereals are included in the diet. This implies that if a food source for these very young children contains a certain substance, this may lead to high levels of exposure. From about one year of age the variation in the diet of children is more or less similar to that of adults, although relative quantities still may vary.
Lastly, a child's body composition affects the rate of contact with exposure media and alters the exposure-uptake relationship (Cohen-Hubal et al., 2000). The youngest children have a relatively low body weight and relatively large skin surface area which influences dermal exposure. Due to a high permeability of the skin, which is highest at birth and which decreases in the first year to adult level (Bearer, 1995; Cohen-Hubal et al., 2000), the age category of babies (0 – 6 months) may have a high dermal exposure. Additionally, subcutaneous fat developed at the age of 2-3 months continues to exist through the early

toddler period and may act as a sink for lipophilic compounds absorbed via the skin (Cohen-Hubal et al., 2000).

2.2.2 Behavioural development

The way children behave and interact with their environment influences exposure to contaminants. Developmental milestones such as crawling and walking are related to increased in motor capacity. These milestones can also be used for sub-classifying children in exposure studies (Van Engelen et al., submitted). For instance, an infant crawls and plays on a floor surface and a toddler with more mobility spends less time playing on the ground inside but more outside in the sandbox or on playing grounds.
As infants develop they begin to explore their environment through mouthing and put all kinds of things, such as toys and pencils, into the mouth. Further, changes in manual co-ordination such as picking up, holding and manipulating occur. Hands may get contaminated while touching surfaces and children may use the contaminated hands for placing objects or food into the mouth, leading to non-dietary oral exposure (Cohen-Hubal et al., 2000).

2.2.3 Physical activities

Specific physical activities lead to exposure via different routes. Factors influencing the exposure of a child are the type and location of the activity and the activity level. Activity patterns vary with gender, age and development stage; further, seasonal and geographical differences may lead to different activity patterns among children of similar development stages. Consequently, the contact rate and thus exposure to diverse media also varies (Cohen-Hubal et al., 2000). For instance, in the age category of school children boys are more likely to play outdoors than girls do, and the type of physical activity is dissimilar from girls e.g. playing soccer versus reading a book in the living room.

2.3 Exposure aspects of child-specific activities

Children can be exposed during a variety of activities and behaviour. We have discerned the following categories: oral exploration, crawling, cuddling, playing, sporting, working, washing (personal care) and general activities such as sleeping and sitting. These categories and their associated exposure routes and sources are described below.

2.3.1 Oral exploration

In childhood development sucking and mouthing hands or objects is natural behaviour, and is especially stimulated during teething. As children grow older, they are less likely to place objects into their mouths. Accordingly, mouthing duration appears to decrease as age increases. The age categories which show mouthing behaviour are babies, infants and toddlers; mouthed items are pacifiers, teething rings, (non-) toys, and fingers. For exploration of their environment, especially infants put almost everything into the mouth.

Oral exploration can be divided in:

- *Mouthing* including sucking as well as licking, chewing and biting which lead to oral intake of pieces material, surface contaminants or of leachable compounds
- *Hand-mouth contact* which leads to ingestion due to transfer of contaminants from surfaces (or soil) via the hand
- *Object-mouth contact* in which toys or other articles act as transfer agents for contaminants on surfaces resulting in oral exposure
- *Pica* leading to deliberate soil ingestion.

2.3.2 Crawling

One of the typical behaviours that infants show is crawling. When they crawl on the floor or carpet, the contact is more intensive than when they are lying, sitting or walking. They are in close contact with inhalable contaminants (dust, vapour) coming from the floor surface. Furthermore, crawling children may have dermal contact with contaminants / residues due to rubbing off surfaces. Transfer from surface to mouth occurs by hand-mouth contact or object-mouth contact resulting in oral exposure.

2.3.3 Cuddling

One of the favourite activities, and not only of the babies, is cuddling. It should be realised that (work) clothes of parents, baby-sitter or siblings can be a source of exposure. The children can be exposed via inhalation (dust, vapour), via the skin (rubbing off) or orally (hand-mouth contact).

2.3.4 Playing

Young children come into contact with sources of contamination during playing, both indoors and outdoors. While playing close to the ground they come into contact with contaminated soil, dust and other residues on surfaces. For playing behaviour a distinction is made between the different sources (table 2):

- *Arts and crafts materials* like finger-paint, face paint, felt pen, chalk, modelling clay. Exposure might occur during inhalation of vapours (e.g. felt pens) or of dust (e.g. chalk). Dermal exposure occurs when children have direct skin contact with face paint and make up, or intensive hand contact with modelling clay or finger paint. Ingestion can occur by hand-mouth contact or by ingestion of chips.
- *Toys* can be made of different materials e.g. metal, wood, plastic or cloth. Dust contaminants on the surface of toys can be inhaled. Toys serve as transfer agents for contaminants on surfaces (floor, rug, table) resulting in dermal exposure and in oral exposure via object-mouth contact. Further, mouthing toys can lead to leaching of substances from toys.
- *Pets* can be treated with shampoo or other products. They roll over surfaces that may be sources for contaminants. While petting or otherwise touching their pets, children can inhale contaminated hair and dust, rub off contaminants, which can in turn be ingested as a result of hand-to-mouth transfer.
- *Outdoors* including locations such as playgrounds, puddles, soil, and grass. The inhalation exposure exists of environmental air contaminants and aerosols. When children play outdoors they have skin contact with different materials such as soil, grass, and playgrounds equipment. Contaminants on these materials may be transferred to the skin of children. While playing with water, compounds may diffuse through the skin. Further, oral exposure may occur via hand-mouth transfer or via ingesting or mouthing pieces of material.

2.3.5 Sporting

While playing sports, children can be exposed to various substances. For example, practising judo children wipe off the floor resulting in skin contact with surface contaminants. Due to a higher ventilation rate the inhalatory exposure to air contaminants is higher while playing sports than in a rest situation. Swimming results in inhalatory, dermal and oral exposure of disinfectants and by-products contained in swimming pools.

2.3.6 Working

Adolescents, desiring to have more pocket money, work on farms, in the catering or they deliver newspapers. In these surroundings there could be more exposure to substances than normally. These young labourers are exposed to evaporation, dust (inhalation, skin contact) from devices, (agriculture) products, news papers etc. When they come home with their working clothes, younger children might be exposed to contaminants (secondary exposure).

2.3.7 Washing and hygiene

Several cosmetics or hygiene products are used for children. Inhalation occurs from different sources such as evaporation from shampoo, dust from towels, powder, and liquid aerosols from baby oil sprays. Dermal exposure to washing and hygiene products is inherently high but may be enhanced by warm skin or skin that is not intact.
Young children (baby, infant and toddler) could incidentally ingest small amounts of water while showering or bathing. Regarding oral hygiene products, younger children ingest more toothpaste than older children do (Bremmer et al., 2006a).

2.3.8 General activities

In this paragraph exposure during general activities, like sitting, sleeping, lying is considered. The inhalatory exposure depends on the location, such as home, school or outdoors. Between the different locations not only sources for evaporation or dust differ, but room volume and ventilation may differ as well. During contact with parents or siblings, secondary indirect exposure may occur, resulting in inhalatory exposure of contaminants or of residues on the parent’s clothes.
Dermal exposure can occur with (bed) clothing and substances may migrate to the skin. When children are lying or sitting, skin contact might also occur through wiping off surfaces. Oral exposure may take place from plates or from bottles contaminated with residues from for example dishwashing product. Further, substances in packaging material can migrate into food or into beverage leading to oral exposure (see table 2).

Table 2: Overview of exposure aspects during age-specific activities

Activity/ behaviour	Age category	Exposure route	Type of contact	Sources[1]	Location
Oral exploration					
Mouthing	Baby, infant, toddler, in particular the infant category	Non-dietary ingestion	Direct oral intake or leaching	Pacifier, teether, (wooden, metal, plastic, cloth) toys, other objects e.g. pencils, clothing, paper, plaster, paintchips, leaves, sand, flowers etc.	Home/ day-care: Living room, other room; also outdoors
Hand-mouth contact	Idem	Non-dietary ingestion	Direct oral intake or constant rate	Transfer from contaminated surfaces etc.	
Object-mouth contact	Idem	Non-dietary ingestion	Idem	Toys or other articles as transfer agents for contaminants on surfaces	
Surfaces	Idem	Non-dietary ingestion	Idem	Crib rails, tables, floor, carpets	
Pica behaviour	Infant, toddler	Deliberate soil ingestion	Direct oral intake	Soil Relatively uncommon; generally inadvertent soil ingestion via mouthing objects or hands	Outdoor
Crawling	Infant	Inhalation	Evaporation, dust	Floors, carpets	Home/ day-care: Living room, other room; also outdoors
		Dermal	Rubbing off	Idem	
		Non-dietary ingestion	Direct oral intake or constant rate	Idem by hand-mouth contact	
Cuddling	Baby, infant, toddler	Inhalation	Evaporation, dust	(work) clothes	Home/ day-care: Living room, other room; also outdoors
		Dermal	Rubbing off	Idem	
		Non-dietary ingestion	Direct oral intake or constant rate	Idem by hand-mouth contact	

Table 2 (continued): Overview of exposure aspects during age-specific activities

Activity/ behaviour	Age category	Exposure route	Type of contact	Sources[1]	Location
Playing					
Arts & crafts	All, except babies	Inhalation	Evaporation, dust	Finger paint, face paint, chalk, felt pen, modelling clay, make-up etc.	Indoors, home/ school/ day-care
		Dermal	Direct skin contact	Idem	
		Non-dietary ingestion	Direct oral intake or constant rate	Chips from ball pen, felt pen etc, dust from chalk Hand-mouth contact	
Toys	All, except adolescent	Inhalation	Evaporation, dust	Contaminants on / in wooden, cloth, plastic, metal toys	Indoors, home/ day-care/ school; On the floor, rug or in the playpen
		Dermal	Rubbing off	Toys as transfer agents for contaminants on surfaces	
		Non-dietary ingestion	Constant rate or leaching	Contaminants on surfaces Contaminants in material	
Pets	All	Inhalation	Dust	Hair, dust from pet	Indoors, home
	All, except babies	Dermal	Rubbing off	Residues on pets	
	Idem	Non-dietary ingestion	Constant rate	Transfer from contaminated surfaces via hand-mouth contact	
Outdoors	All, except babies	Inhalation	Evaporation, dust	Environmental exposure	Playing ground, sandbox, puddle soil, grass, park, (wooden/metal) garden play equipment etc
	Idem	Dermal	Rubbing off Diffusion through skin	Contaminants on surfaces Contaminants in water	
	Infant, toddler	Non-dietary ingestion	Direct oral intake	Paint chips, metal chips, sand, water, etc.	
			Constant rate	Transfer from contaminated surfaces via hand-mouth contact	
			Leaching	Contaminants in material	

Table 2 (continued): Overview of exposure aspects during age-specific activities

Activity/ behaviour	Age category	Exposure route	Type of contact	Sources[1]	Location
Sporting	School child, adolescent	Inhalation	Evaporation, dust	Air contaminants	Indoors/ outdoors: swimming pool, ice-skating arena, sports centre
		Dermal	Rubbing off	Contaminants on surfaces	
			Diffusion through skin	Disinfectants and by-products in swimming pools	
		Non-dietary ingestion	Direct oral intake or constant rate	Swimming pool water	
Working	Adolescent	Inhalation	Evaporation, dust	Machines, tools, raw materials/ produce, (agriculture) products, work clothing, newspapers etc.	Indoors/ outdoors
Washing & hygiene	All	Inhalation	Evaporation, dust, liquid aerosols	Hygiene products, cosmetics, shower water, towels, toilet paper, tissues, napkins (baby, infant)	Bathroom, toilet, bedroom, other room
	All	Dermal	Direct skin contact with (diluted) product	Idem	
	Baby, infant, toddler	Incidental ingestion	Direct oral intake	Bath or shower water	
Oral hygiene	All except babies	Incidental ingestion	Direct oral intake	Toothpaste	

Table 2 (continued): Overview of exposure aspects during age-specific activities

Activity/ behaviour	Age category	Exposure route	Type of contact	Sources[1]	Location
General	All	Inhalation	Evaporation, dust, aerosols	Cuddle toys, (bed)clothing, household textiles, upholstery, mattress, furniture, leather materials, building materials, electronic devices, kitchen equipment, paint, hobby articles, air conditioners, toys, cleaning products, air fresheners etc.	Indoors, home (bedroom, living room) Indoors, recreational
	Baby, infant, toddler	Idem	Idem	Idem	Indoors, day-care
	School child, adolescent	Idem	Idem	Idem	Indoors, school
	All	Idem	Idem	Environmental exposure	Outdoors
	Except adolescent	Idem	Idem	Clothes (baby carrier)	Parental/ sibling secondary indirect exposure
	All	Dermal	Migration Rubbing off	(Bed) clothing All kind of surfaces	
	Baby, infant, toddler	Dermal	Migration Rubbing off	Clothes (baby carrier) Bed (clothing) All kind of surfaces	Parental/ sibling secondary exp.
	All	Ingestion	Direct oral intake, Migration	Articles in contact with food: crockery, Food containers	

[1] The list of sources is indefinitely large, and this selection should be considered as examples only

2.4 Exposure scenarios

To estimate the exposure to substances for children, age-related characteristics, related activity patterns and contact rates with the sources should be considered. Children's exposure scenarios generally include facts, data and assumptions about the following:

- Exposure setting i.e. the location where exposure takes place (micro-environment)
- Exposure pathway(s) i.e. the course a chemical takes from its source(s) to the child being contacted e.g. toys lying on a treated carpet act as a transfer agent for residues, then

children pick up their toys which may lead to dermal exposure to the hands, or to oral exposure caused via hand-mouth contact or object-mouth contact

- Characterisation of the chemical, i.e. amounts, locations, time variation of concentrations, source strength, and environmental pathways from source to exposed individuals, fate of the chemical in the environment.
- Identification of children's age category exposed, and the profile of contact with the chemical based on behaviour, location as a function of time, characteristics of the individuals.
- Assumptions about the transfer of the chemical across the boundary via exposure routes, i.e., ingestion rates, respiration rates, absorption rates, etc. (intake and uptake rates). An exposure route is the particular means of entry into the body, i.e. by inhalation, ingestion, or dermal absorption and the respective boundaries are lung tissue, gastrointestinal tract wall and skin.

(derived from Guidelines for Exposure Assessment, US-EPA, 1992)

Quantitative information on exposure factors can be found in the US-EPA's Child Specific Exposure Factors Handbook (US-EPA, 2006)

2.5 ConsExpo Exposure models

In the absence of measured data on the exposure potential through inhalation, dermal contact or ingestion, mathematical exposure models are frequently used to estimate exposure concentrations. ConsExpo 4.0 is a software tool that can be applied to assess human exposure to chemicals in consumer products both during application and post-application in indoor situations. The tool uses various exposure scenarios and mathematical models for the inhalatory, dermal and oral exposure routes. The required data depends on the selected model. Below, different ConsExpo 4.0 models and accompanying parameters are discussed.

*Table 3***:** *Exposure routes, models and parameters in ConsExpo 4.0*

Exposure route	**Model**	**Parameters**
All	All	General: • use frequency • body weight • product amount or concentration • weight fraction compound (physicochemical properties)
Inhalation		All inhalation models:
Inhalation (1)	Evaporation	• exposure duration • room volume • ventilation
Inhalation (2)	Liquid aerosols	• inhalation rate • respirable fraction
Dermal		
Dermal (1)	Direct skin contact	• exposed area
Dermal (2)	Constant rate	• contact time
Dermal (3)	Rubbing off	• transfer coefficient • dislodgeable amount • contact time
Dermal (4)	Migration	• leachable fraction • skin contact factor
Dermal (5)	Diffusion	• diffusion coefficient • layer thickness • contact time
Ingestion		
Ingestion (1)	Direct oral intake	• ingested amount
Ingestion (2)	Constant rate	• ingestion rate • exposure time
Ingestion (3)	Migration	• initial migration rate • exposure duration • contact area
Ingestion (4)	Migration from packaging material	• thickness package • contact area • package amount • ingested amount

2.5.1 ConsExpo 4.0 inhalation models

ConsExpo 4.0 can estimate inhalation exposure for two scenarios: evaporation and aerosol exposure. Parameters that are important for both scenarios are product and compound data, information on the location of the exposure (room volume, ventilation rate, room-use pattern, proximity to source), and information on the inhalation rate of the age category exposed, which in turn depends on body weight and level of activity.

The two inhalation models in ConsExpo 4.0 are:

- Evaporation model, for volatilised product (inhalation 1). This model describes a scenario in which a compound evaporates from a surface into the room air, for example, from a painted wall, or a can of product. Depending on what product details are available, different sub-models can be selected, describing various ways in which a substance is released: instantaneously (first tier), at a constant rate or via evaporation over time.
- Liquid aerosols model, for generated liquid aerosols from sprays or shower (inhalation 2). An important parameter in this model is the respirable fraction. This parameter defines which fraction of the inhaled particles descends in the lungs, which depends on the particle size. For example, particles larger than 20 μm are all non-respirable and particles smaller than 5 mm are respirable for about 35%. The remainder, deposited in nose, throat or upper bronchial tract, can be swallowed and is assumed to cause oral exposure (Bremmer et al., 2006b).

2.5.2 ConsExpo 4.0 dermal contact models

The dermal exposure model implemented in ConsExpo 4 describes a situation in which a substance is in direct contact with the skin. Within the model, a number of sub-models can be selected, depending on how the substance reaches the skin: instant application, constant rate, rubbing off, migration, and diffusion model, respectively (table 3).

The direct skin contact model (dermal 1) can be used when a product is applied at once to the skin. For instance cosmetics and hygiene products are applied directly on the skin which can be in the undiluted form (body lotion, sunscreen) or in the diluted form (bath with oil, foam).

If information on the application time is available, the constant rate model (dermal 2) can be used, which calculates the exposure over the period during which the product is used.

The rubbing off model (dermal 3) describes when the product is initially applied to a surface and consequently transferred to the skin by dermal contact with the surface. How much of the residue is transferable depends on the amount of product applied, type of formulation, type of surface and amount of dissipation. The percent transferable residue is higher for smooth, hard surfaces than for textured surfaces. Moreover, a higher percentage of residues will be dislodged when dermal contact occurs directly after the application when the surface remains wet, which is of importance for infants interacting with their environment by crawling, or lying on contaminated surfaces. The dislodgeable fraction may also be higher when children touch the treated surface with wet hands. The Technical Notes for Guidance (TNsG, 2002) gives a 20% transfer efficiency for touching with a *dry* hand dried fluid residue on cotton, knitwear, plastic or wood. For touching with a *wet* hand the transfer efficiency is higher i.e. 30%.
The exposed bare skin which is in contact with the treated floor determines the dermal exposure and depends on the types of clothing an infant wears (UF, 2005).

The migration model (dermal 4) describes an active substance migrating from a material e.g. clothing which is in contact with the skin. The leaching or migration factor is the amount of substance leached per unit weight of material per unit of time. It depends on the material from which the leaching takes place and the substance that is released from the material. The other parameters are the contact frequency i.e. the number of times that leaching actually takes place and the skin contact factor i.e. the fraction of the material that actually comes into contact with the skin. For instance the skin contact factor for underwear is higher than for a sweater.

The diffusion model (dermal 5) describes diffusion of a substance through a viscous product, which is loaded onto the skin, for instance a cream. Diffusion depends on how well the substance is distributed in the product and on the thickness of the layer of the product applied to the skin.
Examples of different dermal exposure scenarios for children are:

- contact with dusts (direct or constant rate skin contact model);
- contact with treated surfaces or articles (rubbing off model);
- contact with contaminated areas, clothing or tools (rubbing off or migration model);
- contact with creams (diffusion model).

2.5.3 ConsExpo 4.0 ingestion models

ConsExpo 4.0 can estimate oral exposure for two different scenarios, describing either direct oral ingestion of the product containing the substance (ingestion 1, 2 and 3) or exposure through migration of the substance from packaging material (ingestion 4). Sub-models within the oral ingestion model are direct oral intake (ingestion 1), intake with a constant rate (ingestion 2), and migration of a substance from a product to the saliva in the mouth (ingestion 3).

The latter model is particularly useful to estimate oral exposure from mouthing. Incidental non-dietary ingestion due to oral exploration is an important exposure aspect for young children (infants, toddlers). Young children mouth different objects such as soil and toys, resulting in oral intake of pieces of material or of surface contaminants. During mouthing a substance may leach from the mouthed article. To use the migration model, the contact time, contact area and initial migration rate should be known.

Another model (ingestion 4) is migration from packaging material, which results in ingestion of contaminated food.

Examples of different oral exposure scenarios for children are:

- ingestion of dislodged dust and deposits (direct oral intake or constant rate model);
- mouth treated articles (direct oral intake, constant rate or migration model);
- ingest food contaminated with direct or dislodged deposits (direct oral intake or migration from packaging material model).

3 Biocides

3.1 Categorisation biocides

In the previous chapters children's exposure in general is described which can be used for discussing the exposure to biocides. Different products existing of various materials might contain biocides or might be contaminated with residues of biocides such as preservatives. In this report the biocides are categorised in main categories i.e.:

- Disinfectants and general biocidal products (chapter 3.2);
- Preservatives (chapter 3.3);
- Pest control products (chapter 3.4);
- Other biocidal products (chapter 3.5).

Table 4: Main categories biocides and their accompanying types of products

Type	Name	Type	Name
	Disinfectants & general biocidal products		**Pest Control Products**
1	Human hygiene products	14	Rodenticides
2	Private area and public health area disinfectant, etc.	15	Avicides
3	Veterinary hygiene products	16	Molluscicides
4	Food and feed area disinfectants	17	Piscicides
5	Drinking water disinfectants	18	Insecticides, acaricides, etc.
		19	Repellents and attractants
	Preservatives		
6	In-can preservatives		
7	Film preservatives		**Other biocidal products**
8	Wood preservatives	20	Preservatives for food or feedstocks
9	Fibre, leather, rubber and polymerised materials preservatives	21	Antifouling products
		22	Embalming and taxidermist fluids
10	Masonry preservatives	23	Control of other vertebrates
11	Preservatives for liquid-cooling and processing systems		
12	Slimicides		
13	Metal working fluids		

3.2 Disinfectants and general biocidal products

An overview of disinfectants is given below and is derived from the TNsG (2002) and the Danish Environmental Protection Agency (2001).

Type	Disinfectants & general biocidal products
1	Human hygiene products • skin disinfectants
2	Private area and public health area disinfectants and other biocidal products
2.01	• Disinfectants for private areas • Disinfectants for professional cleaning and industrial use* • Disinfectants for medical equipment*
2.02	Disinfectants for swimming pools
2.03	Disinfectants for air-conditioning systems
2.04	• Disinfectants for chemical toilets • Disinfectants for treatment of waste-water or of hospital waste*
2.05	Other disinfectants within type 2 • Disinfectants for laundries
3	Veterinary hygiene biocidal products** • Disinfectants applied directly to domestic animals • Disinfectants for areas in which animals are housed, kept or transported • Disinfectants for milking equipment
4	Food and feed area disinfectants • Food and feed area disinfectants used in agriculture* • Disinfectants used in the food-processing industry* • Disinfectants used for handling in retail shops or other food handling areas
5	Drinking water disinfectants

* These disinfectants are beyond the scope of this report; only those with an exposure potential for children will be dealt with.

* * Only relevant for children resident at a farm

For describing children's exposure to biocides, exposure aspects during particular activities (table 2) and exposure routes, models and parameters (table 3) are applied and at the end of each paragraph, an overview of the exposure aspects is given for the concerning disinfectant. In section 3.1 human hygiene products such as wipes and disinfecting soap is discussed. The following section 3.2 deals with disinfectants for private area and public health area (five subcategories). Veterinary hygiene products, food and feed area disinfectants and drinking water disinfectants are described in section 3.3, 3.4 and 3.5 respectively.

3.2.1 Human hygiene products Type 1

To type 1 belong the human hygiene products covering the non-cosmetic and non-medical products intended to clean the skin. Human hygiene biocidal products are mainly used in the health care and in the food industry. To avoid contamination and prevent infections in relation to cuts, abrasions and the like, a limited number of products are used in private homes and workplaces. Sub-types of human hygiene products are skin disinfectants, covering liquid disinfectants, antibacterial soaps, hand wipes, moistened lavatory tissues and baby wipes. These wipes / tissues can cause inhalation exposure due to alcohol evaporation. Children's bottoms are wiped with wet tissues which gives dermal exposure. The TNsG (2002) gives for wiping a frequency of 4 times a day and the quantity of liquid deposited on the skin is proposed as 0.5 ml per event.

Washing the hands with antibacterial soaps will be applied for children especially when they come into contact with dirt and soil. The Exposure Factors Handbook (US-EPA, 1997) gives a range of number of times for washing the hands. Most children, circa 50%, in the age of 1 to 17 years old wash hands 3 to 5 times a day. The TNsG gives for the washing procedure a frequency of 4 times a day. Rinse-off products, such as soap, have a retention of 10% which means that 10% of the used amount (residues) stays on the skin (SCCNFP, 2000).

Table 5: Human hygiene products Type 1

Human hygiene products	Activity/ behaviour	Exposed group	Main exposure route(s)	Model	Location/ source
Baby wipes	Washing & hygiene	Babies, infants	Inhalation (1) Dermal (1)	Evaporation Direct skin contact	Bathroom, toilet, bedroom, other room
Lavatory wipes	Washing & hygiene	> Toddlers	Inhalation (1) Dermal (1)	Evaporation Direct skin contact	Bathroom, toilet
Soap: washing hands	Washing & hygiene	> Infants	Dermal (1)	Direct skin contact with (diluted) product	Bathroom, toilet, kitchen

3.2.2 Private area and public health area disinfectant Type 2

Type 2 disinfectants for private area and public health area can be subdivided into:

2.01 Disinfectants for private areas

2.02 Disinfectants for swimming pools

2.03 Disinfectants for air-conditioning systems

2.04 Disinfectants for chemical toilets

2.05 Disinfectants for laundries

Disinfectants for private areas ***Type 2.01***

Type 2.01, disinfectants for private areas primarily include chlorine containing products for bleaching and disinfecting walls, floors and other surfaces principally in kitchens, bathrooms and lavatories. In domestic situations, hypochlorite is normally supplied at 3-5% available chlorine, with typical in-use concentrations at 0.01 to 0.5%. Application such as mopping and wiping depends on the degree of soiling and after this the surfaces are wiped or left to dry. For infants and young children there could be inhalation of volatilised residues. They are in close proximity to potentially contaminated floors, surfaces and air which may result in a higher inhalation exposure.

Infants crawling for 1 to 2 hours on floors or on carpets wipe off the floor resulting in skin contact. As mentioned before dried residues on hard surfaces are more dislodgeable than residues on textured surfaces like carpets resulting in higher dermal exposure (section 2.5.2). In addition, hand-to-mouth and object-to-mouth contact result in oral exposure to contaminants that also occur when children touch and eat foods that have contacted contaminated surfaces. In addition, ingestion occurs when crockery is washed in a dishwashing machine with chlorine containing products; consequently, residues from tableware can dislodge into food or beverages.

Disinfectants for swimming pools ***Type 2.02***

Product type 2.02, biocidal products/ disinfectants to be used in swimming pools etc., covers the treatment of indoor and outdoor public and private swimming pools, leisure centres (water-slides, wave machines), hydrotherapy pools and spa baths. While swimming children experience dermal contact with the treated water, inhalation of volatile and ingestion of a small volume of treated water is inevitable.
The inhalatory exposure in outdoor pools will be negligible, as atmospheric concentrations above the pool water surface are very low, even when their concentrations in water are high. The exposure in outdoor pools is mainly via the skin or via oral intake.

The Exposure Factors Handbook or EFH (US-EPA, 1997) describes several activity patterns. For activity factors, the numbers of times swimming in a month in freshwater is specified for different age categories. The frequency in the age category from 1 - 4 years is 9.5 $month^{-1}$ (75^{th} percentile). Toddlers in the age from 2 to 5 years old might take swimming lessons; therefore, the frequency can be 2 times a week for the duration of 1 hr. The Standard Operating Procedures for swimming pools (SOP 5.0: US-EPA, 1997) gives a duration of exposure of 5 hrs a day for children (age 6 yr.) which is the 90^{th} percentile value for the time spent at home in a pool or spa. For children in general the default value is one per month for 60 minutes (EFH: US-EPA, 1997).

The incidental non-dietary ingestion of residues assumes that children ingest pool water during swimming, playing or diving in the pool and the assumed ingestion rate for children is 0.05 L/ hr. Nonetheless the swallowed volume is unknown, but the given ingestion rate is usable if further data lack (SOP 5.0: USEPA, 1997).

Nowadays ‘swimming’ lessons are given for babies accompanied by an adult. The youngest children are the lightest and have the highest uptake per kg of body weight for the same dermal exposure. Baby swimming lessons are started at the age of about 12 weeks (www.babycentre.co.uk). The site www.babyswimming.com gives that the optimal age to start is from 6 to 12 months and it gives an initial frequency of 4 times a week. Later on the frequency can be between 2 to 4 times a week. The above-mentioned Internet sites indicate that the ‘swimming’ time for babies is limited to 30 minutes. For babies the recommended water temperature is between 29 –30 ^{0}C and the optimal temperature is 32 ^{0}C. The higher water temperature causes higher air concentrations of volatile compounds; moreover, substances penetrate more easily the blood-saturated skin.

Disinfectants for air-conditioning systems ***Type 2.03***

Product type 2.03 encloses biocidal products to be used in air-conditioning systems. They can be applied for preserving the cooling liquid or disinfecting the system. Contamination of the cooling liquid is most likely to happen in open or semi-open systems. The Danish EPA (2001) stated that biocides used for liquid-cooling and processing systems and biocides for air-conditioning systems were very much the same.

During the time spent in a humidified atmosphere, inhalation could lead to secondary exposure of residual biocide. All age-categories could be exposed at an air-conditioned location such as shopping centres or hospitals.

Disinfectants for chemical toilets ***Type 2.04***

Product type 2.04, biocidal products for chemical toilets, may be used in toilets of campers or of boats. The fluids need to mask colour and odour, as well as rendering pathogenic organisms harmless. These toilets are designed to minimise biocide aerosol generation or splashing during use. Children from two years old using these toilets could have dermal contact with the disinfectant.

Disinfectants for laundries ***Type 2.05***

Product type 2.05, other products within biocidal product type 2, is inadequate defined. Examples may be the use of disinfectants for laundry from the health care sector or hotels. The disinfectants have a combined effect as both disinfectants and bleaching agents.

The youngest children wearing clothes and sleeping most of the time under blankets might be dermally exposed to compounds leaching from fabric to the skin. In addition, they could inhale these biocidal products because of the short distance from the nose to the fabric. Furthermore, babies/ infants could mouth fabric leading to oral exposure to leachable compounds.

Table 6: Private area and public health area disinfectants Type 2

Disinfectants	Activity/ behaviour	Exposed group	Main exposure route(s)	Model	Location/ source
Type 2.01 Areas	Crawling	Infant	Inhalation (1, 2)	Evaporation, dust	Indoors, home/ day-care: floors and carpets
	Crawling	Infant	Dermal (3)	Rubbing off	Idem
	Hand-mouth contact	Infant, toddler	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Idem
	Eating	All	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Crockery
Type 2.02 Swimming pools	Swimming (incl. baby swim)	All	Inhalation (1, 3)	Evaporation, Liquid aerosols	Indoors (outdoors)
	Idem		Dermal (3, 4)	Rubbing off Diffusion through skin	Surfaces Pool water
	Idem		Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Pool water
Type 2.03 Air-conditioners	General	All	Inhalation (1)	Evaporation	Indoors, shopping centre, cinema, hospital
Type 2.04 Chemical toilets	General	> Toddler	Dermal (1)	Direct skin contact	Toilet camper, boat, bus
Type 2.05 Other: laundries	General	All	Inhalation (1, 2)	Evaporation Dust	(bed)clothes
	Idem	All	Dermal (2)	Migration	Idem
	Idem	Baby, infant, toddler	Non-dietary ingestion (3)	Leaching	Idem

3.2.3 Veterinary hygiene biocidal products Type 3

These products are used on farms for treating animal housing and livestock market. The disinfectants can be applied directly to domestic animals, for areas in which animals are housed, kept or transported or for milking equipment. Human and animal footbaths belong to this category. Children especially toddlers living on farms as family members could be in contact with freshly treated surface or could fall into a footbath while exploring their environment. The possible routes of exposure are dermal contact and possibly hand-mouth contact (non-dietary ingestion).

3.2.4 Food and feed area disinfectants Type 4

These products are used by professionals only to disinfect equipment, containers, consumption utensils, surfaces or pipework associated with production, transport, storage or consumption of food or of beverages in food handling retail shops (butchers, bakeries) or other food handling areas (cafeterias, canteens).
When feed areas in (fast-food) restaurant are recently disinfected, infants or young children could have skin contact with the treated surface and there could be hand-mouth contact leading to non-dietary ingestion. If food or beverages come into contact with biocidal residues, a certain percentage of residues dislodges to food or beverages (oral exposure).

3.2.5 Drinking water disinfectants Type 5

Drinking water disinfectants are used for disinfecting drinking water by the waterworks or locally by the user before drinking low quality water during travelling and temporary stays in developing countries. Chlorine, ozone, chlorine dioxide, iodine, and silver ion treatment are used to disinfect water. Of this treated tap water children and bottle-fed babies could drink an amount of 0.8 litres a day (dietary ingestion). Further, there is dermal contact and inhalation of aerosols during showering; when taking a bath dermal contact is the most important route of exposure. Incidental non-dietary ingestion might occur during bathing or showering.

Table 7: Disinfectants Type 3.0, 4.0 and 5.0

Disinfectants	Activity/ behaviour	Exposed group	Main exposure route(s)	Model	Location / source
Type 3.0 Veterinary hygiene biocides	Playing, outdoors	> toddler	Dermal (3)	Rubbing off	Outdoors, farm Indoors, barn or shed
	Hand-mouth contact	Toddler	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Idem
Type 4.0 Food and feed area disinfectants	Eating	> infant	Inhalatory (1,2)	Evaporation, dust	Indoors, restaurant
	Idem	Idem	Dermal (3)	Rubbing off	Surfaces
	Idem	Idem	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Food contacting contaminated surfaces
	Hand-mouth contact	Infant, toddler	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Contaminated surfaces, food
Type 5.0 Drinking water disinfectants	Washing	All	Inhalation (1,3)	Evaporation, Liquid aerosols	Shower, bathroom
	Idem	Idem	Dermal (1)	Direct skin contact	Shower water, bath water
	Idem	Idem	(Non) dietary ingestion (1)	Direct oral intake	Idem

3.3 Preservatives

In this chapter different types of preservatives ranging from in-can preservatives (type 6) to metal working fluids (type 13) are discussed. An overview of preservatives is given below and is derived from the TNsG (2002) and the Danish EPA (2001).

Type	Preservatives
6	In can-preservatives
6.01	In-can preservatives for detergents • Laundry products • Surface cleaners • Dishwash products

6.02	In-can preservatives for other products • In-can preservatives for water-based paints, dyes, inks • In-can preservatives for polishes, lubricants etc.
7	Film preservatives • Film preservatives for paints, sealants, and other products • Film preservatives for plastics
8	Wood preservatives
8.01	Pre-treatment in industrial premises: pressure and vacuum impregnation, dipping
8.02	Other wood preservatives: surface treatment
9	Fibre, leather, rubber and polymerised materials preservatives
9.01	Preservatives for textiles and leather
9.02	Preservatives for paper
9.03	Preservatives for rubber and polymerised materials and other preservatives type 9
10	Masonry preservatives
11	Preservatives for liquid-cooling and processing systems
11.01	Preservatives used in once-through systems*
11.02	Preservatives used in recirculating systems
12	Slimicides
12.01	Slimicides for paper pulp
12.02	Slimicides mineral oil extraction *
12.03	Other slimicides*
13	Metalworking-fluid preservatives

* These disinfectants are beyond the scope of this report; only those with an exposure potential for children will be dealt with.

For describing children's exposure to biocides, exposure aspects during particular activities (table 2) and exposure routes, models and parameters (table 3) are applied and at the end of each paragraph, an overview of the exposure aspects is given for the concerning preservative.

3.3.1 In-can preservatives Type 6

This type of biocides is divided in two subcategories:

6.01 Preservatives for detergents

6.02 Preservatives for other products

In-can preservatives for detergents ***Type 6.01***

Product type 6.01, preservatives for detergents, are added to almost all water containing domestic cleaning products, liquid soaps and detergents, fabric conditioners. Preservatives protect the product against decay, discoloration, oxidation and bacterial attack.

Note:

- products like rinse-aids, scale removers and caustic cleaners are not covered
- household bleach belongs to type 2.01, disinfectants
- laundry disinfectants may be type 2.05
- preserved liquid soap for bathing and showering belongs to type 1

These products contain typical concentration of 0.05 % w/w biocide and are used in residential activities such as cleaning the house, washing the laundry or washing the dishes. The secondary exposure due to applying cleaning fluids on floor or on walls might be inhalation of volatilised residues, especially for infants crawling on a freshly cleaned floor (see product type 2.01). There could be non-dietary ingestion for hand-mouth contact. Laundry washed with fluid detergents or fabric softeners contain residues. Skin contact with fabric gives dermal exposure (see product type 2.05) and inhalation might occur. By means of mouthing preservatives can be ingested. For laundry residues, babies are the most vulnerable group of children.

Oral exposure can occur as a result of residues on washed dinnerware. Not rinsing with clean water and not drying the dinnerware results in a higher amount of residue on the dishes and glassware. When food and drink come into contact with the dinnerware, residues migrate into the food or drink. Bottle-fed babies could be exposed to residues left in the feeding bottle.

In-can preservatives for other products ***Type 6.02***

Product type 6.02, preservatives for other products, covers a wide range of products: water-based paints, polishes, adhesives, dyes and inks, as well as textile spinning oil lubricant. An example of secondary dermal exposure is children contacting freshly coated surfaces (paint, polish); further, there could be oral exposure due to ingestion of paint chips. In the case of adhesives, children may use this product for sticking pictures or pieces of paper onto a sheet of paper (board). In the preceding cases, there could be dermal contact, hand-mouth contact and inhalation of volatile compounds as well.

Table 8: In-can preservatives Type 6

In-can preservatives	Activity/ behaviour	Exposed group	Main exposure route(s)	Model	Location/ source
Type 6.01 Detergents	General	All	Inhalation (1, 2)	Evaporation, dust	Indoors: home/ day-care/ school
Laundry products	Mouthing	Baby, infant, toddler	Non-dietary ingestion (3)	Leaching	Clothes
	General	All	Dermal (2)	Migration	Idem
Surface cleaners	Crawling	Infant	Inhalation (1, 2)	Evaporation, dust	Indoors: home/ day-care/ school
	Crawling	Infant	Dermal (3)	Rubbing off	Surfaces
	Hand-mouth contact	Infant	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Idem
Dishwash products	General	All	Ingestion (1)	Direct oral intake	Crockery
Type 6.02 Other	General	All	Inhalation (1, 2)	Evaporation, dust	Indoors, home/ day-care / school
Paint, inks, dyes	Mouthing	Baby, infant, toddler	Non-dietary ingestion (3)	Leaching	Dyes in clothes, inks in newspaper
	General	All	Dermal (2)	Migration	Dyes in clothes
Paint, polishes, adhesives	Touching	Infant, toddler	Dermal (3)	Rubbing off	(wet) surfaces
	Hand / object - mouth contact	Idem	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Paint chips
Lubricants	Playing	Toddler	Dermal (3)	Rubbing off	
	Hand-mouth contact	Idem	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	

Dyes can be found in textile (toys). These compounds can leach from the fabric when it comes into contact with saliva or sweat. The most important routes of exposure are the dermal and the oral route.

Inks used in newspapers can cause dermal contact and oral exposure through object-mouth contact of infants. Further, they can inhale volatilised compounds used in the printing inks. Dermal exposure occurs also when toddlers are playing with newspapers for making paper hats or boats. When they mouth their blackened fingers, there is oral exposure which is less than in the case of object-mouth contact.

Toddlers playing with their go-kart can be in contact with lubricants while ‘fixing’ the chain; further, there could be hand-mouth contact.

3.3.2 Film preservatives Type 7

Film preservatives are used for the preservation of films or coatings in order to protect the initial properties of the surface of materials or objects such as paints, mastics, sealants, fillers and adhesives (Danish EPA, 2001). Consumers use several do-it-yourself products like wall coating and sealant replacement in the house. Further, it includes preservatives to prevent microbe infestation of plasticisers in (soft) plastics like PVC. Examples are flooring, shoes, vehicles, lawn furniture, kitchen products, bathroom products, cleaning products, maritime equipment and toys.

Children could be in contact with wet paint (see type 6.02) and with PVC flooring. The latter causes dermal exposure due to the crawling behaviour of infants, oral exposure due to hand-mouth contact and inhalation due to the small distance to the floor.
Babies and infants show mouthing behaviour. Most of the time they mouth a teething ring or pacifier, or they could mouth plastic toys or plastic non-toys. Due to leaching of plasticisers out of the product, they could ingest preservatives. Another possibility is that an infant chews on a shower curtain (object-mouth contact).

Table 9: Film preservatives Type 7

Film preservatives	Activity/ behaviour	Exposed group	Main exposure route(s)	Model	Location/ source
Type 7	General	All	Inhalation (1, 2)	Evaporation, dust	Indoors, home/ day-care
Paints, sealants	Crawling	Infant	Dermal (3)	Rubbing off	(wet) surfaces
	Hand / object - mouth contact	Infant	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Paint chips
(Soft) plastics	Mouthing	Baby, infant, toddler	Non-dietary ingestion (3)	Leaching	Plastic non-toys (e.g. table cloth), toys, teething ring, pacifier

3.3.3 Wood preservatives Type 8

Wood preservatives exist of type

8.01 Pre-treatment in industrial premises: pressure and vacuum impregnation, dipping

8.02 Other wood preservatives: surface treatment

Wood preservatives ***Type 8.01***

Product type 8.01, pre-treatment in industrial premises, account for dermal exposure for children playing on preserved timber structures. While they are playing they could rub off dislodgeable residues of the wood preservatives. The dislodgeable fraction i.e. the amount which can be rubbed off, depends on the composition of the wood preservatives, the applied amount per m^3 wood, the time past since impregnation, quality of the impregnation process and type of wood. These factors also influence the leaching from the wood to the environment i.e. soil or water which depends on e.g. temperature, moisture, rainfall, placement of wood, pH water. If children are playing on preserved timber structures, they have direct dermal contact; indirect dermal contact occurs with contaminated soil or while swimming in contaminated water.

Oral exposure can occur when children mouth a piece of treated wood. Another possibility is hand-mouth contact with the treated timber or with the contaminated soil. Contaminated soil or water can also be ingested.

Due to burning of treated timber in fire-places, inhalation exposure to wood preservatives may occur and due to dust coming from the fire-place, children playing or crawling on the floor may be dermally exposed.

Other wood preservatives ***Type 8.02***

Product type 8.02, other wood preservatives, consists of solvent or water based products or of gas or volatile liquids. Wood can be sprayed, fumigated, brushed, trowelled, caulked or injected with wood preservatives. When children enter the room while the surfaces are still wet, they inhale the volatilised residues. Additionally, they could have skin contact with the (wet) surface and hand-mouth contact results in oral exposure.

Table 10: Wood preservatives Type 8

Wood preservatives	Activity/ behaviour	Exposed group	Main exposure route(s)	Model	Location/ source
Type 8.01 & type 8.02	General	All	Inhalation (1, 2)	Evaporation, dust	Outdoors, indoors (fire places)
Idem	Mouthing	Infant, toddler	Non-dietary ingestion (3)	Leaching	Timber off-cuts
Idem	Hand / object - mouth contact	Infant, toddler	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Timber off-cuts
Type 8.01	Playing	Infant, toddler	Dermal (3)	Rubbing off	Surfaces of treated wooden objects
Type 8.02	Touching	Infant, toddler	Dermal (3)	Rubbing off	Wet surfaces

3.3.4 Fibre, leather, rubber and polymerised materials preservatives

Type 9

The following product types belong to this category

9.01 Preservatives for textiles and leather

9.02 Preservatives for paper

9.03 Preservatives for rubber and polymerised materials and other biocidal products covered by product type 9

Preservatives for textiles and leather ***Type 9.01***

Product type 9.01 includes textile and leather preservation. The former covers preservation for storage, transport and use of textiles. Insecticide and fungicide are applied to yarn as the final stage of dying; the concentration in finished fibre is 0.2 to 1.4% w/w. The latter, leather preservation, includes fungicides as part of the tanning process and the residual biocide in finished leather is estimated at 1% to 2% (TNsG, 2002).

Examples are

- carpet containing insecticide and fungicide;
- tent and fabrics for outdoor use containing fungicide;
- shower curtains treated with fungicide.

Note: the following examples belong to another category:

- carpet backed with latex treated with fungicide belongs to type 9.03

- textile spinning oil lubricant belongs to type 6.02 (in-can preservatives)
- mosquito net dipped in biocides fit in type 18.02 (insecticides etc.)

Secondary exposure occurs when toddlers and infants are exposed to treated textiles of carpets or of tents. The products have very low vapour pressures; therefore, inhalation can be neglected. A certain amount of residues on the carpet or on the canvas is dislodgeable and could transfer from the surface to the skin while infants and toddlers are crawling or playing on the surface. They could also ingest dust and carpet fibre with residues.

Preservatives for paper ***Type 9.02***

Product type 9.02, preservatives for paper, is used to control fungi on non-food packing materials. As the final stage in paper and cardboard manufacture, these products are applied at 0.1% to 1% of the paper. Where paper and cardboard require preservation against challenging conditions, a higher loading of 4% is required. However, reliable information is not available. Children handling preserved paper cartons have dermal contact and infants chewing on cardboard cartons can ingest pieces of the treated cardboard (TNsG, 2002).

Preservatives for rubber and polymerised materials and other biocidal products covered by product type 9 ***Type 9.03***

Product type 9.03, preservatives for rubber and polymerised materials, are used in rubber and plastic products which are in contact with soil and water. Carpet backing, synthetic rubber geotextiles contain preservatives. When exposed to treated textiles such as carpet backing, toddlers and infants can have dermal contact and subsequently hand-mouth contact. Infants can ingest dust particles.

Table 11: Fibre, leather, rubber and polymerised materials preservatives Type 9

Preservatives Type 9.0	Activity/ behaviour	Exposed group	Main exposure route(s)	Model	Location/ source
Type 9	General	All	Inhalation (1, 2)	Evaporation, dust	Indoors, home/ day-care
Type 9.01	Crawling	Infant, toddler	Dermal (3)	Rubbing off	Textiles and leather articles, e.g. carpets, shower curtains, tents and fabrics for outdoor use
Type 9.01	Hand-mouth contact	Infant, toddler	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Idem
Type 9.02, type 9.03	Touching	All, except babies	Dermal (3)	Rubbing off	E.g. paper articles, carpet backing, synthetic rubber geotextiles
Type 9.02, type 9.03	Mouthing	Infant, toddler	Non-dietary ingestion (3)	Leaching	Idem
Type 9.02, type 9.03	Hand / object - mouth contact	Infant, toddler	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Idem

3.3.5 Masonry preservatives Type 10

Masonry preservatives are used to control lichen, fungi and algae on and in masonry, stone and concrete, in buildings, on paths and on roofs. Preservative coatings belong to type 7 and in-can preservatives to type 6.02.

Consumers undertake mould removal in bathrooms and path cleaning to reduce slipping risks. For the former, one can use ready-for-use trigger sprays; for the latter, one can use garden or household pressure sprayers or a watering can and using a hand-brush or broom.

Secondary exposure occurs when children come into contact with volatilised residues through inhalation and when they have skin contact with wet surfaces; subsequently there could be hand-mouth contact. The youngest group at risk are the toddlers while they play more outdoors than infants do.

Table 12: Masonry preservatives Type 10

Masonry preservatives	Activity/ behaviour	Exposed group	Main exposure route(s)	Model	Location/ source
Type 10	General	All	Inhalation (1, 2)	Evaporation, dust	Indoors, bathroom; outdoors, paths
	Crawling / touching	Infant, toddler	Dermal (3)	Rubbing off (wet) surfaces	Idem
	Hand-mouth contact	Infant, toddler	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Idem

3.3.6 Preservatives for liquid cooling and processing systems Type 11

This type of biocide includes the following product types

11.01 Preservatives used in once-through systems

11.02 Preservatives used in recirculating systems

For secondary exposure of type 11.01 there is insufficient information to make any estimate. Post shock treatment of drinking water is tested to show that is fit for consumption and free of disinfectant (TNsG, 2002). Therefore, only type 11.02 is relevant and will be discussed. Type 11.01 for clean water supplies for paper mills will be mentioned in section 4.7.1.

Preservatives used in recirculating systems ***Type 11.02***

Product type 11.02 is used for the preservation of water or other liquids used in cooling, heating or processing systems by the control of harmful organisms such as bacteria, algae and fungi. Evaporative condensers attached to air conditioning systems, decorative fountains and in circulating aquaria water are included to this type of preservatives.

Liquid aerosols and evaporation cause exposure by inhalation, dermal exposure might occur due to aerosol drift or to misuse (bathing in decorative fountains). Children may have skin contact with wetted surfaces and further hand-mouth contact.

Table 13: Preservatives for liquid cooling and processing systems Type 11

Recirculating system preservatives	Activity/ behaviour	Exposed group	Main exposure route(s)	Model	Location/ source
Type 11.02	General	All	Inhalation (1, 3)	Evaporation, liquid aerosols	Indoors, shopping centre, cinema, hospital Outdoors: fountains
	Touching, misuse (bathing)	Infant, toddler	Dermal (1,3)	Direct dermal contact, Rubbing off (wet) surfaces	Idem
	Hand-mouth contact	Infant, toddler	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Idem

3.3.7 Slimicides Type 12

Slimicides covers the next subcategories

12.01 Slimicides for paper pulp

12.02 Slimicides for mineral oil extraction

12.03 Other slimicides

Only type 12.01 is relevant and will be discussed.

Slimicides for paper pulp ***Type 12.01***

Product type 12.01, slimicides for paper pulp, is added to control aerobic and anaerobic bacteria and fungi which, if not controlled, cause slime deposits, malodour, discolouration, corrosion and fungal mat formation.

In paper (products) the following preservatives can be found:

Type 6.02 In-can preservatives for machinery lubricants

Type 9.02 Preservatives for paper

Type 11.01 Preservatives for clean water supplies to paper mills

Type 12.01 Slimicides for paper pulp

Children handling preserved paper (cartons) have dermal contact and infants chewing on treated paper can ingest pieces (residual biocide 20 to 200 ppm).

Table 14: Slimicides Type 12

Slimicides	Activity/ behaviour	Exposed group	Main exposure route(s)	Model	Location/ source
Type 12.01	General, Cuddling	All	Inhalation (1, 2)	Evaporation, dust	Indoors, paper (products) working clothes
	Touching	All, except babies	Dermal (3)	Rubbing off	Idem
	Mouthing	Infant, toddler	Non-dietary ingestion (3)	Leaching	Idem
	Hand / object - mouth contact	Infant, toddler	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Idem

3.3.8 Metalworking fluids Type 13

Type 13, metalworking fluids, are added to water-based fluids, to preserve these in their action of cooling, lubricating and carrying cuttings from mechanical cutting operations. Professionals use metalworking fluids in tool making and other metalworking operations. While cuddling children may have dermal contact with the work-wear of an adult and might inhale contaminated dust.

Table 15: Metalworking fluids Type 13

Metalworking fluids	Activity/ behaviour	Exposed group	Main exposure route(s)	Model	Location/ source
Type 13	General, Cuddling	All	Inhalation (1, 2)	Evaporation, dust	Indoors, working clothes

3.4 Pest control products

In this chapter different types of pest control products ranging from rodenticides (type 14) to repellants and attractants (type 19) are discussed. An overview of pest control products is given below and is derived from the TNsG (2002).

Type	Pest Control Products
14	Rodenticides
15	Avicides
16	Molluscicides
17	Piscicides
18	Insecticides, acaricides and products to control other arthropods
18.01	Products used by professionals
18.02	Products used by non-professionals
19	Repellents and attractants
19.01	Repellents applied directly on human or animal skin
19.02	Repellents not applied directly on human or animal skin

For describing children's exposure to biocides, exposure aspects during particular activities (table 2) and exposure routes, models and parameters (table 3) are applied and at the end of each paragraph, an overview of the exposure aspects is given for the concerning pest control product.

3.4.1 Rodenticides Type 14

The scope is limited to rodents such as mice and rats; this product type is closely linked with type 23, for the control of other vertebrates. Typical sites of use are domestic, retail, industrial and recreational premises, near animal housing, sewers, docks, waste sites and embankments. For the secondary exposure domestic and recreational premises are the most important environments where children could experience exposure to rodenticides.
Consumers use ready-for-use bait stations such as bait boxes and tubes, often containing grain in a pellet or wax block. These bait stations are protected from interference by children and non-target animals. On recreational premises professional pest controllers might use grain baits in pellet form or in a waterproof sachet for use in wet environments. Concentrates, for preparation of drinking water or specific food baits are also used. The former mentioned products are generally applied rodenticides.

Children can be into contact with exposed baits and dead animals which leads to dermal contact and subsequently hand-mouth contact. An infant can find a poison bait box and transient mouthing leads to ingestion. In the case of grain baits an infant might ingest the treated grain; nevertheless, there is a slight chance that this will happen.
Another route of exposure is the following example of a child who has dermal contact with domestic pet vomit after its bait ingestion. Children from professional users may come into contact with working wear.

3.4.2 Avicides Type 15

This product type is used for the control of birds such as pigeons in food storages, churches, and bakeries etc. where they can be of nuisance of vectors of diseases. Avicide products are baits or contact poisons. There is practically no information on which to base any pattern of use statement. For secondary exposure, see type 14 rodenticides.

3.4.3 Molluscicides Type 16

Molluscicides include products for controlling molluscs, other than for plant protection purposes (agriculture, horticulture). Preventing the growth of mollusc in water systems, preservatives for liquid cooling and procession systems are used (product type 11). Preventing mollusc fouling on the surface of vessels and equipment for aquaculture, antifouling products are used (product type 21). The criteria for non-agricultural, non-water molluscicides are unclear. There is practically no information on which to base any pattern of use statement.
For secondary exposure, see type 14 rodenticides. Molluscicide granules can also kill other animals such as birds, dogs and hedgehogs.

3.4.4 Piscicides Type 17

This product type appear to be limited to use in fish farms at the end of a fish harvest, to clear any large fish that would eat newly introduced fry. Piscicide products are pellets or pour-in liquids. There is practically no information on which to base any pattern of use statement. The risk for secondary exposure is very low.

Table 16: Rodenticides, avicides, molluscicides and piscicides Type 14, 15, 16, 17

Rodenticides	Activity/ behaviour	Exposed group	Main exposure route(s)	Model	Location/ source
Type 14, 15, 16, 17	Cuddling	Baby, infant, toddler	Inhalation (1, 2)	Evaporation, dust	Working clothes
	Idem	Baby, infant, toddler	Dermal (3)	Rubbing off	Idem
	Hand-mouth contact	Baby, infant, toddler	Non-dietary ingestion (1,2)	Direct oral intake or constant rate	Idem
Type 14	Incidentally	Infant, toddler	Non-dietary ingestion (1,2)	Direct oral intake	Exposed baits, dead animals, vomit pet after bait ingestion

3.4.5 Insecticides, acaricides and products to control other arthropods Type 18

This type of biocide includes the following product types

18.01 Products used by professionals

18.02 Products used by non-professionals

Product type 18 is used to control arthropods such as insects, acarides, arachnids and crustaceans as well as vermin on cats and dogs. Insecticides, acaracides and other products are used at places where arthropods are unwanted by humans e.g. flies, ants and cockroaches in kitchens and mosquitoes in bedrooms.

Products used by professionals ***Type 18.01***

Product type 18.01, insecticides, acaricides and products to control other arthropods used by professionals excludes medicines used for the control of parasites etc. on animals. For insects in wood, see type 8.02 and for grain store cleaning, see type 4. All other scenarios are

covered, including stored product pests, and infestations of commercial and residential property and transport.

There are several products:

- sprayers use concentrates diluted for use
- dusting equipments use ready-for-use (r.f.u) dusts
- misting and fogging machines use r.f.u liquids or diluted concentrates
- fumigants are smoke generators and volatile vapours applied via evaporator

The following types of treatment are:

- space treatment against flying insects
- treatments for nest and harbourage (crack and crevice) treatments
- blanket treatment for covering a horizontal and/ or vertical surface
- band treatment for covering insect access routes along floor-wall junctions
- injection for treating sub-soil to protect foundations from termites
- fumigation for treating stacked commodities or freight containers

When infants come into contact with wet sprayed surface, they experience dermal exposure and subsequently there could be hand-mouth contact. The dislodgeable amount of a wet surface is assumed to be higher than of a dry surface. Furthermore, there could be hand-mouth contact.

Products used by non-professionals ***Type 18.02***

Product type 18.02, insecticides, acaricides and products to control other arthropods used by non-professionals, excludes medicines used for the control of parasites etc. on animals. For insects in wood, see type 8.02. Consumers, residents and people at work (incidentally) use this type of product.

For several treatments, the following products, generally supplied as ready-for-use, are used:

- space treatment for knocking down flying insects e.g. pre-pressurised aerosol cans, trigger sprayers, impregnated mats, vapour strips, mothballs, plug-in vaporisers, and smoke coils
- nest and habourage (crack and crevice) treatment e.g. dust puffer packs, aerosol cans, and caulk paste tube
- broadcast treatment for covering a horizontal surface or spot and band treatment for covering insect access routes along floor-wall junctions etc., e.g. aerosol cans, trigger sprays, and dust puffer packs

- other treatments e.g. impregnating bed nets with insecticide to control mosquito bites: solutions for hand-dipping

When an infant is present in the room during application, there is inhalation of aerosols or of contaminated dust while dust is settling. Most of the contaminated dust will be ingested. Crawling infants can dislodge liquid aerosols or contaminated dust settled down on the floor. This is the case with spot treatments, general surface treatments, crack and crevice, as well as air space treatments while using sprays or dust products. Oral exposure might take place due to hand-mouth contact. Besides hand-mouth contact, ingestion of residues can occur when the spraying takes place in the neighbourhood of a kitchen table with food on it.
When using electrical evaporators the active ingredient will spread itself around the room. The compound can be adhered on the ceiling, walls and on the floor, as well as on toys and on bed linen. Children crawling over the floor can be exposed dermally; oral exposure can occur due to hand-mouth contact or to object-mouth contact of toys and/ or bed linen.
Further, there are strips and cassettes from which evaporation of the active substances takes place during the application. They are used in a room to control flying insects and they evaporate through the whole room. Thus, all people present are continuously exposed via inhalation.
When impregnating bed nets are used around children's bed, they can have skin contact and hand-mouth contact. Infants might suck on the net resulting in non-dietary ingestion.
Another illustration is the flea dust treatment of animal bedding. The pet's fur contain residues of the flea dust, a toddler stroking the pet comes into contact with the active ingredient. Furthermore, contaminated hair/ dust particles can be inhaled or ingested.

Table 17: Insecticides, acaricides and products to control other arthropods Type 18

Insecticides, acaracides and other	Activity/ behaviour	Exposed group	Main exposure route(s)	Model	Location/ source
Type 18	Crawling	Infant	Inhalation (1, 2)	Evaporation, dust	Floors, carpets
	Idem	Idem	Dermal (3)	Rubbing off	Idem
	Hand-mouth / object-mouth contact	Baby, infant, toddler, in particular the infant category	Non-dietary ingestion (1, 2)	Direct oral intake, constant rate	Contaminated / treated surfaces or articles, working clothes, bed nets etc.
	Mouthing	Baby, infant, toddler	Non-dietary ingestion (3)	Leaching	Bed nets, contaminated/ treated articles
	General	All	Inhalation (1,2,3)	Evaporation, dust, liquid aerosols	Aerosol cans, dust puffer packs, strips, electrical evaporator etc.
	General	All	Dermal (3)	Rubbing off	Surfaces, bed nets, carpets etc.
Type 18.02	Playing with pets	All, except babies	Inhalation (2)	Hair, dust	Animal bedding, domestic pet
	Idem	All, except babies	Dermal (3)	Rubbing off	Idem
	Hand-mouth contact	Infant, toddler	Non-dietary ingestion (1, 2)	Direct oral intake, constant rate	Idem

3.4.6 Repellents and attractants Type 19

This type can be divided into two groups i.e.

19.01 Repellents applied directly on human or animal skin

19.02 Attractants and repellents not applied directly on human or animal skin

Repellents applied directly on human or animal skin ***Type 19.01***

To *product type 19.01* belong repellents applied directly on human or animal skin. According to the TNsG there is very sparse information concerning these products. The information mentioned below is from the Pest Control Products Fact Sheet (Bremmer et al., 2006b) describing the application of repellents on the human skin.

Insect repellents aim to repel bloodsucking insects such as mosquitoes, midges or sand, black and horse flies, fleas or ticks. The mechanism of action the active ingredients in insect repellents is not revealed yet, their effectiveness is determined experimentally.

The active ingredients in insect repellents are described below.

- DEET (N, N-diethyl-3-methylbenzamide) is the most important active ingredient in insect repellents.
- Citronella oil. Citronella is the active ingredient in most ‘natural’ or ‘vegetable-based’ insect repellents.
- Bite Blocker is a vegetable-based repellent that has been available for a long time in Europe and since 1997 in the US. Bite Blocker seems to use soya oil, geranium oil and coconut oil as active ingredients in its formulation

The products are supplied as a liquid (milk, gel, or lotion) in a plastic bottle, as impregnated cloths, as sticks or as a spray. All of these products are ready to use. They must be applied to the uncovered skin and should prevent insects from landing on the skin. Users sometimes apply the products to their clothes to prevent insects such as ticks from getting into the clothes, or to prevent mosquitoes from biting through the clothes. Exposure occurs when these products are applied to the skin. This obviously results in dermal exposure; further, hand-mouth contact can occur, leading to the ingestion of some of the repellent. With the sprays, inhalatory contact with aerosols is possible. The inhalatory route is excluded due to the use outdoors, and because use indoors only takes place in the summer in situations where there is a high ventilation rate.

In SOP 9.0 (US-EPA, 1997) pet treatment is described. The post-application dermal dose from pesticide residues on pets is described in SOP 9.2.1, followed by SOP 9.2.2 the post-application potential dose among toddlers from incidental non-dietary ingestion of pesticide residues on pets from hand-to-mouth transfer. Here, the toddlers are 3 years old and have a weight of 15 kg.

Attractants and repellents not applied directly on human or animal skin Type 19.02

About *product type 19.02*, attractants and repellents not applied directly on human or animal skin, there is very sparse information available. These products are used to control organisms

such as arthropods by repelling or attracting. Pre-formed pheromone traps with adhesive boards or insecticides are used as attractants. Examples of repellents are:

- vaporising systems used to disperse natural oils
- bone oil painted on surfaces
- granule packs for scattering

Impregnated textiles are addressed in type 9.01, preservatives for textiles and leather; in type 18.02, insecticides, acaricides and products to control other arthropods used by non-professionals. An example for repellents is e.g. products preventing mites from living in textiles. Bird's repellents are mentioned in type 15. Biocides in repellents and attractants for birds are mainly used to prevent game and birds from staying at places where they are unwanted e.g. pigeons at windowsills.

The probable exposure for infants is dermal exposure, hand-mouth contact and inhalation due to application of vaporisers.

Table 18: Repellents and attractants Type 19

Repellents & attractants	Activity/ behaviour	Exposed group	Main exposure route(s)	Model	Location/ source
Type 19.01	General	All	Inhalation (1,3)	Evaporation, liquid aerosols	Outdoors, indoors with high ventilation rate
	General	All	Dermal (1)	Direct skin contact	Liquid, sticks, sprays, impregnated cloths
	Hand-mouth contact	Baby, infant, toddler	Non-dietary ingestion (1, 2)	Direct oral intake, constant rate	Idem
Type 19.01	Playing with pets	All, except babies	Inhalation (2)	Hair, dust	Domestic pets
	Idem	All, except babies	Dermal (3)	Rubbing off	Idem
	Hand-mouth contact	Infant, toddler	Non-dietary ingestion (1, 2)	Direct oral intake, constant rate	Idem
Type 19.02	General	All	Inhalation (1)	Evaporation	Candles, heated blocks
	Object-mouth contact	Infant, toddler	Non-dietary ingestion (1, 2)	Direct oral intake, constant rate	Granules

3.5 Other biocidal products

In this chapter other biocidal products are discussed. An overview of pest control products is given below. This chapter includes biocides with an exposure potential that is low to nil for children. A source such as the working clothes of a parent might be an exposure potential.

Type	Other biocidal products
20	Preservatives for food or feedstock
21	Antifouling products
22	Embalming and taxidermis fluids
23	Control of other vertebrates

3.5.1 Preservatives for food or feedstocks Type 20

Possible professional use scenarios are

- the dipping of fruit in fungicide for storage
- the treatment of cheese rind with antibiotic spray
- to prevent infection with unwanted spores
- protection of air-cured ham from maggot infestation with an insecticide coating

The exposure risk may be due to dietary ingestion. There is no information of secondary exposure.

3.5.2 Antifouling products Type 21

These products are applied to vessels and to nets used in aquaculture. There is no information on application of antifouling products to permanently immersed structures or for stripping expired antifoulant coatings.

As to secondary exposure only bargee's children or children living in the holidays on a ship could be bystanders during vessel coating operations in harbours. There could be inhalatory or dermal exposure, but the chance on occurrence is very low.

3.5.3 Embalming and taxidermist fluids Type 22

This type includes cadaver preparation and tissue samples in healthcare, as well as conventional embalming and taxidermy. The coat can be treated with type 9.01, leather preservatives. Preserved animal specimens are conserved in museums and used in education. See for children's secondary exposure type 9.01. However, the exposed children are here the schoolchildren and they could only have dermal contact. The contact frequency is very low to nil.

3.5.4 Control of other vertebrates Type 23

Much of this statement repeats that for type 14, rodenticides. The scope of type 23 excludes rodents and birds. Products will include those for use in emergencies e.g. rabies outbreak. Typical target species are burrowing animals, moles, squirrels and other creatures classed as vermin. The secondary exposure is described at type 14 i.e. contact with exposed baits and dead animals.

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Internet sites
www.babycentre.co.uk
www.babyswimming.com

APPENDIX 1: Overview children's exposure to biocides

Type	Name	Activity/ behaviour	Children's category	Exposure route
	DISINFECTANTS	General	All	I
		Cuddling	Baby, infant, toddler	I/ D/ HM
1	**Human hygiene products**	Washing/ hygiene		
	Baby wipes		Baby, infant	I / D
	Lavatory wipes		> Toddler	I / D
	Soap: washing hands		> Infant	D
2	**Private area and public health area disinfectant, etc.**			
2.01	Biocidal products for surfaces	Crawling	Infant	I/ D/ NDI/ HM
2.02	Biocidal products for swimming pools	Swimming	All	I / D/ NDI
2.03	Biocidal products for air-conditioning systems	General	All	I
2.04	Biocidal products for chemical toilets	General	> Toddler	D
2.05	Other products: disinfectants in laundries	General	All	I/ D
		Mouthing	Baby, infant, toddler	NDI
3	**Veterinary hygiene products**	Playing outdoors	Toddler	D/ HM
4	**Food and feed area disinfectants**	Eating/ drinking	> Infant	I/ D/ DI/ HM
5	**Drinking water disinfectants**	Washing	All	I/ D/ NDI
		Eating/ drinking	All	DI

I: inhalation; D: dermal contact; DI: dietary ingestion; NDI: non-dietary ingestion; HM: hand-to-mouth transfer leading to NDI; OM: object-to-mouth transfer leading to NDI; M: mouthing leading to NDI

Type	Name	Activity/ behaviour	Children's category	Exposure route
	PRESERVATIVES	General	All	I
		Cuddling	Baby, infant, toddler	I/ D/ HM
6	**In-can preservatives**			
6.01	Preservatives for detergents			
	Laundry products	General	All	D
		Mouthing	Baby, infant, toddler	OM
	Surface cleaners	Crawling	Infant	I/ D/ NDI/ HM
	Dishwash cleaners	Eating/ drinking	All	DI
6.02	Preservatives for other products	General	All	I
	Dyes	General	All	D
	Paint, inks, dyes	Mouthing	Baby, infant, toddler	OM
	Paint, polishes, adhesives	Touching	Infant, toddler	D/ HM/ NDI
	Lubricants	Playing	Toddler	D/ HM
7	**Film preservatives**			
	Paints, sealants	Crawling	Infant	D/ HM
	(soft) plastics	Mouthing	Baby, infant, toddler	OM
8	**Wood preservatives**	Mouthing	Infant, toddler	HM/ OM
8.01	Pre-treatment in industrial premises	Playing	Infant, toddler	D
8.02	Other wood preservatives	Touching	Infant, toddler	D/ HM/ OM
9	**Fibre, leather, rubber and polymerised materials preservatives**	Mouthing	Baby, infant, toddler	HM/ OM
9.01	Preservatives for textiles and leather	Crawling	Infant, toddler	D/ HM
9.02	Preservatives for paper	Touching	All, ex. babies	D/ HM
9.03	Preservatives for rubber and polymerised materials, and other biocidal products	Touching	All, ex. babies	D/ HM

I: inhalation; D: dermal contact; DI: dietary ingestion; NDI: non-dietary ingestion; HM: hand-to-mouth transfer leading to NDI; OM: object-to-mouth transfer leading to NDI; M: mouthing leading to NDI

Type	Name	Activity/ behaviour	Children's category	Exposure route
	PRESERVATIVES	General	All	I
		Cuddling	Baby, infant, toddler	I/ D/ HM
10	**Masonry preservatives**	Crawling/ touching	Infant, toddler	D/ HM
11	**Preservatives for liquid-cooling and processing systems**			
11.01	Preservatives used in once-through systems	--		
11.02	Preservatives used in recirculating systems	Touching	Infant, toddler	D/ HM
		Misuse: bathing	All, ex. babies	D
12	**Slimicides**			
12.01	Slimicides for paper pulp	Touching	All, ex. babies	D
		Mouthing	Infant, toddler	HM/ OM
12.02	Slimicides for mineral oil extraction	--		
12.03	Other slimicides	--		
13	**Metal working fluids**	--		

I: inhalation; D: dermal contact; DI: dietary ingestion; NDI: non-dietary ingestion; HM: hand-to-mouth transfer leading to NDI; OM: object-to-mouth transfer leading to NDI; M: mouthing leading to NDI

Type	Name	Activity/ behaviour	Children's category	Exposure route
	PEST CONTROL PRODUCTS	General	All	I
		Cuddling	Baby, infant, toddler	I/ D/ HM
14	**Rodenticides**	Incidentally	Infant, toddler	NDI
15	**Avicides**	--		
16	**Molluscicides**	--		
17	**Piscicides**	--		
18	**Insecticides, acaricides, etc.**	Crawling	Infant	I/ D/ HM
		Mouthing	Baby, infant, toddler	HM/ OM
		General	All	D
18.01	Products used by professionals	See above		
18.02	Products used by non-professionals	Playing with pets	All ex. babies	I/ D/ HM
19	**Repellents and attractants**	General	All	I
19.01	Repellents applied directly on human skin	General	All	D
		Mouthing	Baby, infant, toddler	HM
19.01	Repellents applied directly on animal skin	Playing with pets	All, ex. babies	I/ D/ HM
19.02	Attractants and repellents not applied directly on human or animal skin	Mouthing	Infant, toddler	NDI
	OTHER BIOCIDAL PRODUCTS	General	All	I
		Cuddling	Baby, infant, toddler	I/ D/ HM
20	**Preservatives for food or feedstocks**	--		
21	**Antifouling products**	--		
22	**Embalming and taxidermist fluids**	--		
23	**Control of other vertebrates**	Incidentally	Infant, toddler	NDI

I: inhalation; D: dermal contact; DI: dietary ingestion; NDI: non-dietary ingestion; HM: hand-to-mouth transfer leading to NDI; OM: object-to-mouth transfer leading to NDI; M: mouthing leading to NDI

APPENDIX 2: Overview SOP's

Standard Operating Procedures (SOP's) for Residential Exposure Assessments

In the table for secondary exposure of biocides, the SOP's are from the US-EPA. The names of the SOP's and the exposed children's category is mentioned below. In these SOP's calculations are made for exposure assessments.

SOP No.	SOP Title	Children's Category	Exposure
5.0	**Swimming pools**		
5.2.1	Post-application potential doses from incidental non-dietary ingestion of pesticide residues while swimming	Child 6 yrs	Ingestion water
5.2.2	Post-application dermally absorbed dose from swimming in pesticide-treated residential swimming pools	Child 6 yrs	Dermal
6.0	**Painting and Wood preservative treatments**		
6.2	Post-application- dermal (refer to 11.2) and inhalation (refer to 13.2) indoor and outdoor	Toddler 3 yrs	Inhalation & dermal
6.3	Post-application potential dose among children from the ingestion of paint chips containing pesticide residues	Infants 0.5-1.5 yrs	Ingestion: paint chips
8.0	**Crack and crevice and broadcast treatment**		
8.2.1	Post-application dermal dose from pesticide residues on carpets	Infant 0.5 – 1.5 yrs & Toddler 3 yrs	Dermal
8.2.2	Post-application dermal dose from pesticide residues on hard surfaces	Infant 0.5 – 1.5 yrs & Toddler 3 yrs	Dermal
8.4	Post-application doses among toddlers from incidental non-dietary ingestion of pesticide residues on indoor surfaces from hand-to-mouth transfer	Toddler 3yrs	Hand-to-mouth transfer

SOP No.	SOP Title	Children's Category	Exposure
9.0	**Pet treatment**		
9.2.1	Post-application dermal dose from pesticide residues on pets	Toddler 3 yrs	Dermal
9.2.2	Post-application potential dose among toddlers from incidental non-dietary ingestion of pesticide residues on pets from hand-to-mouth transfer	Toddler 3 yrs	Hand-to-mouth transfer
10.0	**Detergent/ soaps**		
10.1	Post-application dermal exposure to pesticides in detergent/ bar soap and other consumer products		
11.0	**Impregnated materials**		
11.2	Post-application pesticide residue dermal and inhalation dose from materials impregnated with pesticides	Toddler 3 yrs	Inhalation & dermal
11.3	Post-application doses among toddlers from incidental non-dietary ingestion of pesticide residues contained in materials impregnated with pesticides	Toddler 3 yrs	Object-mouth transfer
14.0	**Rodenticides**		
	Post-application incidental non-dietary ingestion- eating pellets or granules (refer to 2.3.1)	Toddler 3 yrs	Ingestion pellets

APPENDIX 3: Values for children's exposure factors

In this appendix default exposure values for children regarding body weight, body surface area, surface area of body parts, inhalation rate, and time activity patterns (including hand-to-mouth contact and crawling) are proposed. The default values are derived for different age categories, and are based on a large number of information sources. Considering the number and type of sources, it is assumed that these default values are representative for the Dutch and European situation. The default values are only a proposal. If in a specific case specific (measured) data are needed (and available) of course, these data should be used instead.

1. Boundary conditions, 'reasonable worst-case' estimate

The proposed default values can be used to assess children's risk to consumer products and to biocides. In the fact sheets (Bremmer et al., 2006a/b) has been described that the use of the default parameter values result in a relatively high exposure (reasonable worst case). All default parameters are stated as a 75^{th} or 25^{th} percentile. The 75^{th} percentile is used for parameters which give a higher exposure for higher values (e.g. inhalation rate), and the 25^{th} percentile is used in the reverse case (e.g. body weight). If all parameter values are 75^{th} / 25^{th} percentiles, the exposure estimate - the result of the calculation- will approximate the 99^{th}-percentile. Thus, the outcome of an exposure assessment will be a 'reasonable worst-case' estimate for children under less favourable circumstances. Accordingly, in this appendix 75^{th} or 25^{th} percentiles are stated as default values.

2. Age

Several age categories are defined to cover specific exposure related to behaviour and to physiology of children. It is not feasible to generate data for all ages of the specific age categories. Therefore, in this appendix default values are presented for a number of ages, in such a way 'default' age is proposed to define a representative age for a particular age category. As babies grow fast, the mid-age of this age category is taken as default age i.e., 3 months. Infants start to crawl at the age of about 9 to 12 months; therefore, the default age is set at 10.5 months. Toddlers spend more time outdoors and for them a representative age of 3.5 years is chosen. The youngest of schoolchildren and of adolescents have rather low body weight compared to the oldest ones; so, the default ages are set at 6.5 and 13.5 years, respectively.

Appendix Table 1: Age categories of children

Age category	**Age** (years)	**Default age**	**Exposure related behaviour**
Baby	0 – 0.5	3 months	Spend a lot of time sleeping
Infant	0.5 - 2	10.5 months	Crawling, mouthing behaviour
Toddler	2 - 5	3.5 years	Playing outdoors, indoors
Schoolchild	5 -12	6.5 years	Spend time in school, play outdoors
Adolescent	> 13	13.5 years	Spend more time indoors, doing small jobs

3. Body weight and body surface area

A large number of sources from different countries are reviewed with data on body weights for boys and girls of different age (Fredriks et al., 2000; Verweij, 1994; Bremmer et al., 2006a; AUH, 2000; ECETOC, 2001; USEPA, 2006). It was shown that body weight data from all these sources show small differences.

Based on these data, default body weight for the different age categories are derived and these are presented in Appendix Table 2. For the different age categories, the default values for body weight and for body surface area are derived from Dutch data reported in Bremmer et al. (2006a). These values are 25th percentiles.

For babies aged 3 months Bremmer et al. did not report a 25th percentile. However, it was apparent that the 25th percentile for body weight found in the Netherlands is consistent with body weight data in Germany. Therefore, the default value for body weight for a child of 3 months of age is derived from German data of babies aged 0 – 6 months (AUH, 2000).

For an overview of default values for body weight and for body surface area, see Appendix Table 2 and 3, respectively.

Appendix Table 2: Age categories and default values for age and body weight

Age category	**Default values**	
	Age	**Body weight** [a,b] (kg)
Baby	3 months	5.3 [c]
Infant	10.5 months	8.7
Toddler	3.5 years	14.1
Schoolchild	6.5 years	20.6
Adolescent	13.5 years	43.9

a) Source: Bremmer et al. (2006a)
b) 25th percentiles
c) Adapted data from AUH (2000)

Appendix Table 3: Default values for body surface area and surface area by body part

Age	Default value Body surface area[a] (m^2)	Default values Surface area by body part[b] (m^2)							
		Head	Trunk	Arms & hands	Arms	Hands	Legs & Feet	Legs	Feet
3 mo	0.31	0.061	0.100	0.053	0.037	0.016	0.094	0.072	0.022
10.5 mo	0.44	0.077	0.149	0.077	0.055	0.023	0.134	0.103	0.031
3.5 yrs	0.64	0.090	0.214	0.122	0.088	0.035	0.214	0.170	0.045
6.5 yrs	0.84	0.105	0.281	0.164	0.118	0.046	0.291	0.230	0.061
13.5 yrs	1.40	0.132	0.459	0.280	0.200	0.080	0.529	0.424	0.105

[a] Source: Bremmer et al. (2006a)
[b] Calculated from percentages given by Bremmer et al. (2006a)

4. Inhalation rate

Two different types of inhalation rates can be distinguished: daily inhalation rates and specific inhalation rates. The daily inhalation rate is the total volume of air inhaled during the day. The specific inhalation rate is the inhalation rate during a specific activity; specific activities vary from sleeping, resting, light exercise to heavy exercise.

Daily inhalation rates

Inhalation rates of children can be expressed as m^3/day or when adjusted for body weight as m^3/kg/day. The latter is preferred as inhalation rate depends on children's age and on body weight.

To obtain daily inhalation rates different approaches can be used. Brochu et al. (2006b) have reviewed different methodological approaches to estimate daily inhalation rates as a function of age. Inhalation rates can be estimated by using the time-activity-ventilation approach or the metabolic energy conversion approach.
In the time-activity-ventilation approach, daily inhalation rates are based on cumulative minute ventilation rates related with (levels of) activity and their duration throughout the day. In the metabolic energy conversion approach, daily food-energy intake or cumulative energy expenditure required to support (levels of) activity throughout the day are taken into account. For the latter, the total daily energy expenditure (TDEE) can be measured by the doubly-labelled water (DLW) technique (see Brochu et al. 2006a).

Brochu et al. (2006b) have stated that based on time-activity-ventilation approach most inhalation rates estimates are overestimated, whereas most of the inhalation rates using metabolic equivalent approach are underestimated. DLW measurements are considered as an

accurate and precise method. The measurements can be converted into daily inhalation rates per kilo body weight by applying the equation from Layton (1993) (Brochu et al. 2006a/b). This method is practised by Arcus-Arth (not dated) who has stated daily inhalation rates for babies from 0 to 6 months old.

Brochu et al. (2006a) have made a distinction for age groups from 3 months to 23 years. They have measured the total daily energy expenditure through the doubly-labelled water (DLW) technique; subsequently, the daily inhalation rates, expressed as m^3/kg/day, have been calculated by using the equation from Layton.
For different age groups US EPA (2006) has estimated the daily inhalation rate by using a multiple linear regression model (Lordo et al., 2006 in USEPA 2006); however, it is composed of the specific inhalation rates and duration of the different activities that occur during the day.
In the children's categories younger than eleven years, we have compared data from USEPA with data from Brochu et al. (2006a). The 75^{th} percentiles of the daily inhalation rates (expressed as m^3/kg/day) from the USEPA are much higher than those from Brochu.
Cal/EPA (2000) has given mean values and percentiles of general inhalation rate per kilo body weight as well. The categories were made for children 12 years old and younger, and children older than twelve years. For example, for inhalation rate CalEPA has given a single 75^{th} percentile of 0.490 m^3/kg/day (children $\leq$ 12 years) and Brochu et al. have given 75^{th} percentiles ranging from 0.571 to 0.413 m^3/kg/day (adapted data for children < 11 years). The differentiated values for daily inhalation rate from Brochu et al. are preferred over the single value from Cal/EPA.

In conclusion, for daily inhalation rates expressed per kg body weight the data from Brochu et al. (2006a) are used. Brochu et al. have stated values for boys and girls; from these values we have derived daily inhalation rates for the different age categories and the 75^{th} percentiles are used as default values. The daily inhalation rate expressed in m^3/day is obtained by multiplying this (default) inhalation rate in m^3/kg/day with the (default) body weight of the default age for a specific age category. For the daily specific inhalation rates, see Appendix Table 4.

Appendix Table 4: Default values for daily inhalation

Age	**Body weight** (kg)	**Daily inhalation rate** [a] adjusted for body weight (m^3/ kg/day)	**Daily inhalation rate** [b] (m^3/day)
3 months	5.3	0.568	3.0
10.5 months	8.7	0.514	4.5
3.5 years	14.1	0.483	6.8
6.5 years	20.6	0.437	9.0
13.5 years	43.9	0.309	13.6

a) 75th percentiles for children (adapted data from Brochu et al., 2006a)
b) Daily inhalation rate (m^3/day) = daily inhalation (m^3/kg/day) x body weight (kg)

Specific inhalation rates

To assess the inhalation exposure of adults during a specific activity, the algorithms from Freijer et al. (1997) are utilized in making exposure assessments within RIVM. This algorithm is based on body weight and on degree of activity.

Freijer et al. (1997) have distinguished the following levels of activity:

1. sleeping
2. resting: lying down, sitting, standing, driving etc.
3. light exercise: walking, light housework, slow cycling etc.
4. moderate exercise: cycling, walking, light sports
5. heavy exercise with mouth breathing: running, heavy sports

The inhalation rate during a particular activity depends on the body weight of the exposed person (see box). It is investigated if this approach to estimate the specific inhalation rate can be used for children or if another approach is more appropriate.

The specific inhalation rates are calculated using the (adapted) equation from Freijer *et al.* (1997):

$I_m = a\ (M_b)^b$

Where:

I_m = inhalation rate

M_b= body mass of the child in the specific age category (the default values for body weight given by Bremmer *et al.* (2006) are used)

For the different activities, the parameters in the relationship between inhalation rate and body mass are as follows:

Level of activity	***a***	***b***
Sleeping	0.80	0.60
Resting	1.05	0.60
Light exercise	2.30	0.65
Moderate exercise	5.00	0.55
Heavy exercise	11.0	0.45

The values for *a* and *b* were derived by fitting the equation to data presented by the ICRP on the inhalation rate in healthy humans.

A method to calculate the specific inhalation rate is by using the energy expenditure which is an indicator for the specific inhalation rate. The energy expenditure can be calculated by multiplying basal metabolic rate (BMR) with BMR-factors. The BMR depends on body weight, age and gender and the BMR factors depend on a particular activity (level) which might vary from resting (BMR-factor 1.2) to heavy activity (BMR-factor 10). For the various activities statistical software was used to generate a distribution for the BMR factors as done in the Child-specific Exposure Factors Handbook (US EPA, 2006). Subsequently, the specific inhalation rate can be calculated by using the equation from Layton (1993) in which oxygen consumption is related to volume of inhaled air and to energy.

Specific inhalation rates can be measured during laboratory protocols for different activities (Adams, 1993 and Beals et al., 1996). In the inhalation rate measurements, age categories (i.e. 3- 6 yrs, 6-13 yrs and > 13 yrs male/female) and different activity levels (i.e., resting, light, moderate and heavy activity) are considered; however, the body weights of the examined children are not taken into account.

We have compared the derived specific inhalation rates to the measured ones. As Beals et al. (1996) have assigned the activities differently than Adams (1993) and than Freijer et al. (1997), the results from Beals et al. are adapted into other activity levels as to compare the results. For the different age categories the calculations are done by using the default ages with corresponding default body weights.
In general, the measured specific inhalation rates are higher than the calculated ones (Freijer et al., 1997 and adapted data from USEPA, 2006). Further, the differences between measured and calculated specific inhalation rates from Freijer et al. are smaller than the differences between measured and adapted data from USEPA. For the age category 6 to 13 years during heavy exercise, both calculated/adapted inhalation rates are in the same order as the measured ones from Beals et al. (1996) and from Adams (1993).

In conclusion, the algorithm of Freijer et al. (1997) is preferred as it gives a reasonable approximation of the specific inhalation rate by using the level of activity and the (default) body weight of children. The default values proposed for the specific inhalation rates are described in Appendix Table 4.

Appendix Table 4: Default values for specific activity inhalation rates related to different activity levels

Age	**Body weight** (kg)	**Default values for specific activity inhalation rates** (m^3/hr)				
		Asleep	**Resting**	**Light**	**Moderate**	**Heavy**
3 months	5.3	0.09	0.12	0.28	0.52	1.0
10.5 months	8.7	0.12	0.16	0.39	0.68	1.2
3.5 years	14.1	0.16	0.21	0.54	0.89	1.5
6.5 years	20.6	0.20	0.27	0.68	1.1	1.8
13.5 years	43.9	0.32	0.42	1.1	1.7	2.5

[a)] Data infants, toddlers, schoolchildren and adolescents calculated with algorithms from Freijer et al. (1997) by using the default body weight for the different default ages.

5. Time-activity patterns

Data on various time-activity patterns of children such as crawling, hand-mouth contact and sleeping are reviewed. (AUH, 2000; Ter Burg et al., 2007; Groot et al., 1998; HESI, 2004a/b; Rodewijk, 2003; Tulve et al., 2002; USEPA, 2006; Xue et al., 2007).
For these activities default values are proposed.

Crawling

For crawling infants only very limited data is available. For children in the age of 6 to 18 months, a crawling duration of one hour per day (mean of 9 non-zero values) is derived from the study of Rodewijk (2003). In the Pest Control Products Fact Sheet, Bremmer et al. (2006b) have stated that a playing child will crawl over a treated floor surface for 1 hour a day, which is used as a default value. Based on the limited data above, the default value for crawling is set at 1 hour per day.

Hand-mouth contact

Through hand-to-mouth contact compounds can be transferred from the hands/ fingers into the mouth. Thus, due to hand-mouth contact children, especially infants, can be orally exposed.

In the Pest Control Product Fact Sheet (Bremmer et al. 2006b), oral exposure via hand-to-mouth contact is calculated as follows. Dermal exposure of children can take place on any uncovered skin, that is, on the head, the arms and hands, and on the legs and feet. The hands form about 20% of the total uncovered skin. It is assumed that 50% of the product that ends up on the hands is taken in orally due to hand-mouth contact. The ingestion can be calculated based on the assumption that from the total dermal exposure 10% is taken in orally due to hand-mouth contact.

Recently, Ter Burg et al. (2007) have reviewed literature of hand-to-mouth (HTM) behaviour which is related to oral exposure due to ingestion of compound(s) on hands/ fingers. To determine more accurately the total surface area which is in contact with the mouth per hour, relevant parameter default values are defined for HTM contact, extent of insertion (of fingers or whole hand) *into* the mouth, and for skin surface area which actually comes into contact with the mouth. To assess the extent of insertion into the mouth, Ter Burg et al. have introduced a ratio for hand-in-mouth/ hand-to-mouth (HIM/HTM), and as skin contact area the surface area of two fingers. See Appendix Table 5. To derive the total skin contact area, which is in contact with the mouth per hour, the hand-to-mouth frequency should be multiplied with the ratio HIM/HTM values and with the skin contact area.

Appendix Table 5: Default values for hand-mouth contact

Age	HTM[a,b] (contacts/hr)	HIM/HTM[a,c] ratio	Contact area[a,d] (cm^2/event)	Total contact area[e] (cm^2/hr)	Location
3 mo	50	0.5	5.0	125	Indoor
10.5 mo	30	0.5	5.0	75	Indoor
3.5 yrs	20	0.3	10	60	Indoor
6.5 yrs	10	0.3	15	45	Indoor
10.5 mo	20	0.5	5.0	50	Outdoor
3.5 yrs	10	0.3	10	30	Outdoor
6.5 yrs	5	0.3	15	22	Outdoor

a) Source: Ter Burg et al. (2007)
b) HTM: hand-*to*-mouth contact i.e., contact of the hand with the mouth; no distinction is made between touching the mouth or insertion fingers into the mouth
c) HIM: hand-*in*-mouth contact i.e., contact in which hands or fingers are put *into* the mouth, and it is part of the total HTM contact
d) Sum of two fingers
e) Total contact area (cm^2/hr) = HTM (contacts/hr) x HIM/HTM (unitless) x contact area (cm^2/event)

In conclusion, for children of a specific age Ter Burg et al. have calculated the total surface area which is in contact with the mouth per hour. If the amount of a compound on hands is known, it is recommended to use the data from Ter Burg et al. to calculate oral exposure via hand-to-mouth contact. In many cases only the total dermal exposure is known and not the exposure on the hands. Based on the present knowledge, the approach as mentioned in the Pest Control Products Fact Sheet will be the starting point. This means that the ingestion due to hand-to-mouth contact rate can be calculated based on the assumption that from the total dermal exposure 10% is taken in orally.

Sleeping

To make an exposure assessment during night's sleep, default values for night sleep duration are derived. Data are obtained from 'Standards for exposure assessments' (AUH, 2000) and from 'Child-specific Exposure Factors Handbook' (US EPA, 2006) in which hours are stated for sleeping including napping. These data have been modified in order to get the sleeping hours during the night. The proposed default values express the exposure duration during the night when children are asleep in their bedroom. See Appendix Table 6.

Appendix Table 6: Age categories and default values for night sleep

Age category	Default values	
	Age	Night sleep (hr)
Baby	3 months	13
Infant	10.5 months	12
Toddler	3.5 years	11
Schoolchild	6.5 years	10