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Cosmetics Fact Sheet

To assess the risks for the consumer
Updated version for ConsExpo 4

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Abstract

Exposure to compounds in Cosmetics

Exposure to compounds in consumer products can be assessed using the computer program ConsExpo (Consumer Exposure). Given the huge number of consumer products, it is not possible to calculate the exposure for each separate product, so a limited number of groups containing similar products are defined. The information for each group of products is described in a fact sheet. Paint, cosmetics, children's toys and cleaning products are examples fact sheets, which have been published already.
This fact sheet covers the use of cosmetics by consumers. In the fact sheet 35 product categories are described, including shampoo, make-up, lipstick, deodorant and toothpaste. To assess exposure of compounds in the cosmetics default values for all 35 product categories have been determined.

Key words: cosmetics, biocides, exposure, consumer, risk, compounds

Rapport in het kort

Blootstelling aan stoffen uit cosmetica

Voor de conversie van het computerprogramma ConsExpo 3.0 naar 4.0 is de factsheet cosmetica aangepast en herzien en nu ook in het Engels beschikbaar.

ConsExpo 4.0 is een computerprogramma, dat gebruikt kan worden om de blootstelling van mensen aan stoffen in consumentenproducten uit te rekenen. Hierbij wordt rekening gehouden met verschillende blootstellingsroutes (dus via de huid, via inhalatie en via orale opname).
Bij het ConsExpo programma hoort ook een database, waarin standaardwaarden voor vele product typen en voor een groot aantal blootstellingsscenarios worden aangeboden. De beschrijving van deze achtergrondinformatie bij deze standaardwaarden wordt gerapporteerd in zogenoemde ‘factsheets’.
In dit rapport, Factsheet Cosmetica, is de meest recente informatie bijeengebracht om de blootstelling aan stoffen uit cosmetica te berekenen. De verschillende typen cosmetica zijn verdeeld in 35 categorieën, bijvoorbeeld shampoo, make-up, lippenstift, tandpasta en deodorant.
Voor iedere categorie wordt de samenstelling en gebruik van producten uit die categorie beschreven. Daarnaast wordt aangegeven welk model of modellen van ConsExpo het meest geschikt is om de blootstelling uit te rekenen en worden voor alle gegevens die nodig zijn voor de berekening standaardwaarden ingevuld. Naast deze factsheet cosmetica zijn er ook factsheets voor ongediertebestrijdingsmiddelen, verf, reinigingsmiddelen en desinfectantia.

Trefwoorden: cosmetica, blootstelling, consument, risico, stoffen

Contents

Summary

Exposure to and intake of compounds in consumer products are assessed using available mathematical models. Calculations are carried out with the computer program, ConsExpo (Consumer Exposure). Given the huge number of consumer products, it is not possible to define exposure models and parameter values for each separate product, so a limited number of main categories containing similar products are defined. The information for each main category is described in a fact sheet. Paint, pest-control products, children's toys and cleaning products are examples of fact sheets which have been published already. This fact sheet covers the use of cosmetics by consumers for 35 product categories including shampoo, make-up, lipstick, deodorant and toothpaste. Information is given on the composition and the use of products within a product category. Default models and values for all 35 product categories have been determined to assess exposure and intake of compounds in cosmetics.

Samenvatting

Om de blootstelling aan stoffen uit consumentenproducten en de opname daarvan door de mens te kunnen schatten en beoordelen zijn wiskundige modellen beschikbaar. Voor de berekening wordt gebruik gemaakt van het computerprogramma ConsExpo. Het grote aantal consumentenproducten verhindert dat voor elk afzonderlijk product blootstellingsmodellen en parameterwaarden vastgesteld kunnen worden. Daarom is een beperkt aantal hoofdcategorieën met gelijksoortige producten gedefinieerd. Voor elke hoofdcategorie wordt de informatie in een factsheet weergegeven. Verf, ongediertebestrijdingsmiddelen, kinderspeelgoed en reinigingsmiddelen zijn voorbeelden van factsheets die al gereed zijn. In deze factsheet wordt informatie gegeven over het gebruik van cosmetica door consumenten. Het gebruik van cosmetica wordt beschreven met behulp van 35 productcategorieën, zoals shampoo, make-up, lippenstift, tandpasta en deodorant. Het gehele gebied van het cosmeticagebruik wordt met deze productcategorieën bestreken. Voor elke productcategorie wordt ingegaan op samenstelling en gebruik van het type producten. Om de blootstelling en opname van stoffen uit cosmetica te kunnen schatten en beoordelen zijn voor elke productcategorie defaultmodellen met defaultwaarden voor de parameters vastgesteld.

1. Introduction

1.1 General

Descriptive models have been developed within the RIVM to be able to estimate and assess the exposure to substances from consumer products and the uptake of these by humans. These models are brought together in a computer program called ConsExpo 4.0. When a model is chosen in ConsExpo, and the required parameters are filled in, the program calculates the exposure to, and the uptake of, the substance involved.

Because of the large number of consumer products currently on the market, it is not possible to determine exposure models and parameter values for each individual product. Therefore, a limited number of main categories of similar products have been defined. Examples of the main categories are paint, cosmetics, children's toys and pest control products. The relevant information with respect to the estimate of exposure to, and the uptake of, substances from consumer products is given in a fact sheet for each of the main categories. These fact sheets can be used to characterize and standardize the exposure.

This fact sheet supplies information on the main category cosmetics. Within a main category as few categories as possible are defined, which together describe the entire main category. The cosmetics main category includes the following product categories: shampoo, make-up, lipstick, toothpaste and deodorant. The composition and the use of the type of products within the category are examined for every product category. To estimate the exposure and uptake of substances from cosmetics, default models with default parameter values are determined for every product category in this fact sheet. The default models and default parameter values are available via a database. Using this data, standardized exposure calculations for consumers resulting from the use of cosmetics can be performed.

1.2 ConsExpo

ConsExpo is a software tool for Consumer Exposure assessment. ConsExpo is a set of coherent, general models that can be used to calculate the exposure to substances from consumer products and their uptake by humans. It is used for the consumer exposure assessment for New and Existing Substances in scope of Directive 67/548/EC and the Council Regulation 793/93/EC, respectively. Furthermore, ConsExpo is also one of the models that is used to assess the consumer exposure to biocides. (Technical Notes for Guidance (TNsG): Human Exposure to Biocidal Products – Guidance on Exposure Estimation[53)] (http://ecb.jrc.it))

ConsExpo is built up using data about the use of products, and from mathematical concentration models. The program is based on relatively simple exposure and uptake models. The starting point for these models is the route of exposure, i.e. the inhalatory, dermal or oral route. The most appropriate exposure scenario and uptake model is chosen for each route. The parameters needed for the exposure scenario and the uptake models are then filled in. It is possible that exposure and uptake occur simultaneously by different routes. In addition to data about the exposure and uptake, contact data is also needed, such as the

frequency of use and the duration of use. Using the data mentioned above, ConsExpo calculates the exposure and uptake.
ConsExpo 4.0, the most recent ConsExpo version, is described in detail in Delmaar et al. (2005)[15].

ConsExpo 4.0 can be used for a screening assessment or for an advanced (higher tier) assessment. Per exposure route i.e. inhalation, dermal and oral route, different models are offered for calculating external exposure. ConsExpo also integrates the exposure via the different routes resulting in a systemic dose. Different dose measures can be calculated (acute, daily, chronic exposure). ConsExpo can also run calculations using distributed input parameters and sensitivity analysis can be performed.

The computer model is publicly available. Default data are available via the database, which is an integral part of ConsExpo. The software, the user manual and the various factsheets (see section 1.3) can be downloaded via the website of the National Institute for Public Health and the Environment in the Netherlands (RIVM; www.rivm.nl/consexpo)

1.3 Fact sheets

This report is one of a series of fact sheets that describes a main category of consumer products, such as paint, pest control products, children's toys and, in this report, cosmetics. The fact sheets give information that is important for the consistent estimation and assessment of the exposure to, and the uptake of, substances from consumer products.

A separate fact sheet called the 'General fact sheet'[8] gives general information about the fact sheets, and deals with subjects that are important for several main categories. The General fact sheet gives details of:
- the boundary conditions under which the defaults are estimated;
- the way in which the reliability of the data is shown;
- parameters such as the ventilation rate and room size;
- parameters such as body weight and the surface of the human body, or parts thereof.

In the facts sheets, information about exposure to chemical substances is collected into certain product categories. These categories are chosen so that products with similar exposures are grouped. On the one hand, the fact sheet gives general background information; while on the other hand, it quantifies exposure parameters which, together with one or more of the ConsExpo exposure models, produce a quantitative estimate of the exposure.

The fact sheets are dynamic documents. As new research becomes available or as perceptions change, the parameter default values may need to be changed. Additional models can also be developed within ConsExpo; this too will require adaptations. The fact sheets are linked with ConsExpo since the fact sheets define the default values for the parameters used in the different ConsExpo models. Alterations in either the default values or the parameters influence both the fact sheets and (data base of) ConsExpo. We intend to produce updates of the published fact sheets on a regular basis.

This fact sheet is principally aimed at exposure to the whole product and is, as such, independent of the compound. This means that the information about the compound must be

added separately. This mainly concerns information about the concentration and the physico-chemical properties of the compound.

2 Product categories, boundary conditions and general parameter values

This chapter reports the definition of the main category cosmetics and its classification into product categories. It also provides background information on default parameters and the spray model.

2.1 Classification into product categories

For this fact sheet, cosmetics are classified into product categories, according to the type of use and exposure. The aim is to reduce the large number of individual products and applications to a limited number. The method of exposure within each category is very similar, so that one default exposure estimate can be drawn up for all products which belong to that category.

For cosmetics thirty-six product categories are defined, based on the principle that a similar exposure takes place within a category (see Table 1). They try to cover the entire field of cosmetics use by consumers. Oral hygiene products are also included in this fact sheet, although strictly speaking they are no cosmetic products.

In chapter 3, default ConsExpo models for the exposure and for the uptake are assigned to each of the product categories from table 1, and default parameter values are derived. The ConsExpo models are discussed in detail in Delmaar et al. (2005)[15].

If an exposure route for a certain category is considered negligible, no default models are described for that route. When using deodorant, for example, only the dermal and, depending on product type, the inhalation route is of importance.

2.2 The consumer and exposure

Non-professional use only
The default values in the fact sheets have been collected for consumers (private or non-professional users). They are not aimed at describing exposure for people who professionally work with cosmetics, such as hairdressers and beauticians, for example. This fact sheet therefore only describes cosmetics which are available to the consumer for private use.

Using the models in ConsExpo and the default values for consumers presented here as background data, it is nonetheless possible to calculate the exposure and uptake of cosmetic control by professional users. Of course, the differences in products and product use between the consumer and those cosmetic products professionally must be taken into account.

Table 1: Cosmetics product categories

Type of product	**Product categories**
Hair care	Shampoo Conditioner Hairspray, aerosol can Hair styling, gel Hair styling, mousse Hair dye Hair bleaching products Permanent wave - Perm lotion - Fixing lotion
Bathing, showering	Washing hands: soap, gel Showering: soap, gel Bath foam, bath oil, bath salts
Skin care	Cream - Face cream - Hand cream - Body lotion Peeling-gel Face pack Body pack Skin whitening products
Make-up and nail care	Facial make-up Facial cleanser Eye shadow, mascara, eyeliner, eye makeup remover Lipstick, lip salve Nail polish, nail polish remover
Deodorant	Stick / roller Spray
Oral hygiene	Toothpaste: adults, children Mouth wash
Foot care	Antiperspirant Anti-fungicides
Fragrances	Eau de toilette
Men's cosmetics	Shaving cream Aftershave
Sun care cosmetics	Sunscreen lotion
Baby care	Baby salve, baby oil, baby powder
Miscellaneous	Depilatories Essential oils Face paint: adults, children

Men / women

Default values such as the body weight and surface area of body parts are different for men and women. In principle the default value 'adults', an average default value for men and women, is taken (see: 'General Fact Sheet'[8)] for details).

When the default is reported for women or for men only, this is indicated.

Children
The 'normal' use of cosmetics by children, such as the use of baby salves, baby powder, sunscreen lotions and toothpaste, for example, is described in this fact sheet. Other cosmetic products used by children are described in the 'Children's Toys Fact Sheet'[37)].

'*Reasonable worst case' estimate*
The basis for the calculation and/or estimation of the default parameter values is a realistic worst-case scenario, and considers consumers who frequently use a certain pest control product under relatively less favourable circumstances. For example, when using a cosmetic product, basic assumptions are: relatively frequent use, application of a relatively large amount in a small room with a low ventilation rate, and a relatively long stay in that room.

The parameter values in the fact sheets are aimed at (Dutch) consumers. They are chosen such that a relatively high exposure and uptake are calculated, in the order of magnitude of a 99th percentile of the distribution. To achieve this goal, the 75th or the 25th percentile is calculated (or estimated) for each parameter. The 75th percentile is used for parameters which give a higher exposure for higher values, and the 25th percentile is used in the reverse case. For a significant number of parameters, there are actually too little data to calculate the 75th or 25th percentile. In such cases, an estimate is made which corresponds to the 75th or 25th percentile.

Multiplication of two 75th percentile parameter values will result in a 93.75th percentile, whereas multiplication of three 75th percentile parameter values will result in a 98.5th percentile. Since for all parameter values a 75th /25th percentile is calculated or estimated, the resulting outcome in the calculation is a higher exposure and/or uptake. Given the number of parameters and the relationship between the parameters, it is expected that in general the calculated values for exposure and uptake will result in a 99th percentile.
The result is a 'reasonable worst-case' estimate for consumers who use relatively large amounts of cosmetics under less favourable circumstances.

2.3 Reliability of the data

A number of parameters are difficult to estimate based on the literature sources and unpublished research. A value must still be chosen for these parameters; otherwise it is not possible to carry out any quantitative exposure assessment. This is why a quality factor (Q-factor) is introduced[8)], which is in fact a grading system for the value of the estimate of the exposure parameter. Low Q-factors indicate that the default value is based on insufficient (or no) data. If such a default is used in an exposure analysis, it should be carefully considered and, if possible, adapted. If representative data are supplied by applicants or producers, it can replace the default values. High Q-factors indicate that the defaults are based on sufficient (or more) data. These defaults generally require less attention. It is possible that they will need to be adapted according to the exposure scenarios. For example, an exposure estimate might be carried out for a room of a particular size; the well-established default room size should then be replaced by the actual value. A Q-factor is given to all parameter values in the fact sheets, indicating the reliability of the estimate of the default value. The quality factor range has been adapted and it can have a value of between 1 and 4. In previous fact sheets, the quality factor ranged from 1 to 9. Table 2 shows the meaning of the values of the quality factor.

Table 2: Value of quality factor Q

Q	Value
4	Good quality relevant data, parameter value reliable
3	Number and quality of the data satisfactory, Parameter value usable as default value
2	Parameter value based on single data source supplemented with personal judgement
1	Educated guess, no relevant data available, parameter value only based on personal judgement

2.4 General parameters for the spraying process

During spraying the user can inhale droplets of the product. Sprays produce an aerosol cloud of very small to small droplets. The speed with which the droplets fall depends on the size of the droplet; smaller droplets stay in the air longer.
To calculate the inhalation exposure for the user, the 'spray model' from ConsExpo is used for all spray applications. Examples of this are hairspray, deodorant and eau de toilette. To avoid repetition, in this section we discuss some parameters from the 'spray model'.

The spray model is developed on the basis of the results of experimental work and describes the indoor inhalation exposure to slightly evaporating or non-volatile compounds in droplets that are released from a spray can or trigger spray (Delmaar et al.)[15, 51]. For volatile substances, the evaporation model is more appropriate. If the spray model is used for volatile substances the inhalation exposure will be underestimated, because exposure to vapour is not considered in the spray model.
Volatile is defined as compounds with vapour pressure > 0.1 Pa, non-volatile < 0.01 Pa and slightly volatile between 0.01and 0.1 Pa[52].

Spraying towards exposed person

- *Cloud volume*

During the actual spraying of a cosmetic product towards a person, the person is exposed to an aerosol cloud with fine particles. In the ConsExpo 4.0 spray model, the volume of the cloud after 1 second is assumed to further increase linearly in time until spraying stops or the cloud volume equals the volume of the room. It is assumed that during the use of the spray (the actual spraying) the breathing zone of the exposed person is located inside this volume. After spraying, the sprayed material is assumed to be homogeneously dispersed over the entire room.
The default value for cloud volume is set at 1/16 m^3 or 0.0625 m^3. This cloud volume matches a cone measuring 1 m (length) and 0.5 m (diameter); in addition, it matches a sphere with a diameter of 0.5 m.

- *Airborne fraction*

The airborne fraction is the fraction of non-volatile material that becomes airborne in the form of droplets. The 'airborne fraction' combines the fraction non-volatile material that ends up in the smaller droplets and the fraction of droplets that becomes airborne. The latter is closely connected to the type of spray and the way it is used, i.e. spraying on a surface (paint, wood preservative) or spraying in the air (spraying against flies), and on the droplet size distribution that has been specified.
Airborne fractions have been determined experimentally for different sprays. The airborne fraction is derived from the TNO-PML[50)] survey on the exposure from spray cans and trigger sprays (Delmaar et al., in prep.)[51]. In Table 3 the airborne fractions for the investigated spray cans and trigger sprays are presented. Based on these values, default values are set (see Table 4).

Table 3: Airborne fractions of investigated spray cans and trigger sprays

Application	**Percentiles of the initial particle distribution [µm]**			**Main solvents**	**Airborne fraction [%]**
	D_p (0.10)	**D_p (0.50)**	**D_p (0.90)**		
Spray cans					
Air space, against flies & mosquitoes	25	125	414	water	60
Air space, against flies	7	23	109	Isoparafine/ isopropanol	60
deodorant	7.6	22	41	ethanol	100
Hair spray	17	39	69	Dimethyl ether / ethanol	100
Flea spray	9.4	30	142	Benzine/ aceton	50
Plant spray Affecting insects	55	97	232	water	10
Trigger sprays					
Plant spray fine [a], affecting insects	33	88	191	water	20
Plant spray coarse [a], affecting insects	39	127	512	water	20
Spray against crawling insects	29	63	200	water	10
All purpose cleaner	46	133	391	water	10

a) the nozzle can be adjusted so that the plant sprayer generates a fine spray with droplets as small as possible or a spray with coarse droplets

Table 4: Default values for the airborne fraction

	Airborne fraction	**Q**
Air space sprays	1	2
Surface sprays; median of the initial particle distribution < 50 µm	1	2
Surface sprays; median of the initial particle distribution ≥ 50 µm	0.2	2

- *Initial particle distribution*

The droplet size is an important parameter when estimating the exposure. Smaller drops fall at a lower speed and stay in the air for longer. The large droplets will quickly disappear from the air after being formed. As an indication: the falling time of droplets with a diameter of 100 µm from a height of 3 meters is calculated at 11 sec, and for droplets of 10 µm it is calculated at 17 min[20)]. If a larger droplet is sprayed, part of the aerosol cloud will consist of finer droplets which stay in the air for longer, as a result of edge effects around the nozzle and the 'bounce back' effect due to spraying onto a surface. 'Assessment of human exposure to biocides' from the Biocides Steering Group[20)] gives a WHO classification concerning the droplet size of sprays (see Table 5).

Table 5: Classification of aerosol droplets [20)]

Droplet diameter [µm] [a)]	**Classification**
< 15	Fog
< 25	Aerosol, fine
25-50	Aerosol, coarse
51-100	Mist
101-200	Spray, fine
210-400	Spray, medium
>400	Spray, coarse

[a)]: the median diameter; half of the particles are larger, half are smaller

The Dutch Aerosol Association[23)] distinguishes between aerosol sprays in aerosol cans with very fine atomized dry sprays (such as asthma sprays and insecticides) and fine atomized wet sprays (such as hair sprays and paint sprays).
Matoba et al.[27)] measured the droplet size of an aerosol can with a spray for air space applications. The average droplet size was 30 µm with a range of 1-120 µm. Based on the measurements, Matoba et al. classified the droplets into three groups: 10 % of the particles have a droplet size of 60 µm, 80 % have a droplet size of 20 µm and 10 % of the particles have a droplet size of 5 µm. A spray for air space applications generally has a smaller droplet diameter than a spray for surface applications.

TNO-PML[50)] has investigated aerosols from spray cans and trigger sprays, in particular the particle size distributions of the aerosols resulting from the use of various types of aerosol spray cans and of trigger sprays, and the dispersion of the aerosols in a room. Among these sprays three hair sprays and three deodorant sprays were studied, but no fragrances sprays. Results of the TNO-PML[50)] investigation and default initial particle distributions are described in the sections concerned.

- *Inhalation cut-off diameter*

The inhalation cut-off diameter is the measure for the diameter of the spray droplets that can be inhaled and reach the lower areas of the lungs (alveoli, bronchioles, bronchia). Particles that are above this diameter deposit in the higher parts of the respiratory tract and will be cleared via the gastro-intestinal tract, leading to oral exposure. The inhalation cut-off diameter is only an approximation of the complicated process of deposition of particles in the lung. In general its value should be around 10-15 micrometer. The default value is set at 15 μm.

General default values for cosmetic sprays

	Default value	**Q**	**References, comments**
Inhalation			
Exposure, spray model			See above
Spraying towards exposed person			
Cloud volume			See above
Spray cans	0.0625 m^3	2	
Pump sprays	0.0625 m^3	1	
Airborne fraction			See above
Surface sprays; median of the initial particle distribution < 50 μm	1 g/g	2	
Surface sprays; median of the initial particle distribution ≥ 50 μm	0.2 g/g	2	
Inhalation cut-off diameter	15 μm		See above

- *Density*

In the spray model the density of the non-volatile fraction is one of the parameters. Many non-volatile substances in cosmetics are made of large organic compounds with densities usually between 1.0 and 1.5 g/cm^3. For a complex mixture of (especially organic) compounds, the density is set at 1.8 g/cm^3. The density of salts generally varies between 1.5 and 3.0 g/cm^3. In table 6 default values are described for solvents and for non-volatile compounds.

Table 6: Default values for density

Type	**Main ingredient**	**Density** [g/cm^3]	**Q**
Solvents	Volatile organic solvents	0.7	3
	Water	1	4
Non-volatile compounds	Large organic compounds	1.5	3
	Salts	3.0	3
	Complex mixture of compounds, especially organic compounds	1.8	3

3. Defaults for cosmetics

3.1 Hair care

3.1.1 Shampoo

Composition
General composition of shampoo[5, 6]:

66 %	water
14 %	sodium lauryl ether sulphate (surfactant, active cleaning agent)
5 %	betaines (surfactant, foaming agent; also coconut oil-diethanolamide and lauric acid diethanolamide)
2 %	quartenary ammonium compounds (conditioner; also betaines)
1 %	polyethylene glycol-distearate (hair shining agent)
1 %	common salt (viscosity regulator)
0.5 %	fragrance
0.00015 %	kathon CG (preservative)
10.5 %	other ingredients

Use
Van Rooy[1)] indicates that on average some 20 g of shampoo is used 3 or 4 times a week. A 'maximum scenario' is given in which the amount of shampoo used is 3 times as high. The EU's 'Technical Guidance Document' [2)] gives a 'typical amount' of 12 g of shampoo per application. Mennes et al.[4)] indicate that in a trial using volunteers, 20 g of shampoo was used during each wash. Annema [6)] estimates that hairdressers use 15 ml of shampoo per wash. In a report by the Dutch association of aromatic substance and flavouring manufacturers NEA[3)] an amount of 8 g of shampoo is given per wash. Based on the data above, the default value (equivalent to the 75th percentile) is estimated at 20 g of shampoo per wash.

Colipa[16)] states that for shampoo and conditioner, 10 % of the amount used ends up on the scalp, just as with hairspray. This value has been used for hair spray, gel and mousse. Since the hair is washed after the shampoo has been applied, and thus comes into intensive contact with the scalp, this value for shampoo (and for conditioner) is not used, and we assume that the skin of the scalp is exposed to all (diluted) shampoo.

Default shampoo

	Default value	Q	References, comments
General			
Frequency	260 x/year	3	3-4[1)], 2-7[2)], 3[4)], 7[3)] times a week, (default: 260 x/year = 5 x/week)
Dermal			
Exposure, instant application			
Exposed area	1440 cm^2	3	Area hands + ½ area head[8)]
Amount upon head $_{dilution}$	60 g	2	The estimation is that wet hair contains 40 g water + shampoo 20 g (see above)
Weight fraction $_{dilution}$	W_f / 3	2	Shampoo 20 g, total amount upon head 60 g: dilution factor 3; ref [4)] gives a dilution factor of 12.5
Uptake, diffusion			
Exposure time	4 min	2	Mean 1 min., maximal 10 min.[1)], 5 min.[4)]; assuming that shampoo after application is not rinsed out immediately

3.1.2 Conditioner

Composition
Quaternary ammonium compounds (quats) are often used as conditioners. Other substances that are used are silicones, fatty acid-protein compounds, panthenol and betaine compounds[10)]. The active cleaning agent in shampoos often has a strong degreasing character; washing with shampoo therefore strips the hair its natural oily layer. Conditioners have outwardly the same function as the removed oils in that they adhere to the hair and form a shiny layer [10)].

Use
A conditioner is used after the hair has been washed with shampoo. After a few minutes the conditioner is rinsed out, just as with shampoo. As well as being sold separately as conditioner, they are also often added to the shampoos themselves.

Weegels[9)] gives 2.0 g as the average amount of conditioner used (standard deviation 1.0; n=3). The EU's 'Technical Guidance Document' [2)] gives a 'typical amount' of 14 g of conditioner per wash. Weegels' data only concerns a few observations, carried out during research into the use of hair styling products (including hairspray, gel and mousse). Considering the small number of Weegels' observations and the amount of shampoo used per wash (which can be considered as a more or less comparable product), the amount of conditioner from the 'Technical Guidance Document' is considered to be more valuable. The amount of conditioner is estimated at 14 g per wash.

Default conditioner

	Default value	Q	References, comments
General			
Frequency	104 x/year	3	1-2/week[2)] (default:104/ year =2/week)
Dermal			
Exposure, instant application			
Exposed area	1440 cm^2	3	Area hands + ½ area head[8)]
Amount upon head $_{dilution}$	54 g	2	The estimation is that wet hair contains 40 g water + conditioner 14 g (see above)
Weight fraction $_{dilution}$	W_f / 3.9	2	Conditioner 14 g, total amount upon head 54 g: dilution factor 3.9
Uptake, diffusion			
Exposure time	4 min	2	See § 3.1.1.shampoo[1,4)]

3.1.3 Hairspray, aerosol can

Composition
General composition for aerosol can of hairspray[6,23)]:

50 %	propellant (butane, dimethylether)
45-50 %	solvent (ethanol, water)
3 %	fixative (vinyl polymers including polyvinylpyrrolidone)
0.02-0.06 %	polymer neutraliser (tri-isopropanolamine)
0-0.1 %	plasticizers (lanoline derivates, phthalates [6,24)])
0-5 %	perfume

Corrosion inhibitors may need to be added due to the use of water [23)]. Aerosol cans of hairspray usually contain 300 ml.

Use
Weegels [9)] indicates that two thirds of the consumers use their hair care products in the bathroom (14 out of every 22 users). It appears that there was ventilation in all cases (n=21): open door, open window, mechanical ventilation or a combination of these methods. Based on this information, for the defaults it is assumed that the hair care products are used in the bathroom. The 'General Fact Sheet' [8)] gives a value of 10 m^3 as the default value for the volume of bathrooms, and a ventilation rate of 2 h^{-1}.
The amount of hairspray that is sprayed per application is given in various sources: 10 g[2)]; 15 g[6)]; 10 g[7)]; 5 g[3)]; a mean of 4.3 and a standard deviation (SD) of 3.7 g[9)]. The default value is based on Weegels' data[9)]. The 75th percentile is calculated from the mean value and the SD which gives an amount of 6.8 g of sprayed product.
Weegels' [9)] data is used for the default values for the sprayed amount of hairspray, the frequency and the duration of use of hairspray, as this source describes approximately 10 recent measurements of these parameters in the Netherlands.

TNO-PML (2005)[50)] has investigated the mass generation rate of 23 aerosols spray cans and trigger sprays, including 3 hair sprays. The mass generation rate of full and of nearly empty cans was measured.

The median of all full spray cans and trigger sprays was 1.0 g/sec, the 75th percentile 1.5 g/sec.
No distinction could be made between the aerosol cans and trigger sprays, the 75th percentile of the full trigger sprays was 1.5 g/sec, the 75th percentile of the full spray cans 1.6 g/sec.
The mass generation rate of the nearly empty spray can was in some cases 80-90 % of the full can, in some other cases only 30 % of the full can.
In Table 7 the mass generation rate of the 3 hair sprays is described.

Table 7: Mass generation rate of hairspray spray cans [50)]

	Mass generation rate of a full container [g/sec]	**Mass generation rate of a nearly empty container [g/sec]**
Hairspray 1	0.77	0.66
Hairspray 2	0.79	0.30
Hairspray 3	0.63	0.30

Based on Weegels' data[9)] the mass generation rate can be calculated by dividing the amount of hairspray sprayed per application (default value: 6.8 g) by the duration of the spraying (default value: 0.24 min.), resulting in 0.47 g/sec. It is assumed that spraying take place during a time span of 0.24 min, and that spraying actually occurred about half of this time.
The mass generation rate derived from Weegels' data and from the TNO-PML investigation are in the same order of magnitude.
Therefore, the mass generation rate of 0.47 g/sec, calculated from Weegels' data, is set at default value.

Scenario
The spray model is used to assess the inhalatory exposure when spraying hairspray. During spraying the hairspray is atomized; some of the hairspray will end up on the hair or on the scalp, and some will be sprayed next to the hair. This part will end up in the room as aerosol particles. It is assumed that 85 % (5.8 g) of the sprayed hairspray will end up on the hair and the head. With regards the distribution between the amount that ends up on the hair and the amount on the scalp, the EU's 'Technical Guidance Document' [2)] indicates that 10 % of the total amount used (i.e. 10 % of 5.8 g) ends up on the scalp. The surface of the scalp is used as the exposed area. It is assumed that this is half of the surface area of the head.

According to the general composition for aerosol cans of hairspray[6, 23)], hair spray cans contain 50 % propellant, 3 % fixative and 47 % solvent. The 3 % of fixative is set as default values for the weight fraction non-volatile.

TNO-PML[50)] has investigated the initial particle distribution of three hair sprays (see § 2.4). The 10th, 50th, and 90th percentiles for the volume distributions of hair spray cans are given as d_p (V, 0.10), d_p (V, 0.50) and d_p (V, 0.90), which means that 10 %, 50 % or 90 % of the particle volume is below the mentioned size (see Table 8).

Table 8: The 10th, 50th and 90th percentiles of the volume distribution of hair spray cans[50)]

Aerosol spray can	**Full spray can percentiles of the initial particle distribution [µm]**			**Nearly empty spray can percentiles of the initial particle distribution [µm]**		
	D_p (0.10)	**D_p (0.50)**	**D_p (0.90)**	**D_p (0.10)**	**D_p (0.50)**	**D_p (0.90)**
Hair spray 1	17	39	69	18	42	74
Hair spray 2	17	38	66	17	38	66
Hair spray 3	23	50	87	24	50	84

Based on above-mentioned data, the initial particle distribution of a hair spray can is defined as a lognormal distribution with a median of 35 µm and with a coefficient of variation (C.V.) of 0.3 (see Figure 1).

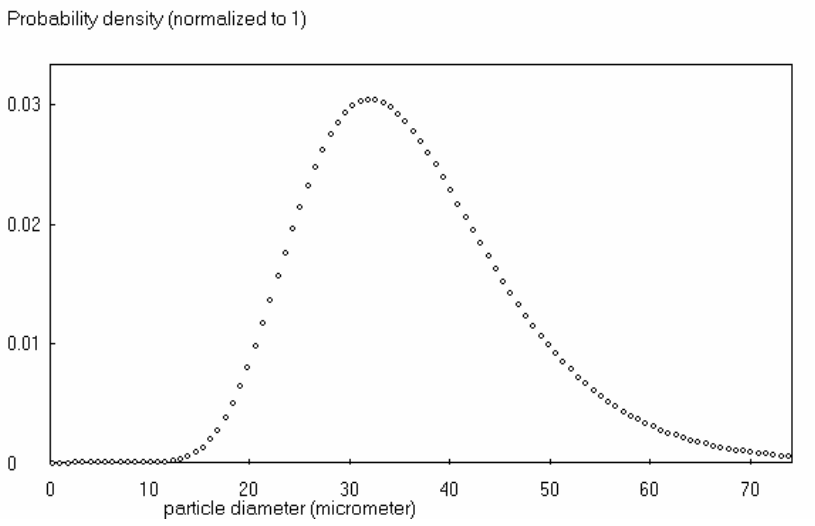

Figure 1: Default initial particle distribution for hair sprays: a lognormal distribution with median 35 µm (C.V. 0.3)

Default hair spray

	Default value	Q	References, comments
General			
Frequency	438 x/year	3	1-2[2]; mean 0.76 SD 0.68[9], 2[3] x/day (default is calculated as follows[9]: 75 perc. mean 0.76 a day and SD 0.68 gives 1.2 x/ day i.e. 438 x/year)
Body weight female	61 kg	4	[8]
Inhalation			
Exposure, spray model, spraying towards exposed person			
Spray duration	0.24 min	3	0.34[6]; 0.17[7]; mean 0.18 SD 0.1[9] min. (default is calculated as follows[9]: 75 perc. mean 0.18 and SD 0.1 min. gives 0.24 min.)
Exposure duration	5 min	2	Estimate: time in bathroom
Room volume	10 m^3	3	Bathroom[8]
Room height	2.5 m	4	Standard room height
Ventilation rate	2 h^{-1}	3	Bathroom [8]
Cloud volume	0.0625 m^3	2	See § 2.4
Mass generation rate	0.47 g/sec	3	Calculated from Weegels[9], see use
Airborne fraction	1 g/g	2	See § 2.4
Weight fraction non-volatile	0.03 g/g	2	see above
Density non-volatile	1.5 g/cm^3	3	See § 2.4
Initial particle distribution			
Median (C.V.)	35 µm (0.3)	3	See above
Inhalation cut-off diameter	15 µm		See § 2.4
Uptake, fraction model			
uptake fraction	1	2	potential dose
inhalation rate	23.1 l/min	3	[17]
oral uptake fraction	1	2	potential dose
Dermal			
Exposure, instant application			
Exposed area	565 cm^2	3	½ area head female[8]
Amount upon head	0.6 g	2	See scenario
Uptake, diffusion			
Exposure time	960 min	2	Estimate: 16 hours upon hair; at night, hair spray is brushed out

3.1.4 Hair styling, gel

Composition

The book 'New cosmetics science' by T. Mitsui (ed.)[40] describes a large number of cosmetic products, including hair care products.

A 'typical formula' for hair gel is given below:

77.3 %	water
20 %	ethyl alcohol
2.7 %	polymers
	other ingredients:
	- perfume
	- humectants (moisturizing compounds)
	- alkali
	- surface-active ingredients
	- chelates

Use
The default values for the frequency of use of gel, the duration of use of the gel, and the amount are all taken from Weegels[9], which describes approximately 10 recent measurements of these parameters in the Netherlands.

Scenario
The exposed area during 'use' is the hands and head (see default hair gel: 2), and during 'contact' it is only the head (see default hair gel: 1). Since it is only the palm of the hands that come into contact with the product, half of the surface area of the hands is used.

With regards the distribution between the amount that ends up on the hair and the amount on the scalp, the EU's 'Technical Guidance Document' [2] indicates that 10 % of the total amount used ends up on the scalp. The surface area of the scalp is used as the exposed area. It is assumed that this is half of the surface area of the head.

Default hair gel

	Default value	Q	References, comments
General			
Frequency	358 x/year	3	Mean 0.59 a day SD 0.57 [9] (default: 358 x/year = 0.98 x/day, i.e. calculated 75th percentile from 0.59 x/day and SD 0.57)
Dermal			
1. Exposure, instant application			
Exposed area	580 cm^2	3	½ area head[8]; see scenario
Amount upon head	0.3 g	2	10 % [2] of 2.9 g product amount which is 75th percentile from mean 1.9 g, SD 1.5[9]
Uptake, diffusion			
Exposure time	1440 min	2	Estimate
Dermal			
2. Exposure, instant application			
Exposed area	1010 cm^2	3	½ area hands + ½ area head[8]; see scenario
Amount product	2.9 g	3	75th percentile from mean 1.9 g, SD 1.5[9]
Uptake, diffusion			
Exposure time	0.63 min	3	75th percentile from mean 0.48 min and SD 0.22 [9]

3.1.5 Hair styling, mousse

Composition
'New cosmetics science' by T. Mitsui (ed.)[40] gives the following 'typical formula' for hair mousse[40]:

63 %	water
13.5 %	ethyl alcohol
6.3 %	humectants
4.5 %	oils
2.7 %	polymers
10 %	propane (propellant)
	other ingredients:
	- perfume
	- preservatives

Use
The default values for the frequency of use of mousse, the duration of use of the mousse, and the amount are all taken from Weegels [9], which describes approximately 10 recent measurements of these parameters in the Netherlands.

Scenario
The exposed area during 'use' is the hands and head (see default hair mousse: 2), and during 'contact' it is only the head (see default hair mousse: 1). Since it is only the palms of the hands that are exposed to the product, half of the surface area of the hands is used.
With regards the distribution between the amount that ends up on the hair and the amount on the scalp, the EU's 'Technical Guidance Document' [2] indicates that 10 % of the total amount used ends up on the scalp. The surface area of the scalp is used as the exposed area. It is assumed that this is half of the surface area of the head.

Default hair mousse

	Default value	Q	References, comments
General			
Frequency	274 x/year	3	Mean 0.41x/day SD 0.50 [9] (default: 274 x/ year = 0.75 x/day i.e. 75th percentile calculated from 0.41 x/day and SD 0.50)
Dermal			
1. Exposure, instant application			
Exposed area	580 cm^2	3	½ area head[8]; see scenario
Amount upon head	0.3 g	2	10 % of 2.7 g product amount[2] which is 75th percentile from mean 2.0 and SD 1.0[9]
Uptake, diffusion			
Exposure time	1440 min	2	Estimate
Dermal			
2. Exposure, instant application			
Exposed area	1010 cm^2	3	½ area hands + ½ area head[8]; see scenario
Amount product	2.7 g	3	75th percentile from mean 2.0 g and SD 1.0 [9]
Uptake, diffusion			
Exposure time	0.67 min	3	75th percentile from mean 0.48 min SD 0.28 [9]

3.1.6 Hair dyes

Composition

There are three different types of hair dye [6]:

1. Temporary hair dye, the hair dye is removed by washing the hair.
   A) Application: as shampoo (colour rinse), is currently hardly used;
   - 0.5-2 % active colour ingredients; high molecular water-soluble textile dyes (monosulphonic, disulfonic and trisulphonic acids of azo, anthraquinone and triarylmethane)

   B) Application in an aerosol can, particularly for special occasions such as sporting events, carnivals and children's parties
2. Semi-permanent hair dye (4 to 5 washes)
   - as for permanent dyes, but without an oxidation agent
   - dyes with a low molecular weight (nitrophenylenediamines,nitroaminophenols, aminoanthraquinones and to a lesser extent azo dyes)
3. Permanent dyes (more than 10 washes)
   Permanent hair dyes are produced in two parts (A and B), just before use the two parts need to be mixed

   A) - primary intermediate (a para-compound such as paratoluenediamine
   - a coupler (e.g. resorcinol, couples with the primary intermediate)

   B) an oxidiser (usually hydrogen peroxide)
   The para-compounds are oxidised into benzoquinoneimines using hydrogen peroxide. The imines react quickly with the couplers or with non-oxidised para-compounds to the colour-forming material. The mixture of colour-forming materials are often found in a shampoo base (pH 9-10, base often ammonia).

Use

Temporary hair dye:	
- aerosol can of hair dye:	the assumption is that the sprayed amount of hair dye is equal to the amount of hairspray, i.e. 6.8 g per application[9]; the frequency is estimated at 4 to 6 times a year.
- shampoo:	12 g per application[2]
Semi-permanent hair dye:	30 g per application, 8-18 times a year[2]
Permanent hair dye:	50 g per application, 8-12 times a year[2]

Gloves are usually supplied with permanent hair dye. It is assumed that gloves are used during its application.

Default hair dye spray

	Default value	Q	References, comments
General			
Frequency	6 x/year	2	Estimate
Inhalation			
Exposure, spray model, spraying towards exposed person			
Spray duration	0.24 min	2	See § 3.1.3
Exposure duration	5 min	2	See § 3.1.3
Room volume	10 m^3	3	Bathroom[8)]
Room height	2.5 m	4	Standard room height
Ventilation rate	2 h^{-1}	3	Bathroom [8)]
Cloud volume	0.0625	2	See § 2.4
Mass generation rate	0.47 g/sec	2	See § 3.1.3
Airborne fraction	1 g/g	2	See § 2.4
Weight fraction non volatile	0.03g/g	1	Estimate derived from hairspray
Density non volatile	1.5 g/cm^3	3	See § 2.4
Initial particle distribution			Estimate derived from hairspray
Median (C.V.)	35 µm (0.3)	1	See § 3.1.3
Inhalation cut-off diameter	15 µm		See § 2.4
Uptake, fraction model			
uptake fraction	1	2	potential dose
inhalation rate	23.1 l/min	3	[17)]
oral uptake fraction	1.	2	potential dose
Dermal			
Exposure, instant application			
Exposed area	580 cm^2	3	Estimate, ½ area head[8)]
Amount upon head	0.6 g	2	See § 3.1.3
Uptake, diffusion			
Exposure time	480 min	2	Estimate: 8 hours

Default hair dye

	Default value	Q	References, comments
General			
Frequency	10 x/year	3	8-12 x per year[2)]
Dermal			
Exposure, instant application			
Exposed area	580 cm^2	3	½ area head[8)]
Amount product	100 g	3	2 x 50 [6)] , 50 g[2)]
Uptake, diffusion			
Exposure time	40 min	3	Estimation: 5 min. application and 5 min. rinsing out; initial period 30 min.; 20-40 min[6)]

3.1.7 Hair bleaching products

Composition
General composition of hair bleaching products[6]:
Home hair bleaching products are usually made up of three parts that are mixed together just before use.

Part 1:		Part 2:		Part 3:
Decolourant cream		*Developer*		*Powder*
60 %	water	80 %	water	sodium or ammonium persulphate
5 %	lipids	1%	foam booster	magnesium carbonate
2 %	emulsifier	8 %	emulsifier	sodium lauryl sulphate
1.5 %	stabilisers	1 %	alkali	
1 %	acid	0.01 %	colouring	
7%	H_2O_2			

The first part contains the actual bleaching agent (H_2O_2) that in this form can be stored in a stable state. The second part is the so called 'bleach base', and contains alkali to realize a high pH. The third part contains a substance (often sodium persulphate: $Na_2S_2O_8$) to improve the bleaching power.

Use
The figures for the permanent hair dye are used for the frequency of hair bleaching (see subsection 3.1.6). It is assumed that the frequency is the same as for hair bleaching products, since they both depend on the hair growth. One of the directions for use stated that there should be at least 3 weeks between 2 hair bleaching sessions, or between a perm and a hair bleaching session. Hair bleaching products are used by relatively few consumers and are affected by trends.

The various hair-bleaching products on sale for consumer use contain differing amounts of decolourant cream (40-120 ml), developer (50-120 ml) and powder (12.5 - 48 g). The parts of the hair bleaching products are often given other names such as, bleaching activator, bleaching powder and decolouration powder. Depending on the product, the total amount varies from 100 g to 228 g per packaging [26]. These amounts only concern the hair bleaching products themselves; hair care products such as conditioners that are supplied in the packaging are not considered.
The total duration of contact varies from 20 -30 min up to 30-45 min 'working-in' time[26].
For the default value, a total duration of contact of 45 min and a total amount of bleaching product of 200 g are assumed.

Gloves are usually supplied with hair bleaching products. It is assumed that gloves are used during its application.

Default hair bleach

	Default value	Q	References, comments
General			
Frequency	10x/year	2	See use
Dermal			
Exposure, instant application			
Exposed area	580 cm^2	3	½ area head[8)]
Amount product	200 g	3	See use
Uptake, diffusion			
Exposure time	45 min	3	See use

3.1.8 Permanent waves

Composition
The general composition of perm lotion is:

92 %	water
7 %	ammonium thioglycolate for home use 5-8 %, legal maximum 8 %; for professionals 7-11 %, legal maximum 11 % (cosmetics decree, 1980)
1 %	cloudifier (ensures the distribution of the perm lotion on the hair)
0.05 %	colouring
0.01 %	perfume
	alkaline compound, ammonium or triethanolamine salts up to pH 9-10

The general composition of the fixing or neutralising lotion:

94 %	water
4 %	H_2O_2
1 %	cloudifier
0.5 %	citric acid
0.1 %	stabilizer
0.05 %	colouring

In addition to the perm lotions containing ammonia, there are also perm lotions without ammonia. Perm lotion and neutralising lotion are also available in aerosol form. The products are then used in the form of a mousse[23, 26)].

Use
Perm lotion is used to make hair more or less permanently curly. In the perming process two steps can be distinguished[6,26)].

1. The hair is washed with shampoo and, after careful rinsing, is curled (with perming rods: rollers or clips) and is moistened with perm lotion. This liquid contains an alkaline reducing agent. The reducing agent breaks the sulphur bridges that hold the elongated creatin chains together. After applying the perm lotion, a plastic cap is put over the hair and a towel is wrapped around the head. The perm lotion needs 10 to 30 minutes to work, with a maximum of 40 minutes. The directions for use clearly indicate that this time may

not be exceeded. When it has been worked in, the perm lotion needs to be removed by thoroughly rinsing the hair with lukewarm water.
2. The next step is the neutralising or fixing of the curls. The liquid used for this purpose is an acid oxidiser. The oxidiser repairs the sulphur bridges, but this time so that the curls are maintained. Three quarters of the fixing lotion is applied to the hair in the perming rods. The fixing lotion must be left on for 5 to 10 minutes. The perming rods are then removed and the hair is thoroughly washed with the remainder of the fixing lotion. It is left in for 0 to 5 minutes and then rinsed out with lukewarm water.

Gloves are usually supplied with perm lotion. It is assumed that gloves are used during its application.

Default hair perm

	Default value	**Q**	**References, comments**
General			
Frequency	4x/year	2	Estimate
Dermal			
Exposure, instant application			
Exposed area	580 cm^2	3	½ area head[8)]
Amount product			
Perm lotion	80 g	3	[26)] ; see above
Fixing lotion	80 g	3	[26)] ; see above
Uptake, diffusion			
Exposure time			
Perm lotion	40 min	3	[26)] ; see above
Fixing lotion	15 min	3	[26)] ; see above

3.2 Bathing, showering

Introduction
Soap is used to cleanse the skin. A bar of 'normal' soap usually contains natural fatty acids such as sodium stearate (C_{17}), sodium palmitate (C_{15}) or sodium oleate (C_{17}) [31)]. The term 'soap' is protected in many countries. Liquid soap products are therefore not allowed to be called soap, and are called synthetic detergents. They contain synthetic active cleaning agents and a lot of water. These surface-active agents increase the washing power and ensure the formation of foam. These substances have a hydrophilic and a lipophilic part, and they are divided into anionic, cationic, amphoteric and non-ionic surface-active agents. These products, such as mousses, gels and liquid soap are growing in popularity. They are used on the entire body.

Washing the skin often with active cleaning agents can cause irritation and sometimes an allergic reaction. The following factors play a role in causing these intolerances[6)]:
- basic character: watery soap solutions are alkali and have a pH of 9-11.
- water absorption of the skin protein keratin: this makes the epidermis softer and the uptake of foreign substances through the skin easier (for example the uptake of preservatives from liquid soap).

- degreasing: the skin is degreased during washing. Particles and micro-organisms attach themselves to the skin more easily and the uptake of substances also becomes easier. To solve this problem, oil or fat is added to the soap solution so that it can put back the oil into the skin. The presence of the surface-active agents means that the fats remain in the solution and they are rinsed away with the water.

3.2.1 Washing hands: soap, gel

Composition

Classical bar of soap [6]		*Liquid soap: synthetic detergent* [6]	
85-95 %	sodium salt from fatty acids	60-80 %	water
Approximately:		Approximately:	
0.5 %	perfume	15 %	surface-active agent (cleaning)
0.1 %	antioxidant	1 %	surface-active agent (foaming agent)
0.01 %	colouring	2 %	lipids: to 'put back' the oils
		2 %	thickening agent
		0.3 %	preservatives
		0.3 %	perfume
		0.01 %	colouring

Use
Hands are washed with ordinary soap or liquid soap. The latter is usually dosed using a dispenser. Research was performed to the amount of gel used for washing hands[26]. For this purpose the amount of liquid soap from a dispenser was weighed. The distribution was 0.53 – 1.27 g of gel per application, with a mean amount of 0.89 g and a standard deviation of 0.17 g. The calculated 75th percentile is used as the default value, which is 1.0 g.

Default soap liquid, solid: washing hands

	Default value	Q	References, comments
General			
Frequency	1825 x/year	3	3-6 x/day[2] (default: 1825 x/yr = 5 x/day)
Dermal			
Exposure, instant application			
Exposed area	860 cm^2	3	Area hands[8]
Amount upon skin $_{dilution}$			
Soap liquid	3.0 g	2	Used amount 1.0 g, dilution factor 3
Soap solid	2.4 g	2	Used amount 0.8 g[2], dilution factor 3
Weight fraction $_{dilution}$	W_f / 3	2	Estimate dilution factor 3 (wetting hands)
Uptake, diffusion			
Exposure time	1 min	2	Estimate

3.2.2 Showering: soap, gel

Use
Groot-Marcus et al.[22)] indicate that the average frequency of showering is 0.61 times a day, and the mean (measured!) showering time is 5.07 min (SD=2.9), with an average water usage of 33.2 litres per shower (n=86). This is used to *calculate* a 75th percentile for the showering time at 7 min and 5 sec per shower, and to *estimate* a 75th percentile for the showering frequency at 0.9 times per day, or 329 times per year.

During a shower, some people wash themselves with soap or gel with the water still streaming over their body. In 'Notes of guidance for testing of cosmetics ingredients for their safety evaluation' by the SCCNFP [33)], a retention coefficient of 1 % is assumed for shower gel, since shower gel dissolves easily in water and is used on wet skin. The retention coefficient is the relative amount of gel that remains on the skin after showering. For the default in this report we assume that the gel is applied to wet skin and is then rinsed off under the shower. Based on the showering time measured by Groot-Marcus [22)], 4 minutes is taken to be the default value for the time during which the soap is applied.

Research was performed to the amount of shower gel used [26)]. Twelve people used an amount of gel that varied between 0.93 to 10.36 g of gel per application. The calculated mean was 6.32 g with a standard deviation of 3.43 g. The EU's 'Technical Guidance Document' [2)] gives an amount of 5 g. This value is in the same order of magnitude as the value which was found from our own research. The 75th percentile is used as the default value; 8.7 g of gel per shower (calculated from mean 6.32 g and SD 3.43 g). In own research the amount of soap used per shower was investigated [26)]. Ten people used an average of 4.73 g of soap per shower. The 75th percentile is used as the default value: 7.0 g of soap per shower (calculated from the mean 4.73 g and SD 3.41 g).

Default soap liquid, solid: showering

	Default value	Q	References, comments
General			
Frequency	329 x/year	3	[22)] see use; 1-2 x/day[2)]
Dermal			
Exposure, instant application			
Exposed area	17 500 cm^2	4	[8)] total body area
Amount upon skin $_{dilution}$			
Soap liquid	26.1 g	2	Used amount 8.7 g; dilution factor 3
Soap solid	21.0 g	2	Used amount 7.0 g; dilution factor 3
Weight fraction $_{dilution}$	W_f / 3	2	Estimate dilution factor 3 (use on wet skin)
Uptake, diffusion			
Exposure time	4 min	3	See use

3.2.3 Bath products

In this subsection, bath products such as bath foam, bath salts and bath oil are described.

Composition

Bath foam [38)]

60-80 %	water
20-25 %	surface-active agent (cleaning)
0.2-2 %	surface-active agent (foam stabiliser)
0.5-5 %	lipids: to 'put back' the oils
0-3 %	thickening agent (to increase the viscosity)
0.1 %	preservatives
0.3-3 %	perfume
0.1-0.2 %	colouring

Bath salts

Bath salts come in powder, granule and tablet form. Bath salts are made up of inorganic salts. The general composition of bath salts[40)]:

45-50 %	sodium sulphate
15-50 %	sodium bicarbonate
1 %	sodium carboxymethylcellulose (granules)
8 %	sodium carbonate (tablet)
22 %	succinic acid (tablet)
	other ingredients:
	- colouring agent
	- perfume

Bath oil

Bath oils can be divided into various categories depending on the solution, dispersion etc. after the oil has been added to the water [40)]:

- floating type: oil droplets float on the water surface
- spreading type: thin film of oil spreads out over the water surface
- dispersal type: oil is dispersed in small particles into the bath water
- milky type: oil gives a white cloudy dispersion in the bath water

With regards the use of essential oils in bath water, see subsection 3.12.3.

Use

A NIPO report about the water consumption in the Netherlands indicates that 120 litres of water is used in a bath [30)].

The EU's 'Technical Guidance Document'[2)] gives 17 g as the amount of bath foam used. This value is set as default value.

Default bath products: bath foam, bath salts and bath oil

	Default value	Q	References, comments
General			
Frequency	104 x/year	3	1-2 x/week[2)]; adults: 0.6 – 1.0/week[30)]
Dermal			
Exposure, instant application			
Exposed area	16 340 cm^2	4	[8)] area body - area head
Amount upon skin $_{dilution}$	16 340 g	1	Estimate: 1 cm skin layer
Weight fraction $_{dilution}$			
Bath foam	W_f / 7000	3	Dilution factor 1700; 17g[2)] in 120 L[30)]
Bath salts	W_f / 4800	3	Dil. factor 4800; tablet of 25 g in 120 L[30)]
Bath oil	W_f / 13000	3	Dilution factor13000; 9 g in 120 L[30)] i.e. 10 ml bath oil with density of 0.9 g/cm^3
Uptake, diffusion			
Exposure time			
Bath foam/ bath salts	30 min	2	Estimate
Bath oil	20 min	2	Directions for use: 15-20 min

3.3 Skin care

General
This section mainly deals with *skin care products* such as creams, body lotion, face packs and mud baths. Products, which beautify the skin, such as facial make-up, eye shadow and lipstick, are discussed in the following section where possible. To prevent repetition is not kept too strictly to these classifications. For example, in the sub-section about lipstick, lip salves are also included.

Scenario
As skin care and skin beautifying products are mainly used by women, the defaults are set up for women. In the parameter values, this is reflected in the body weight and the surface area of the body parts.

3.3.1 Creams

Composition
Many different sorts of products are applied to the skin to care for the skin. In addition to semi-solid creams, liquids are also applied. There are products for particular parts of the body such as face creams (day cream, night cream) and hand cream, and products which can be applied to the whole body, such as body milk. Reference [6)] gives a general formula for creams (cream, salve, body milk, lotion, day cream, night cream, moisturising cream):

20-90 %	water
10-80 %	lipids
1-5 %	polyol (to hold in the moisture, so that the cream does not dry out)
2-5 %	surface-active agent (emulsifier)
0-5 %	special additive
0.5 %	preservative
0.2 %	perfume

Use
The amount of cream and the frequency of application is described in Table 9. Research was performed to the amount of hand cream used per application[26]. The amount used was determined for 11 people. The spread was large, at 0.27 to 3.36 g. The mean was 1.05 g with a standard deviation of 0.90 g. The 75th percentile is used as the default value: 1.7 g of hand cream per application (calculated from the mean 1.05 g and SD 0.90 g).

Table 9: Use of creams

Type of cream	Amount per application	Number of applications per day
General cream	1 mg/ cm^2 [2]	1-2 [2]
Face cream	0.8 g [2,3]	1-2 [2]; 2 [3]
Body lotion	7.5 g [2]; 8 g [3]	1-2 [2]; 0,71 [3]
Scented cream	5 g [3]	0.29 [3]
Hand cream	1.7 g [26]	---

Default face cream

	Default value	Q	References, comments
General			
Frequency	730 x/year	3	1-2[2]; 2[3] x per day
Body weight female	61 kg	4	[8]
Dermal			
Exposure, instant application			
Exposed area	565 cm^2	3	½ area head female [8]
Amount product	0.8 g	3	See use
Uptake, diffusion			
Exposure time	720 min	3	12 hours, estimate as a result of frequency

Default hand cream

	Default value	Q	References, comments
General			
Frequency	730 x/year	2	Estimate; cream in general use:1-2[2] x per day (default: 730 x/year = 2 x /day)
Dermal			
Exposure, instant application			
Exposed area	860 cm^2	3	Area hands[8]
Amount product	1.7 g	3	See use
Uptake, diffusion			
Exposure time	720 min	3	12 hours, estimate as a result of frequency

Default body lotion

	Default value	Q	References, comments
General			
Frequency	730 x/year	3	1-2[2] ; 0.71[3] x per day
Body weight female	61 kg	4	[8]
Dermal			
Exposure, instant application			
Exposed area	15 670 cm^2	4	Area body – area head female [8]
Amount product	8 g	3	7.5 g[2]; 8 g[3]
Uptake, diffusion			
Exposure time	720 min	3	12 hours, estimate as a result of frequency

3.3.2 Peeling / scrubbing

Composition
Peeling-gel is based on water with water-soluble polymers, to which 'abrasives', humectants, surface-active ingredients, preservatives, colouring and perfume are added[40]. Plastic granules, ground nutshells or fruit stones and silicates are used as the abrasives [39]. A general formula for peeling cream or gel was not found.

Use
Peeling creams or gels are used to cleanse the skin of the face, to stimulate blood circulation and/or to achieve 'soft' skin. They remove the uppermost layer of the epidermis. According to the instructions a peeling gel can be used once or twice a week. The gel should be applied to the moist facial skin and then rinsed off with water. A face cream is then applied. Data about the amount of cream or gel required to 'scrub' the face was not found. As default value for the amount of peeling creams or gels, the default value for face creams is used (0.8 g per application).

Default peeling gel

	Default value	Q	References, comments
General			
Frequency	104 x/year	3	1-2 x per week: directions for use
Body weight female	61 kg	4	[8]
Dermal			
Exposure, instant application			
Exposed area	565 cm^2	3	½ area head female [8]
Amount product	0.8 g	2	See above
Uptake, diffusion			
Exposure time	5 min	2	Estimate

3.3.3 Face packs

Composition
The general formulas for peel-off masks [40], for mud and gel face packs (based on various formulas [40]) are given below:

Ingredients	*Peel-off face packs* [40]	*Mud packs* [40]	*Gel packs* [40]
Water	40-80 %	40-80 %	40-80 %
Ethanol	up to 15 %	5-10 %	5-10 %
Lipids	up to 15 %		
humectants[1]	2-15 %	15-25 %	15-25 %
Film polymers	10-30 %		1.5 %
Powder	up to 20 %	20 %	
- silicates, titanium dioxide			
Surface-active ingredients	up to 2 %		1%
Clay minerals		2 %	
Alkali			0.5 %
Other ingredients			
- preservative	x	x	x
- perfume	x	x	x
- colouring	x		
- buffer	x		

[1] moisturizing compounds
x: ingredient in face packs

Peel-off face packs are also available in powder form. This type of peel-off face pack is made of 50 % silicates and 50 % gel-forming agents, such as sodium carbonate, calcium sulphate and sodium alginate [40]. When this powder comes into contact with water, calcium alginate is formed. This substance ensures that a film layer is formed on the skin.
There are also algae face packs, which contain minerals and trace elements[28].

Use
In a similar way as for peeling gels, face packs are used to cleanse the skin of the face, to stimulate blood circulation and to achieve a 'soft' skin. Face packs have a relaxing effect. Ready to use face packs are available, such as gel, mud and peel-off face packs. They are also sold in powder form. After mixing the powder with water, the mixture can be applied to the face. As the face pack dries, the skin contracts and cools off due to evaporation. This gives a refreshing feeling. After approximately 20 minutes, the face pack is removed with water or is peeled off. Face cream is then applied to the skin.

Sachets of face pack powders are sold, each containing 10 or 15 g of powder[26]. One tablespoon of water needs to be added to this powder before use. Sachets containing 15 to 20 ml of gel face pack are also available[26]; these are ready to use. The default value is set at 20 g.
According to the instructions on the packaging, face packs need to be left on for lengths of time varying from 5-10, 10-15 and 15-20 minutes. The default value for the contact duration is set at 20 minutes.

Note
The surface-active agents and alcohols degrease the skin, resulting in a dry skin.

Default face pack

	Default value	Q	References, comments
General			
Frequency	104 x/year	3	1-2 x per week[40)]
Body weight female	61 kg	4	[8)]
Dermal			
Exposure, instant application			
Exposed area	565 cm^2	3	½ area head female [8)]
Amount product	20 g	3	See above
Uptake, diffusion			
Exposure time	20 min	3	See above

3.3.4 Body packs: mud bath / clay bath

Composition
Mud baths contain clay minerals and inorganic salts. For example, Dead Sea mud contains 28 % salts. Algae packs contain minerals and trace elements, including iodine[28)].

Use
During a mud bath or clay bath, a mixture of mud and cream is rubbed onto the body. There are also products consisting of powder that need to be mixed with water. Another possibility is that the body is treated with an algae pack, consisting of a gel-like algae substance. After application, the body is wrapped in film. It has to be left on for 20 minutes at approximately 35^{o} C, after which the body is rinsed off with water. This type of mudpack is usually part of a 'beauty-day'. Those who attend such a day usually do so only a few times a year. For the default value a relative frequent use of once every 3 months [26)] is assumed.

No data were found about the amount of product used per application. The initial estimate is based on facial mudpacks. This amount is scaled up to the entire body surface, excluding the surface of the head. For facial mud packs a default values of 15 g per application is used (see § 3.3.3). For a mud bath / clay bath, this amount is multiplied by a factor 15670 / 565. This is the (body surface area – head surface area) divided by the surface area of a woman's face. A default value of 416 g was calculated.

Default body pack

	Default value	Q	References, comments
General			
Frequency	4 x/year	2	See above
Body weight female	61 kg	4	[8]
Dermal			
Exposure, instant application			
Exposed area	15 670 cm^2	4	[8] area body – area head
Amount product	416 g	2	See above
Uptake, diffusion			
Exposure time	20 min	3	See above

3.3.5 Skin whitening products

Introduction
Dark-skinned people who want to lighten their skin colour as much as possible can use bleaching agents or 'skin whitening creams'. These products are based on cream whose composition is described in subsection 3.3.1. In addition to the bleaching agent, the cream contains UV-filters.
As of 1 January 2001, bleaching agents with hydroquinone as active ingredient are no longer permitted in the Netherlands. The use of creams with hydroquinone had been permitted only on small areas [41]. These creams are intended to bleach skin that contains excessive amounts of pigment (hyperpigmentation).

Use
The label of the product should indicate that the whitening cream may only be used for small areas. Application to large areas is not advisable[41], see note. When bleaching agents are used in the name of beauty, the product is applied to larger surface areas. The area of woman's face is taken as the default. The packaging should also include a warning that the whitening cream may not be used for longer than three months[44]. There is a chance that women will use the product every day[44]. For the default value an every day use for three months is assumed.

Note
In the cosmetics report 'Hydroquinone in bleaching agents' (in Dutch) [41] various products containing hydroquinone have been investigated. Side-effects can occur when using hydroquinone, such as black skin discoloration and depigmentation. The report also describes the toxicological drawbacks to the use of hydroquinone.

Default skin whitening cream

	Default value	Q	References, comments
General			
Frequency	91 x/year	2	Estimate, see use
Body weight female	61 kg	4	[8]
Dermal			
Exposure, instant application			
Exposed area	565 cm^2	3	½ area head female [8]
Amount product	5 g	3	[48]
Uptake, diffusion			
Exposure time	1440 min	3	24 hours

3.4 Make-up and nail care

General
This section mainly deals with products, which *beautify* the skin such as facial make-up, eye shadow and lipstick. *Skincare products* were covered in the previous section where possible. To prevent repetition is not kept too strictly to these classifications. For example, in the sub-section about lipstick, lip salves are also included.

Scenario
Because skin-beautifying products are mainly applied by women, the defaults assume use by women. In the parameter values this is reflected in the body weight and the surface area of the body parts.

3.4.1 Facial make-up

Composition
The general formulas for compact foundations, water/oil emulsions and for oil/water emulsions are given below:

Ingredients	*Compact foundations* [40]	*Water/oil emulsions* [40]	*Oil/water emulsions* [40]
Powder	15-93 %	10-35 %	5-25 %
Oil	2-70 %	15-50 %	10-30 %
Water (only in emulsions)	5-30 %	20-60 %	40-80 %
Other ingredients			
- preservative	x		x
- perfume	x	x	x
- stabiliser		x	
- antioxidant	x		

x: ingredient in facial make-up

The powder in foundations contains pigments (iron oxides), silicates (talc, kaolin, and mica), titanium dioxide, zinc stearate, and nylon powder. In dual-use foundation the powders are treated with silicon [40]. Dual-use foundations can be applied to the face using a dry or wet pad.

Use
Foundation is applied as a layer of make up over the face cream (face cream was discussed in the previous section 3.3). This can act as the basis for a layer of powder. There are various types of facial make-up: compact, cream and liquid make-up. In compact make-up the powder constituents are bonded using oil.

Foundations are often emulsions. With the help of surface-active agents, liquid droplets are dispersed into a different liquid, the continuous phase. This phase is oil in water/oil emulsions and water is the continuous phase in oil/water emulsions. The water/oil emulsions and oil/water emulsion are for cream and for liquid foundation.
No data was found for the frequency of use and the amount of facial make-up used. Once a day is taken as the default value for the frequency, and for the amount of facial make up, the face cream value is used.

Default facial make-up

	Default value	Q	References, comments
General			
Frequency	365 x/year	2	1x per day, estimate
Body weight female	61 kg	4	[8]
Dermal			
Exposure, instant application			
Exposed area	565 cm^2	3	½ area head female [8]
Amount product	0.8 g	2	Estimate, face cream 0.8 g [2,3]
Uptake, diffusion			
Exposure time	960 min	3	16 hours, estimate

3.4.2 Facial cleansers

Composition
The general formula of make-up removers (based on the different formulas[40]):

8-64 %	water
3-63 %	lipids (lotions contain no lipids)
10-30 %	humectants (moisturizers)
1-15 %	surface-active agents
up to 0.1 %	alkali
	other ingredients:
	- preservatives
	- colouring
	- perfume
	- chelates

In addition to the above-mentioned ingredients, foam contains approximately 6 % alkali and 33 % higher fatty acids. Alcohol-based lotion contains 15 % ethyl alcohol and 1.5 % detergent. Cleansing milk contains 0.15% polymer[40)].

Use
There are various types of facial cleansers on the market. In addition to make up removers there are cleansing lotions and foams suitable for cleaning the face and removing any light make up. Cleansing milk, cream, and gel contain more lipids and can also remove heavier make-up. Humectants have the ability to absorb a lot of water. They ensure the moisturising effect of the cosmetics product[40)]. Most make-up removers are wiped off with a tissue or rinsed off with water after use.

Scenario
Make-up removers are used to remove make up; cleansing lotions are also available which are only used to clean the face. There are also products that can be used for both purposes. For the default the use of facial cleanser both in the evening and in the morning is assumed.

Default cleansing lotion/ make-up remover

	Default value	Q	References, comments
General			
Frequency	730 x/year	3	1-2[2)]; 2[3)] x per day, see scenario
Body weight female	61 kg	4	[8)]
Dermal			
Exposure, instant application			
Exposed area	565 cm^2	3	½ area head female [8)]
Amount product	2.5 g	3	[2)]
Uptake, diffusion			
Exposure time	5 min	2	Estimate

3.4.3 Eye shadow, mascara, eyeliner, eye makeup remover

eye shadow
Eye shadow is applied to the eyelids and to the skin under the eyebrows; it is creamy. The general formula for eye shadow is [6)]:

60-80 %	lipids (binding agent)
10-30 %	colour pigments
7 %	zinc stearate (attachment)
5 %	titanium dioxide (covering)
0.1 %	preservative

For eye shadow 24 cm^2 (4 x 3 x 2 cm^2) is taken as the exposed area.

Default eye shadow

	Default value	Q	References, comments
General			
Frequency	730 x/year	3	1-3 x/day[2)]
Body weight female	61 kg	4	[8)]
Dermal			
Exposure, instant application			
Exposed area	24 cm^2	2	See above
Amount product	0.01 g	3	[2)]
Uptake, diffusion			
Exposure time	480 min	3	Estimate as a result of frequency

Mascara

Mascara is applied to the eyelashes; it is semi-liquid.
The general formula for mascara and waterproof mascara is given below:

Ingredients	*Mascara* [6)]	*Waterproof mascara* [40)]
Water	70 %	10 %
Lipids	20 %	50 %
Colour pigments	5-10 %	10 %
Surface-active agents	5 %	
Polyacrylates		30 %
Preservative	0.05-0.3 %	x
Perfume		x

x: ingredient in mascara

For mascara 1.6 cm^2 (4 x 0.1 x 4 cm^2) is taken as the exposed area.

Default mascara

	Default value	Q	References, comments
General			
Frequency	365 x/year	3	1 x/day[2)]
Body weight female	61 kg	4	[8)]
Dermal			
Exposure, instant application			
Exposed area	1.6 cm^2	2	See above
Amount product	0.025 g	3	[2)]
Uptake, diffusion			
Exposure time	960 min	3	Estimate as a result of frequency

Eyeliner

Eyeliner is applied as a thin line on the eyelid just above or below the eyelashes.
General formula for eyeliner pencil and stick-type eyeliner:

Ingredients	*Eyeliner pencil* [40)]	*Stick-type eyeliner* [40)]
Water		83 %
Lipids	50 %	
Colour pigments	20 %	5 %
Titanium dioxide	5 %	
Silicates (kaolin and talc)	25 %	
Humectants (moisturizers)		10 %
Polymer emulsion		2 %
Preservative		x
Antioxidant	x	

For eyeliner 3.2 cm^2 (4 x 0.2 x 4 cm^2) is taken as the exposed area.

Default eyeliner

	Default value	**Q**	**References, comments**
General			
Frequency	365 x/year	3	1 x/day[2)]
Body weight female	61 kg	4	[8)]
Dermal			
Exposure, instant application			
Exposed area	3.2 cm^2	2	See above
Amount product	0.005 g	3	[2)]
Uptake, diffusion			
Exposure time	960 min	3	Estimate as a result of frequency

Eye make-up remover

Eye make-up remover is used to remove eye shadow and other eye make-up. Both oil-based and water-based eye make-up removers are available[40)]. The oil-based remover is used for heavy make-up. The water-based remover can be used after using the oil-based remover, to remove the oiliness and any remaining make-up.

General formula for oil-based make-up remover [40)]:

8 % water
62 % lipids
15 % humectants (moisturizers)
15 % surface-active agents

An area of 50 cm^2 (5 x 5 x 2cm^2) is used as the exposed area for eye make-up remover.

Default eye make-up remover

	Default value	Q	References, comments
General			
Frequency	365 x/year	3	1-2 x/day[2)]
Body weight female	61 kg	4	[8)]
Dermal			
Exposure, instant application			
Exposed area	50 cm^2	2	See above
Amount product	0.5 g	3	[2)]
Uptake, diffusion			
Exposure time	5 min	2	Estimate

3.4.4 Lipstick, lip salve

Composition
General formula for lipstick [6)]:

60 %	lipids (wax)
30 %	lipids (solvent)
5-8 %	colour pigment (often xanthene dyes)
0.05 %	antioxidant
0.1 %	perfume

Use
The amount of lipstick used per application is 0.01 g[2, 37)]. It is assumed that the entire product is taken in orally.

Default lipstick/ lip salve

	Default value	Q	References, comments
General			
Frequency	1460 x/year	3	2-6 x/day [2)]; default: 4 x/day
Body weight female	61 kg	4	[8)]
Oral			
Exposure, direct intake			
Amount ingested	0.01 g	3	See above
Uptake, fraction model			
uptake fraction	1	2	potential dose

3.4.5 Nail cosmetics

Nail cosmetics include products such as nail polish, nail polish remover, nail strengthener and nail hardener. The function of nail strengtheners is to strengthen weak, brittle nails; nail hardeners make the nails harder[34)]. Artificial nails are also available. These acrylic nails are designed to enhance the natural nails. Hard artificial nails can be glued onto your own nails

for temporary use. Liquid artificial nails are applied just like nail polish by a professional nail stylist [34,42)].

Nail polish

Composition and use
Nail polish is applied to the nails of the hands and feet using a very fine brush.

The general composition of ordinary nail polish is given in reference [39)]:
72 % organic solvents
10 % cellulose nitrate
5 % plasticizer
10 % synthetic resin
3 % colouring

The composition of the mixture of solvents depends on the ingredients used in the nail polish. The solvents must be able to dissolve cellulose nitrate, resins and plasticizers. The viscosity must be suitable to allow the polish to be applied to the nails easily; the evaporation speed is also important. The drying time of nail polish should be between 3 and 5 minutes[40)].

Reference [40)] shows that nail polish contains 75 % organic solvents:
20 % ethyl acetate
15 % butyl acetate
5 % ethyl alcohol
35 % toluene

Other possible solvents in nail polish are butanol, amyl acetate, and isopropyl alcohol [42)]. Cellulose nitrate is used as a film polymer in nail polish. The addition of plasticizers gives the film polymer more flexibility and makes it more resistant to breaking[6,40)]. These days acetyl-tributyl citrate is usually used as the plasticizer. Camphor is still used because it is a good plasticizer [40)]; phthalates are sometimes used[6)]. An important constituent of nail polish is resins such as alkyd, sulphonamide and acrylic resins. Used together with cellulose nitrate they increase the bond and the shine of the nail polish [40)].

To colour nails, pigments are usually added to nail polish, in the same way as for blusher and eye shadow. Both organic pigments and inorganic pigments such as titanium oxide are used. Pigments are coloured, solid substances whose particles disperse in the solvent; they are physically or chemically inert [6)].

Nail polish is available in various forms, such as base coat and topcoat. Base coat consists of more than 10% synthetic resin. Topcoat contains more cellulose nitrate and plasticizer but less synthetic resin than normal nail polish [39)]. They are used in this order: base coat, nail polish and then top coat[40)].

Scenario
The amount of nail polish used per application is given in reference[2)] as 0.25 g[2)]. For the dermal exposure the amount applied to the nail is not important, only the amount that is applied to the skin. It is assumed that a fingernail has an area of 1 x 1.5 cm, then the total fingernail area is 15 cm^2. For the contact of nail polish with the skin, a nail perimeter (i.e. the two sides of the nail and the nail bed) of 4 cm is assumed with a breadth of 1 mm. This gives

an exposed area of 4 cm^2 for the skin around the fingernails. The amount of product that gets onto the skin is then 0.25 x 4 / 19 = 0.05 g.

The evaporation includes the parameter 'molecular weight matrix'. This parameter is used to calculate the relative vapour pressure of the component in question. The 'molecular weight matrix' is dealt with in more depth in the Paint Fact Sheet [45]. The molecular weight matrix is roughly equal to the mean molecular weight of the solvents divided by the total contribution of these solvents.
Reference [40] shows that nail polish contains 75 % organic solvents; ethyl acetate (Mw = 88), butyl acetate (Mw = 116), ethyl alcohol (Mw = 46) and toluene (Mw = 92) in the ratio 4 : 3: 1: 7 [40]. The molecular weight matrix is calculated as:
[4/15 * 88 + 3/15 * 116 + 1/15 * 46 + 7/15 * 92] : 0.75 = 124 g/mol.

The application of the nail polish takes place close to the face. Therefore it is assumed that when the nail polish is applied evaporation takes place in an initial area of 1 m^3.

Default nail polish

	Default value	**Q**	**References, comments**
General			
Frequency	156 x/year	3	2-3 times a week[2]
Body weight female	61 kg	4	[8]
Inhalation			
Evaporation, evaporation from a constant surface			
Exposure duration	5 min	2	Estimate
Product amount	0.25 g	3	[2]
Room volume	1 m^3	1	See scenario
Ventilation rate	1 hr^{-1}	1	[8]) bedroom
Release area	19 cm^2	2	See scenario
Application duration	5 min	2	Estimate
Temperature	20° C	4	Room temperature
Mass transfer rate	Langmuir		See help file ConsExpo
Mol. weight matrix	124 g/mol	2	See scenario
Uptake, fraction model			
uptake fraction	1	2	potential dose
inhalation rate	23.1 l/min	3	[17]
Dermal			
Exposure, instant application			
Exposed area	4 cm^2	2	See scenario
Amount upon skin	0.05 g	2	See scenario
Uptake, diffusion			
Exposure time	3360 min	3	Estimate as a result of frequency

Nail polish remover

Composition

The general composition of nail polish remover is[40]:

66 %	acetone
20 %	ethyl acetate
5 %	butyl acetate
1 %	lipids (e.g. lanolin derivative)
8 %	water
	- colouring
	- perfume

Use

Nail polish can be removed using organic solvents. The nail polish remover is applied to a piece of cotton wool or a cotton wool pad, and is then used to remove the nail polish from the nails. In this way the skin surrounding the nails can come into contact with the remover, thus degreasing the skin. Some removers contain moisturisers.

Scenario

For the contact of the remover with the skin, a nail circumference of 4 cm is assumed with a breadth of 2 mm at the side of the nails and a breadth of 5 mm at the base of the nail. This gives an exposed area of $[1.5 * 0.2 * 2 + 1 * 0.5] * 10 = 11$ cm^2 for the skin around the finger nails. About the used amount of nail polish remover no data was found. The amount of product that ends up on the nails and skin is estimated at 0.5 g. The amount that ends up on the skin is then approximately 0.2 g ($0.5 * 11 / 26$ g; see scenario nail polish).

For the molecular weight matrix of the remover acetone (Mw = 58), ethyl acetate (Mw = 88), butyl acetate (Mw = 116) are assumed as solvents in the ratio 13:4:1 [40]. The molecule weight matrix is calculated as $[13/18 * 58 + 4/18 * 88 + 1/18 * 116] : 0.91 =$ 75 g/mol (see nail polish scenario).
Just as for nail polish, an initial area of 1 m^3 is assumed during the use of the remover.

Default nail polish remover

	Default value	Q	References, comments
General			
Frequency	156 x/year	3	2-3 times a week[2)]
Body weight female	61 kg	4	[8)]
Inhalation			
Evaporation, evaporation from a constant surface			
Exposure duration	5 min	2	Estimate
Product amount	0.5 g	2	Estimate
Room volume	1 m^3	1	See scenario
Ventilation rate	1 hr^{-1}	1	[8)] bedroom
Release area	25 cm^2	2	Fingernail area of 15 cm^2 plus exposed area of 11 cm^2; see scenario
Application duration	5 min	2	Estimate
Temperature	20° C	4	Room temperature
Mass transfer rate	Langmuir		See help file ConsExpo
Mol. weight matrix	75 g/mol	2	See scenario
Uptake, fraction model			
Uptake fraction	1	2	potential dose
Inhalation rate	23.1 l/min	3	[17)]
Dermal			
Exposure, instant application			
Exposed area	11 cm^2	2	See scenario
Amount upon skin	0.2 g	2	Estimate, see scenario
Uptake, diffusion			
Exposure time	5 min	2	Estimate

Other nail cosmetics products

Nail strengthener
Nail strengthener is used to strengthen weak and breakable nails. The product is applied on top of the nail base coat. There are cream products which some moisturising ingredients and there are products which are applied using a fine brush, just as with nail polish. The composition is approximately equal to that of ordinary nail polish, but without colouring[39)]. They often contain toluene-sulphonamide-formaldehyde co-polymer synthetic resins[34)].

The general composition of nail strengthener is[42)]:
- approximately 80 % water
- approximately 5 % formaldehyde
- approximately 1% lactic acid

Nail hardener
This product is used to harden weak and breakable nails. Nail hardener is applied to the nails using a fine brush. These hardeners contain 5 – 10 % potassium aluminium sulphate or 0.2 – 5 % formaldehyde[34)].

Hard artificial nails
Hard artificial nails are attached to the fingernails or toenails using glue. These products are not only used for broken, torn or too short fingernails, but are also used on a large-scale for decorative purposes on 'normal' nails. A typical set contains glue and artificial nails.
The glue for applying the artificial nails contains[34)]:
- methyl, ethyl, butyl, cyclohexyl, and allyl esters of α-cyanoacryl acid;
- thickeners;
- stabilizers such as hydroquinone, N,N-dimethyl-p-toluidine.

The artificial nail contains acrylic resins, PVC (polyvinylchloride) and phthalate plasticizer[39)]. The real nail underneath can be damaged when the artificial nail is removed. Nitromethane is used as a solvent to remove hard artificial nails[34)].

'Liquid' artificial nails
A professional nail stylist can use artificial nails to enhance broken and/or nails that are too short. To do this, the stylist mixes liquid (monomer) and polymer powder and applies this to the nails using a fine brush. The liquid nails harden within 5 minutes due to polymerisation [42)]. A set for the application of artificial nails by a nail stylist contains 1 g of polymer powder and 14 g of monomer-liquid, combined with mixing palettes and spatulas[35)].
The powder consists of[42)]:
- approximately 98 % acrylic-type polymer (e.g. polyalkylmethacrylate)
- approximately 2 % initiator (e.g. benzoyl peroxide)

An often used liquid is[42)]:
- approximately 99 % acrylic-type monomer (methyl, ethyl, or butyl methacrylate)
- approximately 1 % stabiliser (e.g. hydroquinone)

Another possible composition for the liquid [42)] is:
- approximately 70-90 % acrylic-type monomer (ethyl methacrylate)
- approximately 5-20 % flow control agent
- < 10 % crosslinker
- < 1% plasticizer (e.g. dibutyl phthalate)
- < 1% UV-protection
- < 1 % activator for the initiator (e.g. N,N-dimethyl-p-toluidine)
- < 1 % stabiliser (methyl ester of hydroquinone)

Another system of achieving artificial nails is that of light-cured nail gels. These UV-gels contain photo-bonded acrylates that harden on the nails under the influence of UV-light. This is a viscous solution consisting of various acrylates which is applied directly onto the nails. The acrylates include methylacrylated and acrylated urethanes, triethyleneglycol dimethacrylate, methacrylated epoxy resin and hydroxyl functional methacrylates[42)]. The formulas are described in 'Synthetic nail products; health and legislation' (in Dutch)[42)].
Artificial nails are applied by professionals or semi-professionals. These products are sold directly to the public on a limited scale[42)]. They should be applied to healthy nails and may not be used on nails that are infected[34)] by micro-organisms. These 'liquid' artificial nails can only be removed using nitromethane[34)].

Notes
- When using nail products dermal and inhalation exposure can occur.
- The 'Synthetic nail products; health and legislation' report (in Dutch)[42)] describes various nail products and the related health risks.
- During the application of artificial nails, a professional or semi-professional user must take protective measures such as a 'ventilated' table and localised air extraction. In this way inhalation exposure can be reduced. Another important point during a manicure is the dermal exposure to the various substances used in the nail cosmetics.
- Gaikema and van Buuren[42] argue that only the dermal exposure is important for the consumer

3.5 Deodorant

Composition
Deodorant is used in an aerosol can, as a stick (solid) or as a roller (liquid). The general composition of these three forms is shown below:

Ingredients	*Stick* [6)]	*Roller* [6)]	*Spray* [6,23)]
Propellant (iso-butane, dimethylether)			50-60 %
Solvent (ethanol, water)			37-47 %
- ethanol	10 %		
- water		60-80 %	
Carrier liquid	60 %		
Lipids	5%	5-15 %	
Surface active agent	8%	2-5 %	
Polyol		5 %	
Antiperspirant	10 %	10 %	
Anti-bacterial agent	0.5 %	1-3 %	
Perfume	1.5 %	0.3 %	1 %
Additives			2.5 %

Additives deodorant sprays
- a limited number of deodorant sprays contains an antiperspirant as ingredient[23)]
- anti-bacterial agents are used to suppress the proliferation of bacteria on the skin which are responsible for body odour. Some preparations use essential oils (perfume) as an anti-bacterial agent[23, 40)]
- because ethanol degreases the skin, one of the additives acts as an agent to 'put-back' lipids to the skin[23)]

Use
The Dutch consumer organisation [12)] has carried out research into the use frequency of deodorants and which types are used.

Frequency of use [12)]:		Type of deodorant used[12)]:	
71 %	1x per day	53 %	roller
7 %	2 x per day	19 %	aerosol can
9 %	3-6 x per week	12 %	stick
12 %	< 3 x per week	11 %	vaporizer
		3 %	cream
		2 %	other

Scenario
The inhalation exposure when using a deodorant spray is described using the spray model. It is assumed that 85 % of the deodorant ends up on the skin.

TNO-PML (2005)[50)] has investigated the mass generation rate of 23 aerosols spray cans and trigger sprays, including 3 deodorants (spray cans). The mass generation rate of full and of nearly empty cans was measured.
The median of all full spray cans and trigger sprays was 1.0 g/sec, the 75th percentile 1.5 g/sec.
No distinction could be made between the aerosol cans and trigger sprays, the 75th percentile of the full trigger sprays was 1.5 g/sec, the 75th percentile of the full spray cans 1.6 g/sec.
The mass generation rate of the nearly empty spray can was in some cases 80-90 % of the full can, in some other cases only 30 % of the full can.
In table 10 the mass generation rate of the 3 deodorants is described.

Table 10: Mass generation rate of deodorant spray cans [50)]

	Mass generation rate of a full container [g/sec]	**Mass generation rate of a nearly empty container [g/sec]**
deodorant 1	0.62	0.55
deodorant 2	0.76	0.68
deodorant 3	0.77	0.61

The mass generation rate of the 3 full deodorant spray can fluctuates between 0.6 and 0.8 g/sec. Based on these values the default value for the mass generation rate of deodorant sprays is set at 0.8 g/sec. This is the mass generation rate during the actual spraying. It is assumed that during the total duration of use (10 sec) the actual spraying only occurs for half of that time. The mean mass generation rate during the entire duration of spraying is used as default value, i.e. 0.40 g/sec.

For deodorant sprays, the default value for the non-volatile fraction is derived from the above-mentioned composition and is set at 3 % non-volatile.

Tuinman[50)] has investigated the initial particle distribution of three deodorant sprays (see section 2.4). The 10th, 50th, and 90th percentiles for the volume distributions of all deodorant spray cans are given as d_p (V, 0.10), d_p (V, 0.50) and d_p (V, 0.90). This means that 10 %, 50 % or 90 % of the particle volume is below the mentioned size (see Table 11).

Table 11: 10th, 50th and 90 th percentiles of the volume distribution of deodorant spray cans[50)]

	Full spray can percentiles of the initial particle distribution [µm]			**Nearly empty spray can percentiles of the initial particle distribution [µm]**		
	D_p (0.10)	**D_p (0.50)**	**D_p (0.90)**	**D_p (0.10)**	**D_p (0.50)**	**D_p (0.90)**
Deodorant spray 1	7.6	22	41	6.3	18	32
Deodorant spray 2	4.5	14	38	5.7	17	41
Deodorant spray 3	3.7	13	27	6.0	18	36

Based on above-mentioned data, the initial particle distribution of a deodorant spray can is defined as a lognormal distribution with a median of 10 µm and with a coefficient of variation (C.V.) of 0.3 (see Figure 2).

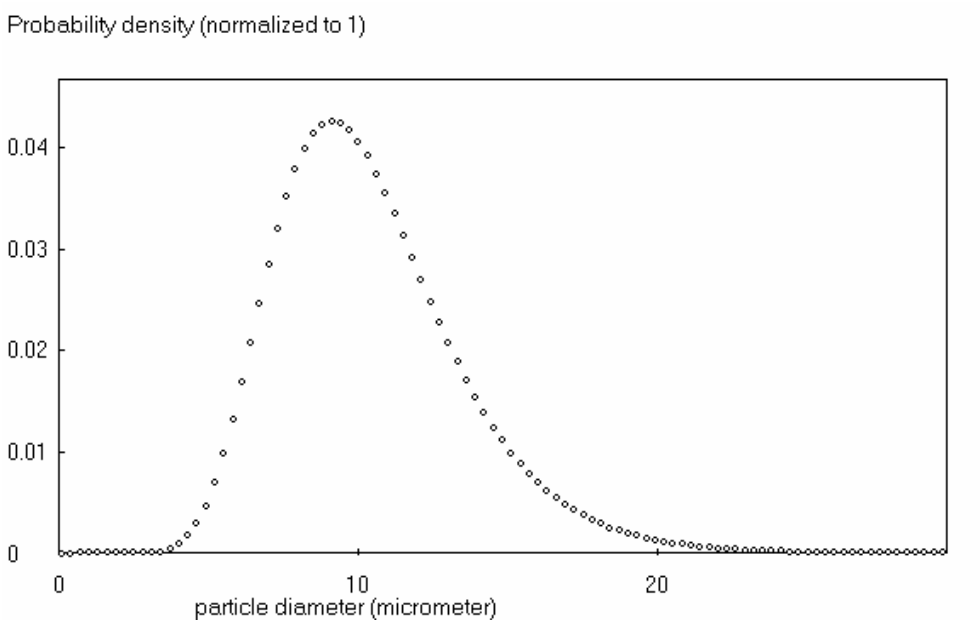

Figure 2: Default initial particle distribution for deodorant sprays: a lognormal distribution with median 10 µm (C.V. 0.3)

Default deodorant stick/ roller

	Default value	Q	References, comments
General			
Frequency	365 x/year	3	Roller 1x per day [2)]
Dermal			
Exposure, instant application			
Exposed area	100 cm^2	2	Estimate
Amount product	0.5 g	3	[2)]
Uptake, diffusion			
Exposure time	1440 min	3	Estimate as a result of the frequency

Default deodorant spray

	Default value	Q	References, comments
General			
Frequency	730 x/year	3	Spray 1-3 x per day [2)]
Inhalation			
Exposure, spray model, spraying towards exposed person			
Spray duration	0.17 min	2	Estimate; default: 0.17 min = 10 sec
Exposure duration	5 min	2	Estimate: time in bathroom after spraying
Room volume	10 m^3	3	Bathroom[8)]
Room height	2.5 m	4	Standard room height
Ventilation rate	2 h^{-1}	3	Bathroom [8)]
Cloud volume	0.0625	2	See § 2.4
Mass generation rate	0.40 g/sec	3	See above
Airborne fraction	1 g/g	2	See § 2.4
Weight fraction non-volatile	0.03 g/g	2	see above
Density non-volatile	1.8 g/cm^3	3	See § 2.4
Initial particle distribution			
Median (C.V.)	10 µm (0.3)	3	See above
Inhalation cut-off diameter	15 µm		See § 2.4
Uptake, fraction model			
uptake fraction	1	2	potential dose
inhalation rate	23.1 l/min	3	[17)]
oral uptake fraction	1	2	potential dose
Dermal			
Exposure, instant application			
Exposed area	100 cm^2	2	Estimate
Amount upon skin	2.6 g	2	85 % of 3.0 g [2)] product; see scenario
Uptake, diffusion			
Exposure time	720 min	3	Estimate as a result of frequency

3.6 Oral hygiene

3.6.1 Toothpaste

Composition
The general composition of toothpaste is[10]:
- fine abrasive
- cleaning agent: lauryl ether sulphate, alkylpolyglycolethers, alcohol ethoxy/propoxylates
- fluoride (maximum 0.15 %): the fluoride-level in children's toothpaste: maximum 0.038 %[10].

Use
The toothpaste use for various age categories is described in 'Dentrifice usage and ingestion among four age groups' (n=56-73)[11] (see Table 12).

Table 12: Used amount and orally ingested amount of toothpaste per brushing

Age-category [year]	Mean amount [g]	Mean amount orally ingested [g]	90th percentile orally ingested [g]
2 – 4	0.86	0.30	0.73
5 – 7	0.94	0.13	
11 – 13	1.10	0.07	
20 – 35	1.39	0.04	0.12

In addition to the mean value, ref[11] also gives the 90th percentile of the amount that is taken in orally. The standard deviation is calculated based on the 90th percentile and the mean (a normal distribution is assumed). The 75th percentile is calculated from the mean value and the standard deviation. This gives the following result:
- adults have a 75th percentile of 0.08 g
- children from 2 to 4 years have a 75th percentile of 0.53 g

From the above-mentioned measurement data it appears that the amount of toothpaste that a young child swallows when brushing their teeth is very different to the amount that an adult swallows. We have therefore given a default for adults and a default for children.

Default toothpaste, adults

	Default value	Q	References, comments
General			
Frequency	730 x/year	3	1-2[2] /day
Oral			
Exposure, direct intake			
Amount ingested	0.08 g	3	See use
Uptake, fraction model			
uptake fraction	1	2	potential dose

Default toothpaste, children 2.5 year

	Default value	Q	References, comments
General			
Frequency	730 x/year	3	1-2[2)] /day
Body weight child	12.5 kg	4	Child 2.5 year [8)]
Oral			
Exposure, direct intake			
Amount ingested	0.53 g	3	See use
Uptake, fraction model			
uptake fraction	1	2	potential dose

3.6.2 Mouthwash

Composition
Mouthwash can contain disinfectants [10)] such as:
- cetylpyridinium chloride,
- benzoate,
- chlorohexidine,
- bromochlorophene.

These substances are meant to kill (harmful) micro-organisms.

Use
The amount of mouthwash used per application was found to be 10 g of ready-to-use product [2, 16)]. COLIPA[16)] indicates that 1 g of this can be taken in orally.

Default mouthwash

	Default value	Q	References, comments
General			
Frequency	1460 x/year	3	1-5 x/day[2,16)] ; 4 x per day, used as astringent[18)]; default 1460 x/year = 4x/day
Oral			
Exposure, direct intake			
Amount ingested	1 g	3	[16)] See above
Uptake, fraction model			
uptake fraction	1	2	potential dose

3.7 Foot care

3.7.1 Antiperspirant cream

Composition
The general formula of creams is discussed in subsection 3.3.1. Aluminium compounds are added as antiperspirants, for example aluminium capryloyl hydrolyzed collagen (product information).

Use
After cleaning the feet, antiperspirant cream is lightly rubbed in, in the morning and evening (directions for use). An amount of 1 mg/cm^2 is given[2)] for the use of cream in general (see subsection 3.3.1). The surface area of feet is 1170 cm^2 [8)]. The amount of cream used is calculated at 1.2 g.

Default foot cream antiperspirant

	Default value	Q	References, comments
General			
Frequency	730 x/year	3	1-2[2)] x per day; directions for use
Dermal			
Exposure, instant application			
Exposed area	1170 cm^2	3	Area feet[8)]
Amount product	1.2 g	3	See above
Uptake, diffusion			
Exposure time	720 min	3	Estimate as a result of frequency

3.7.2 Anti-fungicides

Composition [34)]
- formaldehyde < 0.2 %
- paraformaldehyde < 0.2 %
- undecylenic acid and derivatives < 0.2 %
- anti-microbial ingredients
- moisturising ingredients
- keratolytic ingredients such as ureum, carbamide and salicyclic acid
- ketoconazole, econazole and other anti-fungicides, e.g. miconazole nitrate 20 mg/g[26)]

Use
Anti-fungal products are effective against infections caused by fungus, yeast and certain bacteria. For fungal infections the infected parts of the feet are washed, dried carefully and then the cream is applied. The cream should be applied in the morning and evenings until the infected areas have cleared up totally. That can take between 2 and 5 weeks. The treatment

should be continued for 10 days to prevent the skin fungus from returning (directions for use).
For fungal infections of the nails the cream is applied to the affected nails. For the dermal exposure the amount that is applied to the nail is not important, only the amount that is applied to the skin.
An amount of 1 mg/cm^2 is given for the use of cream in general[2)] (see subsection 3.3.1). The surface area of feet is 1170 cm^2 [8)]. It is assumed that the cream is applied to 100 cm^2 of the skin of the feet. The amount of cream used is calculated at 0.1 g.

Default foot cream anti-fungal

	Default value	Q	References, comments
General			
Frequency	90 x/year	3	See above (90 x/year = 2 x/day x 45 days)
Dermal			
Exposure, instant application			
Exposed area	100 cm^2	2	See above
Amount product	0.1 g	2	See above
Uptake, diffusion			
Exposure time	720 min	3	Estimate as a result of frequency

3.8 Fragrances

Introduction
In perfumes, eau de toilette and eau de cologne the concentration of fragrances determines the difference between the products. Perfume contains the highest concentration of fragrance. Scent raw materials, 'fragrances' or 'essences' (see subsection 3.12.2) are an essential ingredient of perfumes and other scented products. In addition to the natural fragrances there are also synthetically prepared fragrances. A perfume is made up of the individual components of a mixture of fragrances. These are carefully tuned to each other to produce a new aroma[32)]. Ethanol is usually used as a solvent. The various types of perfume also contain a fixing agent that slows down the evaporation speed of the volatile ingredients. The fixing agent also refines and extends the 'heart beat': the essential fragrance that is formed after application must remain for between 2 to 4 hours[6; 32)]. Examples of perfume fixative are balsam of Peru, coumarin and musk [6)]. Finally there are modifiers. These fragrances support the main ingredients in the composition or they create a special effect [32)].
According to the Dutch Cosmetics Association (NCV) eau de toilettes have the largest share of the market. Men are also using more, and more eau de toilettes instead of aftershave[38)].

Default models and default values are described for the use of an eau de toilette pump spray With regards the amount and frequency of use of eau de cologne and perfume data were given, no European data were found, only data from the USEPA[47)].

Composition
Perfumes are made up of various components such as aromatic oils, which in turn contain numerous hydrocarbons [43)], fixing agents, modifiers and usually ethanol as a solvent. It is the

concentration of the fragrances that makes the distinction between perfumes, eau de toilettes and eau de colognes (see Table 13).

Table 13: Composition and used amount of perfume, eau de toilette and eau de cologne

	Fragrance (%)	**Ethanol (%)**	**Used amount (g)**
Perfume	15-20 [32] 12-20 [6] 10-25 [31] 15-30 [40]	75-90 [31]	0.23 [47]
Eau de perfume	7-15 [40]		
Eau de toilette	5-12 [32] 2-8 [6] 8 [3] 5-10 [40]	80-85 (product information)	0.75 [2,3] 0.72 [26]
Eau de cologne	2-6 [32] 2-5 [40]	60-80 [31]	0.65 [47]

Use
The perfume is sprayed onto the skin at pulse points, such as on the wrist and in the neck under the ears. To keep the essence of the fragrance, it is best to spray the eau de toilette on the hand and then to let it evaporate. Consumers apply less eau de toilette when the concentration of fragrance is higher than when the concentration is lower. This also depends on the composition of the fragrance that is used. Use varies from 1 to 5 times a day[2].
Due to the high concentration of fragrance in perfume, only a small amount needs to be used. Perfume can be applied using a pump spray (or a stick). Eau de cologne, with its low concentration of fragrance, is sprinkled on the body or onto a handkerchief and then dabbed on the face or neck.

Scenario eau de toilette spray
The scenario describes the use of an eau de toilette pump spray. The inhalatory exposure during the use of eau de toilette spray is described using the spray model. The total amount of eau de toilette sprayed depends on the number of times sprayed and the type of spray nozzle. Research was performed to the amount of eau de toilette that is released per time of spraying. The mean for the first product was 0.080 g (SD 0.00894), from which the 75th percentile is calculated: 0.0861 g. For the second product, the mean was 0.0942 g (SD 0.000824); the calculated 75th percentile is 0.0948 g[26]. The number of times that the eau de toilette was sprayed varied from 1x (n=1), 2x (n=3), 4x (n=2) up to 8x (n=1). For the default a consumer who uses the eau de toilette generously (8 x spray) is assumed. This gives as value for the total amount of eau de toilette 8 x 0.090 = 0.72 g. This value agrees with the amounts given in the literature[2,3]: 0.75 g.
The value of 0.72 g from own research was used as default value. The mean mass generation rate is calculated from the sprayed amount (0.72 g) and the total duration of spraying (5 sec), which is 0.14 g/sec.
Based on composition of eau de toilette (see Table 13) the default value for the fraction non-volatile is set at 5 %.

No fragrance sprays were measured in the investigation performed by TNO-PML[50]. Because of the lacking data for eau de toilette sprays and perfume sprays, as default the initial distribution of a trigger spray with very small particles is taken which is defined as a

lognormal distribution with median 50 µm and coefficient of variation (C.V.) 0.6. (see: Pest Control Products Fact Sheet [46]).
It is assumed that 85 % of the eau de toilette ends up on the skin, therefore 0.61 g (0.85 x 0.72 g) ends up on the skin. The default value for the exposed body surface is set at 8 x 25 cm^2 = 200 cm^2.

Default eau de toilette spray

	Default value	**Q**	**References, comments**
General			
Frequency	1095 x/year	3	1-5[2]; 1[3] x/day; default: 3x/day
Inhalation			
Exposure, spray model			
Spray duration	0.08 min	2	Estimate; 5 sec, based on values for trigger sprays [50]
Exposure duration	5 min	2	Estimate: time in bathroom after spraying
Room volume	10 m^3	3	Bathroom[8]
Room height	2.5 m	4	Standard room height
Ventilation rate	2 h^{-1}	3	Bathroom [8]
Cloud volume	0.0625 m^3	1	See § 2.4
Mass generation rate	0.14 g/sec	2	See above
Airborne fraction	0.2 g/g	2	See § 2.4
Weight fraction non-volatile	0.05 g/g	2	See above
Density non-volatile	1.5 g/cm^3	3	See § 2.4
Initial particle distribution			
Median (C.V.)	50 µm (0.6)	1	See above
Inhalation cut-off diameter	15 µm		See § 2.4
Uptake, fraction model			
uptake fraction	1	2	potential dose
inhalation rate	23.1 l/min	3	[17]
Dermal			
Exposure, instant application			
Exposed area	200 cm^2	2	Estimate, see scenario
Amount upon skin	0.61 g	2	See above
Uptake, diffusion			
Exposure time	320 min	3	Derived from frequency: 3 x/day

Perfume
The 'Exposure Factors Handbook' of the US-EPA [47] gives the following values for perfume.

	mean	90th percentile
frequency	0.26 times a day	1.0 times a day
amount	0.23 g per application	

Based on this data a 75th percentile of the frequency of use is calculated at 0.65 times a day, or 237 times a year. It is assumed that 85 % of the perfume ends up on the skin, i.e., 0.20 g. As perfume contains more fragrance than eau de toilette, the body surface onto which the perfume is sprayed will be smaller. The default value for the exposed body surface is set at 4 x 25 cm^2 = 100 cm^2.

Notes
- 'Beautiful is another topic' (in Dutch)[6] describes many types of fragrances used and their side effects.
- 'Plant preparations used as ingredients of cosmetics products'[43] describes the aromatic oils and their effects.

3.9 Men's cosmetics

3.9.1 Shaving soap, cream and foam

Composition
Different types of products are used for 'wet' shaving: shaving soap (stick of tablet form), cream (tube) and foam (aerosol can).

A formula for shaving cream and shaving foam is:

Ingredients	*Shaving cream* [40]	*Shaving foam* [40]
Water	36.5 %	71 %
Fatty acids	30 %	6 %
Oils	25 %	
Glycerine	10 %	10 %
Surface-active agents		5 %
Alkali		
- KOH, NaOH	8.5 %	
- Triethanolamine		4 %
Perfume	x	x
Antioxidant	x	
Propellant: propane		4 %

x: ingredient in shaving cream or foam

Use
Shaving soap looks like normal soap, but a lot of glycerine and fatty ingredients have been added. The soap and cream are applied with a brush onto wetted skin. Foam is sprayed onto the hands and applied to the face using the hands. A uniform, viscous, thick foam layer is formed that is long lasting. Glycerine used as a moisturizer and fatty acids lower the 'foaming power' of the soap: a good balance between the various components is needed [40]. The use of shaving cream is described as the default.

Default shaving cream

	Default value	Q	References, comments
General			
Frequency	365 x/year	3	1 x/day[2)]
Body weight male	74 kg	4	[8)]
Dermal			
Exposure, instant application			
Exposed area	305 cm^2	3	¼ area head male [8)]
Amount product	2 g	3	[2)]
Uptake, diffusion			
Exposure time	5 min	2	Estimate

3.9.2 Aftershave

Composition
A formula for aftershave is[40)]:

55 %	ethanol
42 %	water
2 %	humectant (moisturizer)
1 %	surface-active agent
0.1 %	allantoin
	- perfume
	- plant extracts

Use
Aftershave lotions prevent infections in any small wounds that occur during shaving. The evaporation of ethanol causes the skin to contract and cool off[40)].

Default aftershave

	Default value	Q	References, comments
General			
Frequency	365 x/year	3	1-2 x/day[2)]
Body weight male	74 kg	4	[8)]
Dermal			
Exposure, instant application			
Exposed area	305 cm^2	3	¼ area head male [8)]
Amount product	1.2 g	3	[2)]
Uptake, diffusion			
Exposure time	1440 min	2	Estimate as a result of frequency

3.10 Sun cosmetics

Composition
There are various cosmetic sunscreen products on the market, such as sunscreen cream, lotion and oil. There are also products that can be used after sunbathing. The general composition of creams is described in subsection 3.3.1. Sunscreen creams contain ± 5-6 % sun filters and ± 5 % titanium dioxide (white pigment)[40]. Sunscreen lotion contains approximately 10% sun filters[40]. Sunscreen oil does not offer as much protection against sunburn; the oil contains approximately 2-3 % UV absorbing ingredients [40] which act as the protection factor.

Use
Sunscreen oil is more suitable for tanned and less sensitive skin. Because sunscreen lotion is used most in the Netherlands, this application is described.
Ref [2] gives 2-3 times per day for a period of 2 weeks/ year for the use of sunscreen cream, and 1 week in the winter for just the face. Based on this data the default value assumes use 3 times per day over a period of 25 days. (default:75x/ year = 3 x/day, 25 days/year)

Note
In 1992 there were 23 legally permitted sun filters for cosmetic products[13].

Default sunscreen lotion

	Default value	Q	References, comments
General			
Frequency	75 x/year	3	See above
Dermal			
Exposure, instant application			
Exposed area	17 500 cm^2	4	[8]
Amount product	10 g	3	Cream 8 g, lotion 10 g[2]
Uptake, diffusion			
Exposure time	150 min	2	Estimate

3.11 Baby care products

Composition and use

Baby salve
Baby salve is used for babies' sore bottoms. For the composition of the salve see the general formula for creams in subsection 3.3.1. Baby salve can contain 15 % zinc oxide (ZnO) [19].
The zinc oxide salve is used frequently in the first months of life; its use usually tails off gradually[19]. If the salve is used then the frequency is 2 x/day.

Default use of zinc oxide salve:

frequency	365 x/year	[19] ½ year, 2 times per day
amount of product	100 g/year	[19] 365 times 270 mg

Baby oil
The most important ingredient of oil is the triglycerides of fatty acids and glycerine. There are vegetable and animal oils. No European data were found about the amount used and the frequency of use. The USEPA's 'Exposure Factors Handbook' (1997) gives the following values:

	mean	90th-percentile
frequency (n = 1129)	1.2 times a day	3.0
amount of product	1.3 g per application	

Based on this data, a frequency of 730 times per year is taken as the default value.

Baby powder:
'New cosmetics science' by T. Mitsui (ed.) [40] gives the following 'typical formula' for baby powder:

93 %	talcum powder
3 %	zinc oxide
4 %	magnesium stearate
	other ingredients:
	- germicides
	- perfume

The usage data comes from the USEPA (1997):

	mean	90th percentile
frequency (n = 1129)	1.5 / day	3.0
amount of product	0.8 g per use	

Based on this data, a frequency of 730 times per year is taken as the default value.

Surface area
The default of the total body surface area of a child of four and a half months is 0.346 m^2, and the surface area of the torso is 32.8 % of this body surface [8]. The estimate for the surface of a baby's bottom is 1/6 of the exposed area of the torso, that is 1/6 x 0.328 x 3460 cm^2 = 190 cm^2.

Default baby products: baby cream, baby oil and baby powder

	Default value	**Q**	**References, comments**
General			
Frequency	730 x/year	2	Estimate; default: 730 x/ year = 2 x/day
Body weight child	6.21 kg	4	[8] child, age 4.5 month
Dermal			
Exposure, instant application			
Exposed area	190 cm^2	2	See above
Amount product			
Baby cream	0.27 g	2	See above
Baby oil	1.3 g	2	See above
Baby powder	0.8 g	2	See above
Uptake, diffusion			
Exposure time	720 min	2	Estimate as a result of frequency

3.12 Miscellaneous

In this section products that do not fit in the other product categories are discussed, that is, depilatories, essential oils and face paint.

3.12.1 Depilatories

Composition
In addition to mechanical removal, there are two cosmetic depilatories available: hair removal wax and hair removal cream or spray. Hair removal spray is a foam in an aerosol can. The general formulas for depilatory products are given below.

Wax [6, 14, 40]:

70 %	wax (melting point approximately 45 °C
30 %	lipids (waxes and oils)
0.2 %	perfume

Depilatory cream [6, 14, 40]:

60-70 %	water
5 %	thickener
20-30%	lipids
2-5 %	surface-active agent
2 %	substance to achieve high pH (approximately 12.6 to 12.7) (calcium and strontium hydroxide[26])
3-5 %	depilatory (lithium, strontium, potassium or calcium thioglycolate, and sometimes also barium or calcium sulphide)
0.5 %	perfume

Depilatory foam [40]:

66.5 %	water
10 %	humectant (moisturizer)
6 %	depilatory agent (thioglycolic acid)
4.5 %	alkali (NaOH)
3 %	surface-active agent
2 %	lipids
	perfume
6 %	propane
2 %	dimethyl ether

The four depilatory foams we have investigated, contain sodium or potassium thioglycolate as the depilatory agent, and sodium or potassium hydroxide to achieve a high pH[26].

Use
There is a liquid hair removal wax on the market. After application the wax is removed using the strips supplied. Hair removal strips with wax already applied are also available. The instructions supplied with depilatory creams indicate that the skin should be wetted with cold water. The cream is spread onto the relevant area of skin using the supplied spatula.

'The cream needs to be left on for between 8 and 10 minutes, but never longer than 15 minutes. Check to see when the hairs come out. Remove the cream using the spatula and rinse the skin with cold water'.
Depilatory sprays are applied in the same way. The foam is sprayed onto the skin where the hair is to be removed. After the allotted time the foam is removed using a spatula or by rinsing[26]. The instructions for some of the creams state that they can be used for legs and armpits, but not for the bikini line or the face. Another cream states: 'for legs, armpits and face, do not use around the eyes'. All the sprays indicate that they should be used for removing hair from the legs and armpits[26].

Female's legs are used as default value for the surface area from which hair is removed. Based on this data it is easy to calculate the hair removal for other parts of the body, for example the armpits (area for hair removal: 180 cm^2) or the shins (area for hair removal: 1840 cm^2).

Default depilatory cream

	Default value	Q	References, comments
General			
Frequency	17 x/year	2	Wax indicates that hairs will not grow back for between 3 and 6 week depending on the hair growth[26]; 17x/year = 1 x/3 weeks
Body weight female	61 kg	4	[8]
Dermal			
Exposure, instant application			
Exposed area	5530 cm^2	3	Area female legs [8]
Amount product	5.5 g	2	1 mg/ cm^2 [2]; hair removal from legs
Uptake, diffusion			
Exposure time	15 min	3	5-10 [6]; 10-15 [14]; 8-10 max. 15 min [26]

3.12.2 Essential oils

Introduction
Essential oils are strongly smelling liquids that do not mix with water. They cause the characteristic smell of plants, such as roses and lavender for example. The oil is obtained using steam distillation or by extraction from various parts of plants. Essential oils give the fragrance to various cosmetic products, and as such are the 'essence' of perfume, eau de toilette and aftershave, for example. Other names for essential oils are aromatic, or ethereal, volatile oils or essences. In addition to the natural pure oils, there are synthetically prepared essential oils and essences that are mixed with alcohol or oil.
Essential oils are used during aromatherapy due to their supposed healing properties.

Composition
The composition of essential oils not only depends on the plant sorts used and the part of the plant used, but also on the procedures used in the preparation of the essences. Essential oils can contain different hydrocarbons such as terpenes, aldehydes and alcohols. Many essences

and their composition are described in 'Plant preparations used as ingredients of cosmetics products' [28].

Use
Aromatic oils can be used in the following ways:
- as an air freshener
- for massages
- in a bath
- in a steam bath

Air freshener
Essential oil evaporates with the help of an aroma lamp. On top of the lamp is a small tray filled with water into which the oil is dropped. Under this tray is a small candle which warms the water and essential oil. The aroma of the oil spreads through the room. There should always be sufficient water in the tray. Six to 12 drops of essential oil is normally enough for an area of approximately 30 m^3 [29]. A user said that he used the aroma lamp to evaporate oil 14 times per month. They are usually used in the living room. The size and contents of the tray into which the essential oil is added depends on the aroma lamp.

Massages
Massage oil can be made by using 'basic oil' with almond oil, wheat germ oil and jojoba oil as ingredients. Between 2 and 3 % of essential oil is added to this mixture [29]. Patri [28] gives a concentration of 1-3 % for the various essences in massage products. Only massage oil containing wintergreen oil has a concentration of 2.5-5 %. Massage oil is usually oilier and easier to rub in than body lotion. During a massage oil is rubbed into the body several times, and it is assumed that the use of massage oil is in the same order of magnitude as that of body lotion (default value 8 g, see subsection 3.3.1).

Bath
Approximately 10 drops of essential oil would be added to a bath filled with 120 litres of water [30] (1 drop of oil being 0.05 ml). If essential oil is added to water it will either float or disperse, depending on the type of oil. The essential oil is sometimes mixed with 50 ml emulsifier or baby oil, and then added to the bath water [29]. Various ready-to-use bath oil products contain up to approximately 10 % essential oil, depending on the type of oil. Products containing pine oil (*Pinus sylvestris*) or rosemary oil contain up to 30% essential oil. Ten millilitres of these are used [26,28]. At a density of 0.9 g/cm^3, this means an amount of 9 g. The NIPO report 'the Dutch make water go a long way' (in Dutch) assumes that 120 litres of water is used per bath[30]. As default value it is assumed that 10 ml of bath product (i.e. 9 g) with 30 % essential oils is added to 120 litres of bath water.

Steam bath
The prescribed number of drops is added to a dish of warm water. The dish and the head are covered with a towel and the vapours are inhaled for between 5 and 10 minutes. This is not a cosmetic application and is therefore not discussed here further.

Note
Natural ingredients in essential oils can also have undesirable side effects[28].
Some examples of these are:
- ingredients that can cause an allergic reaction, such as cinnamic aldehyde in cinnamon oil, eucalyptol in eucalyptus oil, thymol in thyme oil and menthol in peppermint oil;
- safrole in camphor oil and in cinnamon oil can have a carcinogenic effect (in mice and rats);
- methylsalicylate with a pharmacological working is present in the essential oil wintergreen.

Carpentier's book [29] gives the consumer information about the use of essential oils. 'Plant preparations used as ingredients of cosmetics products' [28] contains a great deal of information about the composition and effects of natural plant ingredients in cosmetic products. Criteria for the safe use of essential oils and extracts are also described.

Default essential oil: massage

	Default value	**Q**	**References, comments**
General			
Frequency	24 x/year	2	Estimate, 2 x/month
Dermal			
Exposure, instant application			
Exposed area	16 340 cm^2	4	[8]) area body – area head
Amount product	8 g	3	See: use, massages
Uptake, diffusion			
Exposure time	30 min	2	Estimate

Default essential oil: bath

	Default value	**Q**	**References, comments**
General			
Frequency	52 x/year	3	1-2 x/week[2]; adults: 0.6 – 1.0 / week[30]
Dermal			
Exposure, instant application			
Exposed area	16 340 cm^2	4	[8]) area body – area head
Amount upon skin $_{dilution}$	16 340 g	1	Estimate: 1 cm skin layer
Weight fraction $_{dilution}$	W_f / 13000	3	Dilution factor 13000: 9 g in 120 litre[30] (10 ml oil with density of 0.9 g/cm^3)
Uptake, diffusion			
Exposure time	20 min	3	Directions for use: 15-20 min

Default essential oil: air freshener

	Default value	Q	References, comments
General			
Frequency	168 x/year	2	See: use, air freshener
Inhalation			
Evaporation, constant rate			
Exposure duration	240 min	2	4 hrs
Product amount	1.08 g	3	1 drop oil is about 50 µl which equals 45 mg (density 0.9 g/cm^3); 24 drops oil equal 1.08 g
Room volume	58 m^3	4	Living room[8)]
Ventilation rate	0.5 h^{-1}	3	Living room[8)]
Emission duration	180 min	1	Estimate
Uptake, fraction model			
uptake fraction	1	2	potential dose
inhalation rate	23.1 l/min	3	[17)]

3.12.3 Face paint

Composition

In general, the composition of face paint (‘grease paint’ or make-up) is comparable to that of oil-based make-up. The general formula for oil-compact-foundation is [40)]:

- 35-60 % powder
- 40-65 % oil
- no water

The powder contains pigments, colouring and silicates. In addition to oil-based face paint, water-based face paint is also available.

Use

Children like to have their faces painted at parties. Adults paint their faces for certain occasions such as carnivals, sporting events and for amateur dramatics. Defaults are given for a four and a half year old child and for an adult. Half of the surface area of the head is used as default value for the exposed area; i.e. for adults[8)] 580 cm^2 and for a child of 4.5 years [37)] 475 cm^2.

With regard to the amount of face paint used, it is assumed that this is 3 times as large as the amount used for a general cream (see subsection 3.3.1), that is 3 mg/cm^2. For an adult this means an amount of 1.7 g of face paint and for a child it means 1.4 g of face paint.

Default face paint: adult

	Default value	Q	References, comments
General			
Frequency	6 x/year	2	Estimate
Dermal			
Exposure, instant application			See above
Exposed area	580 cm^2	3	½ area head[8)]
Amount product	1.7 g	2	3 mg/ cm^2
Uptake, diffusion			
Exposure time	480 min	2	Estimate, 8 hours

Default face paint: child

	Default value	Q	References, comments
General			
Frequency	12 x/year	2	Estimate
Body weight child	16.3 kg	4	[8)] child 4.5 year
Dermal			
Exposure, instant application			See above
Exposed area	475 cm^2	3	½ area head[37)]
Amount product	1.4 g	2	3 mg/ cm^2
Uptake, diffusion			
Exposure time	480 min	2	Estimate, 8 hours

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