

Unclassified

English - Or. English

9 January 2026

**ENVIRONMENT DIRECTORATE
CHEMICALS AND BIOTECHNOLOGY COMMITTEE**

Report on the OECD Database on Children's Exposure Factors

Series on Testing and Assessment No. 422

This Guidance Document is accompanied by:

<https://www.oecd.org/content/dam/oecd/en/topics/policy-sub-issues/testing-of-chemicals/oecd-database-on-childrens-exposure-factors.xlsx>

JT03579183

Please cite this publication as:

OECD (2025), *Report on the OECD Database on Children's Exposure Factors*, Series on Testing and Assessment No. 422, OECD Environment, Health and Safety, Paris, [https://one.oecd.org/document/ENV/CBC/MONO\(2025\)22/en/pdf](https://one.oecd.org/document/ENV/CBC/MONO(2025)22/en/pdf).

Contact us

**OECD Environment Directorate,
Environment, Health and Safety Division
2 rue André-Pascal
75775 Paris Cedex 16
France**

E-mail: ehscont@oecd.org

© OECD 2025



Attribution 4.0 International (CC BY 4.0)

This work is made available under the Creative Commons Attribution 4.0 International licence. By using this work, you accept to be bound by the terms of this licence (<https://creativecommons.org/licenses/by/4.0/>).

Attribution – you must cite the work.

Translations – you must cite the original work, identify changes to the original and add the following text: *In the event of any discrepancy between the original work and the translation, only the text of original work should be considered valid.*

Adaptations – you must cite the original work and add the following text: *This is an adaptation of an original work by the OECD. The opinions expressed and arguments employed in this adaptation should not be reported as representing the official views of the OECD or of its Member countries.*

Third-party material – the licence does not apply to third-party material in the work. If using such material, you are responsible for obtaining permission from the third party and for any claims of infringement.

You must not use the OECD logo, visual identity or cover image without express permission or suggest the OECD endorses your use of the work. Any dispute arising under this licence shall be settled by arbitration in accordance with the Permanent Court of Arbitration (PCA) Arbitration Rules 2012. The seat of arbitration shall be Paris (France). The number of arbitrators shall be one.

About the OECD

The Organisation for Economic Co-operation and Development (OECD) is an intergovernmental organisation in which representatives of 38 countries in North and South America, Europe and the Asia and Pacific region, as well as the European Union, meet to co-ordinate and harmonise policies, discuss issues of mutual concern, and work together to respond to international problems. Most of the OECD's work is carried out by more than 200 specialised committees and working groups composed of member country delegates. Observers from several Partner countries and from interested international organisations attend many of the OECD's workshops and other meetings. Committees and working groups are served by the OECD Secretariat, located in Paris, France, which is organised into directorates and divisions.

The Environment, Health and Safety Division publishes free-of-charge documents in twelve different series: **Testing and Assessment; Good Laboratory Practice and Compliance Monitoring; Pesticides; Biocides; Risk Management; Harmonisation of Regulatory Oversight in Biotechnology; Safety of Novel Foods and Feeds; Chemical Accidents; Pollutant Release and Transfer Registers; Emission Scenario Documents; Safety of Manufactured Nanomaterials; and Adverse Outcome Pathways.** More information about the Environment, Health and Safety Programme and EHS publications is available on the OECD's World Wide Web site (<https://www.oecd.org/en/topics/chemical-safety-and-biosafety.html>).

This publication was developed in the IOMC context. The contents do not necessarily reflect the views or stated policies of individual IOMC Participating Organizations.

The Inter-Organisation Programme for the Sound Management of Chemicals (IOMC) was established in 1995 following recommendations made by the 1992 UN Conference on Environment and Development to strengthen co-operation and increase international co-ordination in the field of chemical safety. The Participating Organisations are FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank, Basel, Rotterdam and Stockholm Conventions and OECD. The purpose of the IOMC is to promote co-ordination of the policies and activities pursued by the Participating Organisations, jointly or separately, to achieve the sound management of chemicals in relation to human health and the environment.

Foreword

Children have distinct physical and physiological characteristics from adults and show unique behavioural traits, making them more vulnerable to environmental risks. Specifically, their inhalation rate and food and beverage intake are relatively higher than those of adults, and their unique behaviours such as hand-to-mouth activities are likely to increase their exposure to environmental hazards.

To assess children's exposure, various exposure factors are needed to evaluate the risk of the concentration of substances in for instance air, water, food, soil, or products, including both physiological as well as behavioural factors such as respiratory inhalation, food and beverage intake, exposure duration and frequency. This document does not include pesticides or exposure factors developed specifically for assessing exposure to pesticides.

As exposure factor data is often determined at a national level, it is worthwhile to compile and share exposure factors for children to assist children-specific exposure assessment across different countries worldwide. Against this backdrop, the OECD Working Party on Exposure Assessment (WPEA) initiated a project to develop the OECD Database on Children's Exposure Factors by collecting and compiling exposure factor data used by OECD member countries. This report provides a summary and overview of the results of the OECD project on the children exposure factor database, carried out by WPEA.

A survey was conducted in Q2 2023 to collect additional information on children-specific exposure parameters from WPEA member countries. The initial draft of the database was developed based on the cross-country comparison study of children's exposure factors presented in the Korean Exposure Factors Handbook for Children (2019), published by the Korean National Institute of Environmental Research (NIER). Using the Korean database as a foundation, the OECD Database on Children's Exposure Factors was created by incorporating the survey responses.

The OECD Database on Children's Exposure Factors is a comprehensive, searchable Excel-based data sheet that includes various exposure factors for children. These factors include body weight, body surface area, inhalation rate, and time-activity patterns, which are essential for assessing children's exposure to environmental agents. The database draws upon national exposure factor handbooks from countries such as Australian, Japan, Korea, the United States, and Nordic countries, as well as research studies published in international academic journals and scientific literature.

This report provides a summary and an overview of the data provided in the OECD Database on Children's Exposure Factors, the database itself contains more detailed and extensive information. This report presents only the key information extracted from each section of the Excel-based database. For detailed data and country-specific figures, users are encouraged to consult the full Excel file. Please note that the structure and sectioning of this report and the Excel database differ slightly, as the database is organized by detailed data categories while the report follows a broader thematic structure.

The development of the OECD Database on Children's Exposure Factors will enable risk assessors, including national regulators and (international) industry professionals, to conduct efficient exposure assessments by identifying and utilising the appropriate exposure factors from the database for each assessment. In particular, in countries or regions that experience difficulties conducting exposure

assessments due to the lack of specific exposure factors, the OECD Database on Children's Exposure Factors can provide exposure factors in order to improve exposure and risk assessment activities aimed at children. Furthermore, the database enables the comparison of exposure factor data among different countries and is expected to contribute directly to saving resources and international harmonization in the establishment of exposure factor data among member countries.

Based on database development, the OECD will further strengthen the scientific foundation for protecting children's health, drawing on its accumulated expertise and experience in the field of children's environmental health.

The findings of this study are expected to serve as critical baseline data for policymakers to protect children's health worldwide and to contribute to the sustainable development of the international community.

This report is published under the responsibility of the Chemicals and Biotechnology Committee.

Table of contents

About the OECD	3
Foreword	4
1. Physiological Factors	9
References	32
2. Inhalation Rate	34
References	42
3. Food Intake	43
References	46
4. Time-Activity Patterns	48
References	58
5. Consumer Product Use Patterns	60
References	72
6. Soil and Dust Ingestion	74
References	79
7. Life Expectancy	80
References	82
Annex A.	83

Tables

Table 1.1. Status of Body Weight Data by Country	10
Table 1.2. Comparison of Body Weight by Country (Asia)	11

Table 1.3. Comparison of Body Weight by Country (Europe)	12
Table 1.4. Comparison of Body Weight by Country (North America/Oceania)	13
Table 1.5. Status of Body Height Data by Country	14
Table 1.6. Comparison of Body Height by Country (Asia)	16
Table 1.7. Comparison of Body Height by Country (Europe/North America/Oceania)	17
Table 1.8. Status of Body Surface Area Data by Country	19
Table 1.9. Comparison of Body Surface Area by Country (Asia)	20
Table 1.10. Comparison of Body Surface Area by Country (Europe/North America/Oceania)	21
Table 1.11. Surface Area of Body Parts – Mean Percent of Total Surface Area (Korea)	22
Table 1.12. Surface Area of Body Parts – Mean Percent of Total Surface Area (Netherlands)	23
Table 1.13. Surface Area of Body Parts – Mean Percent of Total Surface Area (US)	23
Table 1.14. Surface Area of Body Parts – Mean Percent of Total Surface Area (Australia)	24
Table 1.15. Comparison of Head Surface Area by Country	25
Table 1.16. Comparison of Torso (Trunk) Surface Area by Country	26
Table 1.17. Comparison of Arms Surface Area by Country	27
Table 1.18. Comparison of Hands Surface Area by Country	28
Table 1.19. Comparison of Legs Surface Area by Country	29
Table 1.20. Comparison of Feet Surface Area by Country	30
Table 2.1. Status of Inhalation Rate Data by Country	35
Table 2.2. Comparison of Daily Average Inhalation Rate by Country (Asia), Unadjusted for Body Weight	37
Table 2.3. Comparison of Short-Term Inhalation Rate by Country (Korea, Japan)	38
Table 2.4. Comparison of Short-Term Inhalation Rate by Country (Netherlands, US)	38
Table 2.5. Comparison of Short-Term Inhalation Rate by Country (Korea)	39
Table 2.6. Comparison of Short-Term Inhalation Rate by Country (Japan)	39
Table 2.7. Comparison of Short-Term Inhalation Rate by Country (Netherlands)	40
Table 2.8. Comparison of Short-Term Inhalation Rate by Country (Nordic Countries)	40
Table 2.9. Comparison of Short-Term Inhalation Rate by Country (UK)	41
Table 2.10. Comparison of Short-Term Inhalation Rate by Country (United States)	41
Table 3.1. Status of Food Intake Data by Country	44
Table 4.1. Status of Location-Based Activity Time Data by Country	49
Table 4.2. Comparison of Location-Based Activity Time by Country (1)	51
Table 4.3. Comparison of Location-Based Activity Time by Country (2)	52
Table 4.4. Status of Behaviour Frequency and Duration Data by Country	53
Table 4.5. Comparison of Hand-to-Mouth Frequency and Duration by Country	55
Table 4.6. Comparison Object-to-Mouth Frequency and Duration by Country	56
Table 4.7. Netherlands – Default Mouthing Times for Children	57
Table 4.8. Australia – Suggested Values for Mouthing Duration (Mean)	57
Table 5.1. Status of Care Product Data by Country	61
Table 5.2. Comparison of Shampoo by Country	63
Table 5.3. Comparison of Body Wash/Shower Gel by Country	65
Table 5.4. Comparison of Lotion by Country	66
Table 5.5. Comparison of Wet Tissues by Country	67
Table 5.6. Status of Toy Products Data by Country	69
Table 5.7. Comparison of Pacifiers by Country	70
Table 5.8. Comparison of Teethers by Country	71
Table 5.9. Comparison of Clay by Country	71
Table 6.1. Status of Data on Ingestion of Soil and Dust by Country	75
Table 6.2. Comparison of Soil and Dust by Country (Mean)	77
Table 6.3. Incidental Water Ingestion During Swimming: U.S., Australia	78
Table 6.4. Adherence to Skin (US)	78
Table 7.1. Life Expectancy at Birth by Country (WHO)	81

Figures

Figure 1.1. Comparison of the Representative Body Weight Values for the Oldest Age Group by Country	14
Figure 1.2. Comparison of the Representative Body Height Values for the Oldest Age Group by Country	18
Figure 1.3. Comparison of the Representative Body Surface Area Values for the Oldest Age Group by Country	22

Figure 2.1. Comparison of the Representative Daily Inhalation Rate Values for the Oldest Age Group by Country 37

1. Physiological Factors

The country-specific exposure factor sources include various data points, such as those from different percentiles of the distribution. This is important because, for example, lower percentile body weight and height values may be used in exposure calculations as conservative estimates. Since the statistical values used vary by country, this report focuses on the representative values (such as the average or median) adopted in different countries. More detailed values can be found in the OECD Database on Children's Exposure Factors.

In terms of age group classification, differences exist among country-specific exposure factor sources. Previous research has shown that the definition of "children" varies between country. However, due to limitations in analysing the overall raw data, this comparison was based on existing published data.

1.1. Body Weight

1.1.1. Overview

Body weight is an important factor in exposure assessment as it reflects differences resulting from age or body size and directly influences the extent to which the human body is exposed. However, infants and children are particularly vulnerable to harm from exposure to environmental pollutants not only due to their greater dose-to-body-weight ratio but also because of other factors such as immature toxicokinetic mechanisms, differences in absorption rates, and distinct behaviours that can lead to increased exposure.

It is critical to choose body weight values suitable for the characteristics of the subjects under assessment. As children's body weights greatly vary with age, it is advisable to apply representative weight values for the specifically concerned age group. It is important to use body weight values that accurately represent children's body weight in individual countries.

When conducting an exposure assessment, an average daily dose (ADD) of environmental hazards can be calculated using the following general equation, which incorporates the body weight value. The concentration of the agent (CA), intake rate (IR), exposure frequency (EF), exposure duration (ED), and exposure time (ET) are multiplied together and then divided by the averaging time (AT) and body weight (BW).

$$ADD = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT}$$

ADD	Average Daily Dose (mg/kg-day)
CA	Concentration of Agent (e.g., air, mg/m ³)
IR	Intake Rate (e.g., inhalation rate, m ³ /hr)
ET	Exposure Time (hr/day)
EF	Exposure Frequency (day/year)
ED	Exposure Duration (year)
BW	Body Weight (kg)
AT	Averaging Time (day)

1.1.2. Status of Data by Country

The findings from the OECD Database on Children’s Exposure Factors Development Project indicate that, among OECD member countries, 13—including Canada, Germany, Japan, Korea, the Netherlands, and the United States—have compiled representative body weight values for children in their respective countries.

Table 1.1. Status of Body Weight Data by Country

Category	Asia		Europe				North America		Oceania
	Korea	Japan	Germany	Netherlands	Nordic countries	UK	Canada	US	Australia
Body Weight	0	0	0	0	0	0	0	0	0

1.1.3. Comparison by Country

Korea established the representative body weight values based on the Korea National Health and Nutrition Examination Survey (KNHANES) data and weight measurement data from other research studies. The average body weight of Korean children increased with age, with boys weighing 5.9 kg and girls 5.2 kg under 3 months, and boys weighing 67.3 kg and girls 56.8 kg at 16 to 18 years.

Japan used measurement data from domestic studies. The table below shows the average values by age, with 2-year increments starting from 1 year old. At 1 year old, boys weighed 10.3 kg and girls 9.7 kg, while at 19 years old, boys weighed 60.6 kg and girls 48.7 kg.

Table 1.2. Comparison of Body Weight by Country (Asia)

(unit: kg)		
Gender	Korea ¹⁾	Japan ²⁾
	Mean (recommended value)	Mean
All	0 -< 3 months: 5.6	-
	3 -< 6 months: 7.5	
	6 -< 9 months: 8.7	
	9 -< 12 months: 9.7	
	1 - 2 years: 12.2	
	3 - 6 years: 18.8	
	7 - 9 years: 30.0	
	10 - 12 years: 43.8	
	13 - 15 years: 57.4	
16 - 18 years: 62.4		
Boy	0 -< 3 months: 5.9	1 year: 10.3
	3 -< 6 months: 8.0	3 years: 13.8
	6 -< 9 months: 8.9	5 years: 18.2
	9 -< 12 months: 10.1	7 years: 24.7
	1 - 2 years: 12.6	9 years: 30.1
	3 - 6 years: 19.2	11 years: 41.3
	7 - 9 years: 30.9	13 years: 44.7
	10 - 12 years: 44.7	15 years: 59.2
	13 - 15 years: 61.5	17 years: 64.0
16 - 18 years: 67.3	19 years: 60.6	
Girl	0 -< 3 months: 5.2	1 year: 9.7
	3 -< 6 months: 7.0	3 years: 13.9
	6 -< 9 months: 8.4	5 years: 17.7
	9 -< 12 months: 9.2	7 years: 21.8
	1 - 2 years: 11.8	9 years: 30.4
	3 - 6 years: 18.4	11 years: 36.5
	7 - 9 years: 29.0	13 years: 48.8
	10 - 12 years: 42.7	15 years: 51.2
	13 - 15 years: 52.8	17 years: 52.6
16 - 18 years: 56.8	19 years: 48.7	

1) Korean National Institute of Environmental Research (NIER). "Korean exposure factors handbook for children." (2019).

2) Ministry of Health Law. "The National Health and Nutrition Survey (NHNS) Japan." (2019).

Germany provided the 50th percentile data as the representative values for each age group based on surveys of children in the country. At 1 year old, boys weighed 10.03 kg and girls 9.34 kg, while at 17 years old, boys weighed 69.15 kg and girls 59.47 kg.

The Netherlands presented modelled children's body weight data (based on a large dataset of measurements from The Hague, adjusted according to the realistic composition of the Dutch population to address the unrepresentative distributions of the measurements across age, sex and ethnicity). For infants under 1 month old, boys weighed 3.1 kg and girls 3.3 kg, while at 16 to 18 years old, boys weighed 68.4 kg and girls 62.1 kg.

Northern European countries (The Nordic Council: Denmark, Finland, Iceland, Norway, Sweden) use the body weight data from the United States Environmental Protection Agency (US EPA) Child-Specific Exposure Factors Handbook as the representative body weight value for children in their countries. Data from the United States was used as the representative body weight value for children in these countries due to its reliability. For infants under 1 month old, 4.8 kg was used as the representative value, and for children aged 16 to 21 years, 71.6 kg was used.

The United Kingdom uses body weight measurements for children from national health surveys. The table below shows the data in 2-year increments, starting from 3 years old. At 3 years old, boys weighed 16.4 kg and girls 16.0 kg, while at 15 years old, boys weighed 62.9 kg and girls 58.4 kg.

Table 1.3. Comparison of Body Weight by Country (Europe)

(unit: kg)				
Gender	Germany ¹⁾	Netherlands ²⁾	Nordic countries ³⁾	UK ⁴⁾
	P50	P50	Mean	P50
All	-	-	0 -< 1 month: 4.8 1 -< 3 months: 5.6 3 -< 6 months: 7.4 6 -< 11 months: 9.2 1 -< 2 years: 11.4 2 -< 3 years: 13.8 3 -< 6 years: 18.6 6 -< 11 years: 31.8 11 -< 16 years: 56.8 16 -< 21 years: 71.6	-
Boy	12 months: 10.03 3 years: 15.03 5 years: 19.05 7 years: 24.58 9 years: 31.00 11 years: 38.88 13 years: 48.81 15 years: 61.69 17 years: 69.15	0 - 1 month: 3.1 1 - 3 months: 5.4 3 - 6 months: 7.1 6 - 12 months: 9.2 1 - 2 years: 11.5 2 - 3 years: 14.1 3 - 6 years: 18.2 6 - 11 years: 29.7 11 - 16 years: 52.8 16 - 18 years: 68.4	-	3 years: 16.4 5 years: 20.4 7 years: 25.8 9 years: 32.0 11 years: 40.2 13 years: 50.8 15 years: 62.9
Girl	12 months: 9.34 3 years: 14.42 5 years: 18.84 7 years: 24.06 9 years: 30.55 11 years: 39.37 13 years: 50.02 15 years: 56.80 17 years: 59.47	0 - 1 month: 3.3 1 - 3 months: 5.0 3 - 6 months: 6.5 6 - 12 months: 8.5 1 - 2 years: 10.9 2 - 3 years: 13.6 3 - 6 years: 17.8 6 - 11 years: 29.6 11 - 16 years: 51.2 16 - 18 years: 62.1	-	3 years: 16.0 5 years: 20.4 7 years: 25.9 9 years: 32.7 11 years: 42.4 13 years: 51.8 15 years: 58.4

1) Neuhauser, Hannelore, et al. "Referenzperzentile für anthropometrische Maßzahlen und Blutdruck aus der Studie zur Gesundheit von Kindern und Jugendlichen in Deutschland (KiGGS)." (2013).

2) Te Biesebeek, J. D., et al. "General Fact Sheet: General default parameters for estimating consumer exposure-Updated version 2014." RIVM rapport 090013003 (2014).

3) Nielsen, Elsa, and Pelle Thonning Olesen. Existing default values and recommendations for exposure assessment: Revision of the 2011 report, a Nordic exposure group project 2022. Nordic Council of Ministers, 2023.

4) Perez, A., et al. "Report from the commission on dietary food additive intake in the European Union." Contact Dermatitis 58.1 (2008): 47-48.

Canada uses data collected in the United States as the body weight data for infants under 2. For children older than 2 years, the median values for children's body weight from a national survey are used for exposure assessments. By age, 6.3 kg was used for infants under 5 months, and 62 kg was used for children aged 14 to 18 years old. Moreover, Canadian data does not distinguish between boys and girls as observed from other countries' data.

The United States uses average values calculated from domestic research data as representative values. For infants under 1 month, the value was 4.8 kg and for children aged 16 to 21 years, it was 71.6 kg. Boys weighed more than girls across all age groups.

Australia sourced data that uses body weight data on children collected from national nutrition surveys. The average weight for children aged 2 to 4 years was 15 kg and for those aged 16 to 18 years, it was 69 kg.

Table 1.4. Comparison of Body Weight by Country (North America/Oceania)

Gender	Canada ¹⁾	US ²⁾	Australia ³⁾
	P50 (recommended value)	Mean (recommended value)	Mean
All	0 - 5 months: 6.3 6 - 11 months: 9.1 1 year: 11.0 2 - 3 years: 15.0 4 - 8 years: 23.0 9 - 13 years: 42.0 14 - 18 years: 62.0	birth -< 1 month: 4.8 1 -< 3 months: 5.9 3 -< 6 months: 7.4 6 -< 12 months: 9.2 1 -< 2 years: 11.4 2 -< 3 years: 13.8 3 -< 6 years: 18.6 6 -< 11 years: 31.8 11 -< 16 years: 56.8 16 -< 21 years: 71.6	2 -< 4 years: 15.0 4 -< 8 years: 24.0 8 -< 12 years: 37.0 12 -< 16 years: 56.0 16 -< 18 years: 69.0
Boy	-	birth -< 1 month: 4.9 1 -< 3 months: 6 3 -< 6 months: 7.6 6 -< 12 months: 9.4 1 -< 2 years: 11.6 2 -< 3 years: 14.1 3 -< 6 years: 18.8 6 -< 11 years: 31.9 11 -< 16 years: 57.6 16 -< 21 years: 77.3	-
Girl	-	birth -< 1 month: 4.6 1 -< 3 months: 5.7 3 -< 6 months: 7.2 6 -< 12 months: 9 1 -< 2 years: 11.1 2 -< 3 years: 13.5 3 -< 6 years: 18.3 6 -< 11 years: 31.7 11 -< 16 years: 55.9 16 -< 21 years: 65.9	-

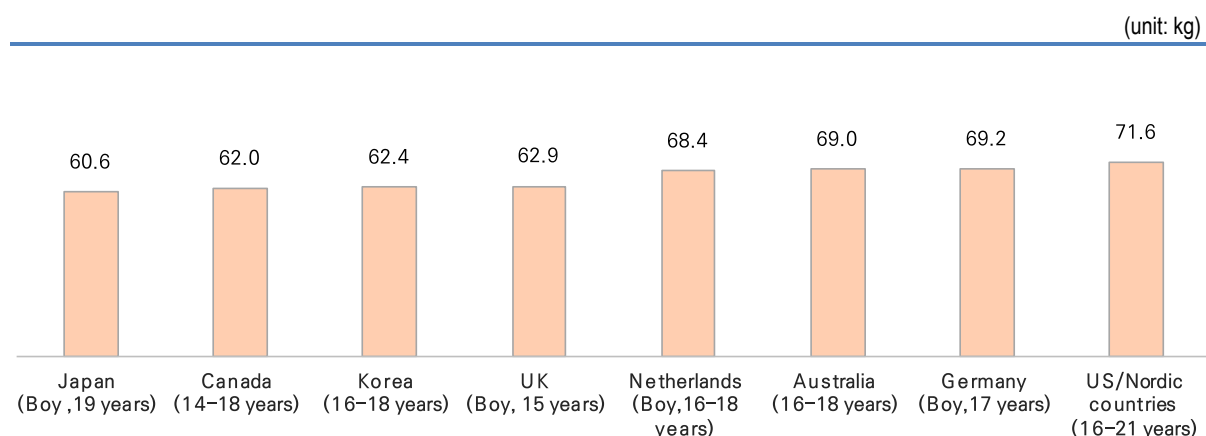
1) Health Canada, "Canadian exposure factors used in human health risk assessments," <https://www.canada.ca/en/health-canada/services/chemical-substances/fact-sheets/canadian-exposure-factors-human-health-risk-assessments.html>

2) US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.

3) Commonwealth of Australia. Australian exposure factor guidance, Guidelines for assessing human health risks from environmental hazards, 2012.

The graph below shows a comparison of the representative body weight values for the oldest age group by country. The United States (which uses the same values as Nordic countries) had the highest average value of 71.6 kg for the 16-21 age group, while Japan had the lowest with 60.6 kg for 19-year-olds.

Figure 1.1. Comparison of the Representative Body Weight Values for the Oldest Age Group by Country



* In cases where overall data was not available, boys' body weight was used.

1.2. Body Height

1.2.1. Overview

Body height is used less frequently than body weight in exposure assessments but can be important in specific exposure scenarios. It is closely related to body weight and body surface area. Since height is relatively easy to measure, it is often used as a variable in regression equations to estimate body weight and body surface area.

1.2.2. Status of Data by Country

The findings from the OECD Database on Children's Exposure Factors Development Project indicate that, among OECD member countries, five, including Australia, Japan, Korea, the Netherlands, and the United States, have compiled representative body height values for children in their respective countries.

Table 1.5. Status of Body Height Data by Country

Category	Asia		Europe	North America	Oceania
	Korea	Japan	Netherlands	US	Australia
Body Height	0	0	0	0	0

1.2.3. Comparison by Country

Korea established the representative body height values based on the Korea National Health and Nutrition Examination Survey (KNHANES) data and height measurement data from other research studies. The average body height of Korean children increased with age, with boys measuring 59.1 cm and girls 57.4 cm under 3 months, and boys measuring 173 cm and girls 161.2 cm at 16 to 18 years.

Japan used measurement data from domestic studies. The table below shows the average values for specific age groups, with 2-year increments starting from 1 year old. At 1 year old, boys measured 79.6 cm and girls 76.6 cm, while at 19 years old, boys measured 170.4 cm and girls 156.7 cm.

The Netherlands presented modelled children's body height data (based on a large dataset of measurements from The Hague), adjusted according to the realistic composition of the Dutch population to address the unrepresentative distributions of the measurements across age, sex and ethnicity. For infants under 1 month old, the 50th percentile was 51.7 cm for boys and 51.3 cm for girls. For those aged 16 to 18 years, the 50th percentile was 175.8 cm for boys and 167.3 cm for girls.

The United States uses average values calculated from domestic research data as representative values. At 2 years old, boys measured 91.2 cm and girls 90.1 cm, while at 19 years old, boys measured 176.7 cm and girls 163.1 cm. Height generally increased with age, but in girls, there was a slight decrease between ages 17 and 19 years, with 163.2 cm and 163.1 cm, respectively.

Australia sourced data using the body height data on children collected from the national nutrition surveys. The average height for children aged 2 to 4 years was 96 cm and for those aged 16 to 18 years, it was 171 cm.

In most age groups, boys were taller than girls, and height generally increased with age. However, in Japan, the average height for both boys and girls decreased between ages 17 and 19 years.

In Asia, while direct comparisons are difficult due to differences in age groups, Korean children—both boys and girls—were generally taller than their Japanese counterparts.

Table 1.6. Comparison of Body Height by Country (Asia)

(unit: cm)		
Gender	Korea ¹⁾	Japan ²⁾
	Mean (recommended value)	Mean
All	0 -< 3 months: 58.3	
	3 -< 6 months: 65.4	
	6 -< 9 months: 70.4	
	9 -< 12 months: 74.4	
	1 - 2 years: 85.7	
	3 - 6 years: 109.0?	-
	7 - 9 years: 131.7	
	10 - 12 years: 149.9	
	13 - 15 years: 164.4	
16 - 18 years: 167.5		
Boy	0 -< 3 months: 59.1	1 year: 79.6
	3 -< 6 months: 66.7	3 years: 95.6
	6 -< 9 months: 71.4	5 years: 110.5
	9 -< 12 months: 75.0?	7 years: 122.7
	1 - 2 years: 86.4	9 years: 132.5
	3 - 6 years: 109.5	11 years: 147.2
	7 - 9 years: 132.5	13 years: 156.5
	10 - 12 years: 150.1	15 years: 169.3
	13 - 15 years: 168.8	17 years: 171.5
16 - 18 years: 173.0?	19 years: 170.4	
Girl	0 -< 3 months: 57.4	1 year: 76.6
	3 -< 6 months: 64.1	3 years: 95.7
	6 -< 9 months: 69.5	5 years: 107.5
	9 -< 12 months: 73.8	7 years: 121.1
	1 - 2 years: 85.1	9 years: 133.1
	3 - 6 years: 108.4	11 years: 144.0?
	7 - 9 years: 130.8	13 years: 154.8
	10 - 12 years: 149.7	15 years: 159.2
	13 - 15 years: 159.6	17 years: 158.4
16 - 18 years: 161.2	19 years: 156.7	

1) Korean National Institute of Environmental Research (NIER). "Korean exposure factors handbook for children." (2019).

2) Ministry of Health Law. "The National Health and Nutrition Survey (NHNS) Japan." (2019).

Children in the Netherlands, the United States and Australia were generally taller than children in Korea and Japan (Asia). In particular, Dutch girls aged 16 to 18 years measured 167.3 cm, which is taller than girls in other countries.

Table 1.7. Comparison of Body Height by Country (Europe/North America/Oceania)

(unit: cm)			
Gender	Netherlands ¹⁾	US ²⁾	Australia ³⁾
	P50	Mean	P50
All	-	-	2 -< 4 years: 96.0 4 -< 8 years: 120.0 8 -< 12 years: 141.0 12 -< 16 years: 162.0 16 -< 18 years: 171.0
Boy	0 - 1 month: 51.7 1 - 3 months: 57.9 3 - 6 months: 64.2 6 - 12 months: 72.6 1 - 2 years: 82 2 - 3 years: 92.9 3 - 6 years: 108.1 6 - 11 years: 134.6 11 - 16 years: 163.8 16 - 18 years: 175.8	2 years: 91.2 3 years: 98.6 5 years: 113 7 years: 126.2 9 years: 138.1 11 years: 148.7 13 years: 160.1 15 years: 173.8 17 years: 175.3 19 years: 176.7	-
Girl	0 - 1 month: 51.3 1 - 3 months: 56.5 3 - 6 months: 62.5 6 - 12 months: 70.8 1 - 2 years: 80.5 2 - 3 years: 91.6 3 - 6 years: 107.3 6 - 11 years: 134.5 11 - 16 years: 159.7 16 - 18 years: 167.3	2 years: 90.1 3 years: 97.6 5 years: 112.4 7 years: 124.4 9 years: 136.9 11 years: 151.4 13 years: 159.1 15 years: 162 17 years: 163.2 19 years: 163.1	-

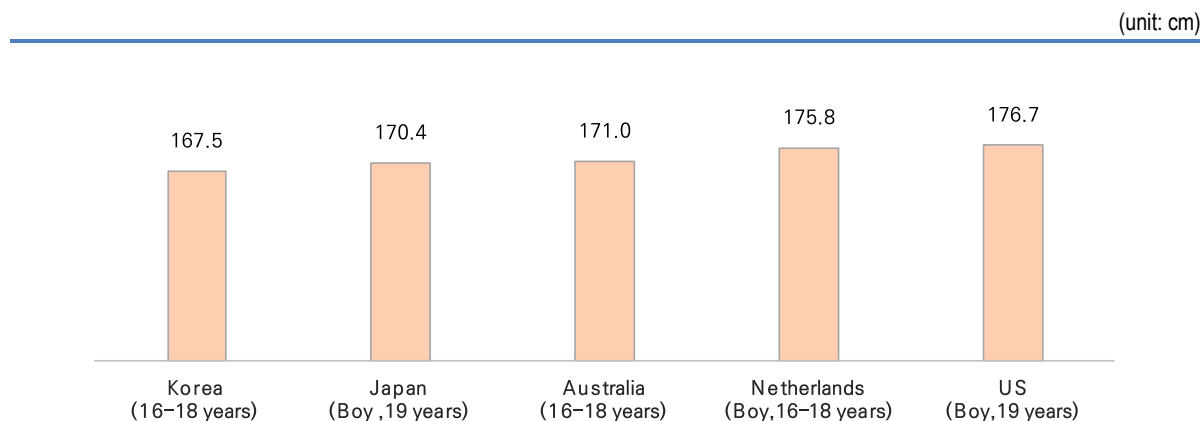
1) Te Biesebeek, J. D., et al. "General Fact Sheet: General default parameters for estimating consumer exposure-Updated version 2014." RIVM rapport 090013003 (2014).

2) US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.

3) Commonwealth of Australia. Australian exposure factor guidance, Guidelines for assessing human health risks from environmental hazards, 2012.

The graph below shows a comparison of the representative body height values for the oldest age group by country. The United States had the highest (176.7 cm), followed by the Netherlands (175.8 cm) and Australia (171.0 cm).

Figure 1.2. Comparison of the Representative Body Height Values for the Oldest Age Group by Country



* In cases where overall data was not available, boys' body height was used.

1.3. Body Surface Area

1.3.1. Overview

Dermal exposure occurs through contact with various products and substances, such as water, soil, liquids, and gases, during everyday activities like bathing, laundry, swimming, and gardening, as well as through contact with surfaces like clothes, floors, and carpets. Body surface area (BSA), defined as the total area of a human body's skin surface, is an important exposure factor when there is a need to estimate exposure on the surface of the skin. Especially, as for children in general their relative body surface area, per kg of weight, is larger compared to adults.

Body surface area can be directly measured by wrapping or coating certain body parts with specific material (e.g., bandage) and measuring the area or by using devices like 3D scanners. As it is difficult to measure the population in such a way, research has focused heavily on indirect methods. They involve measuring the body surface area of a certain group and developing a model to estimate surface area using other easily measurable indicators, such as height or weight.

In order to calculate accurate exposure estimates on the surface of the skin, the surface areas of actual exposed body parts are required. The surface area of each body part can be estimated by applying the body part surface area percentages to the entire body surface area.

The average daily dose (ADD) of chemical substances exposed through the skin can be calculated using surface area, as described in the general equation below, by multiplying the surface area (SA, cm²) by daily absorption per event (DA_{event}, mg/cm²-event), exposure frequency (EF, events/year), and exposure duration (ED, years) and then dividing by the body weight (BW, kg) and the averaging time (AT, days). The daily absorption per event is calculated by multiplying the permeability coefficient (cm/hr) by the concentration of the agent in contact with the skin (mg/cm³) and the duration of skin contact (hours/event).

$$ADD = \frac{DA_{event} \times ED \times EF \times SA}{BW \times AT}$$

ADD	Average Daily Dose (mg/day-kg)
DA_{event}	Daily Absorption (mg/cm ² -event)
EF	Exposure Frequency (events/year)
ED	Exposure Duration (years)
SA	Surface Area (cm ²)
BW	Body Weight (kg)
AT	Averaging Time (days)

1.3.2. Status of Data by Country

The findings from the OECD Database on Children's Exposure Factors Development Project indicate that, among OECD members, 11 countries, including Japan, Korea, the Netherlands, and the United States, have compiled representative body surface area values for children in their respective countries.

Korea has provided the body surface area data by dividing the body into eight parts: head, torso, arms, hands, legs, thighs, calves, and feet. Other countries like the Netherlands, Nordic countries, Canada, the United States, and Australia have provided data for six parts: head, torso, arms, hands, legs, and feet.

Table 1.8. Status of Body Surface Area Data by Country

Category	Asia		Europe		North America		Oceania
	Korea	Japan	Netherlands	Nordic countries	Canada	US	Australia
Body Surface Area (total)	0	0	0	0	0	0	0
Head Surface Area	0		0	0	0	0	0
Torso (trunk) Surface Area	0		0	0	0	0	0
Arms Surface Area	0		0	0	0	0	0
Hands Surface Area	0		0	0	0	0	0
Legs Surface Area	0		0	0	0	0	0
Thighs Surface Area	0						
Calves Surface Area	0						
Feet Surface Area	0		0	0	0	0	0

1.3.3. Comparison by Country

1) Body Surface Area, Total

Korea has calculated body surface area (BSA) using the equation below, proposed by the Ministry of Food and Drug Safety (2009), which takes into account the relative ratios of weight, height, and surface area of each body part. Then, the body surface area percentages for specific ages or body parts are applied to the derived body surface area to calculate the surface area of each body part. The average body surface area ranges from 0.46 m² for children under 12 months up to 1.76 m² for children aged 16 to 18 years.

$$BSA = 0.03915 * Wt^{0.50} * Ht^{0.34}$$

BSA	Body Surface area (m ²)
Wt	Weight (kg)
Ht	Height (cm)

In the case of Japan, only the average values for children aged 16 years and older were available, with 1.69 m² for boys and 1.51 m² for girls.

Table 1.9. Comparison of Body Surface Area by Country (Asia)

		(unit: m ²)	
Gender	Korea ¹⁾	Japan ²⁾	
	Mean (recommended value)	Mean	
All	0 -< 12 months: 0.46 1 - 2 years: 0.62 3 - 6 years: 0.83 7 - 9 years: 1.12 10 - 12 years: 1.41 13 - 15 years: 1.67 16 - 18 years: 1.76	-	
Boy	0 -< 12 months: 0.47 1 - 2 years: 0.62 3 - 6 years: 0.84 7 - 9 years: 1.14 10 - 12 years: 1.43 13 - 15 years: 1.75 16 - 18 years: 1.84	> 16 years: 1.69	
Girl	0 -< 12 months: 0.44 1 - 2 years: 0.61 3 - 6 years: 0.82 7 - 9 years: 1.10 10 - 12 years: 1.40 13 - 15 years: 1.59 16 - 18 years: 1.66	> 16 years: 1.51	

1) Korean National Institute of Environmental Research (NIER). "Korean exposure factors handbook for children." (2019).

2) AIST, Exposure factors handbooks (2007)

The Netherlands has calculated body surface area (SA) using the equation below (US-EPA, 2011) based on body weight and height of boys and girls. The 25th percentile value was used as default value, with 0.2 m² for children under 1 month up to 1.68 m² for children aged 16 to 18 years.

$$SA = 0.02350H^{0.42246}W^{0.51456}$$

SA	Body Surface area (m ²)
H	Height (cm)
W	Weight (kg)

Nordic countries have used the values from the Netherlands as they considered that the Netherlands used more up-to-date data compared to the United States and that the average surface area values for certain body parts from the United States were unrealistic. (e.g., reduction in head surface area between 1-2 years and 2-3 years of age).

Canada has calculated body surface area employing the same Gehan & George (1970) model as the Netherlands. For infants under 2 years of age, body weight data from the United States have been used to predict surface area, whereas for children aged 2 years and older, representative values of body weight obtained from domestic surveys have been employed. The table below presents values only for

children aged 2 years and older. For children aged 2–3 years, the average was 0.65 m², and for those aged 14–18 years, the average was 1.72 m².

The United States has used the height and weight data obtained from domestic surveys to calculate body surface area. For children under 1 month, the average was 0.29 m², and for those aged 16 to 21 years, it was 1.84 m².

Australia has used values from the United States, as they provide representative body surface area data for the widest range of body parts.

Table 1.10. Comparison of Body Surface Area by Country (Europe/North America/Oceania)

(unit: m ²)			
Gender	Netherlands ¹⁾ Nordic countries ²⁾	Canada ¹⁾	US ²⁾ Australia ³⁾
	P25 (recommended value)	Mean (recommended value)	Mean (recommended value)
All	0 - 1 month: 0.20		0 -< 1 month: 0.29
	1 - 3 months: 0.28		1 -< 3 months: 0.33
	3 - 6 months: 0.34		3 -< 6 months: 0.38
	6 - 12 months: 0.41	0 - 5 months: 0.35	6 -< 12 months: 0.45
	1 - 2 years: 0.47	6 - 11 months: 0.45	1 -< 2 years: 0.53
	2 - 3 years: 0.57	1 year: 0.53	2 -< 3 years: 0.61
	3 - 6 years: 0.69	2 - 3 years: 0.65	3 -< 6 years: 0.76
	2 - 6 years: 0.64	4 - 8 years: 0.89	6 -< 11 years: 1.08
	6 - 11 years: 0.93	9 - 13 years: 1.34	11 -< 16 years: 1.59
	11 - 16 years: 1.40	14 - 18 years: 1.72	16 -< 21 years: 1.84
16 - 18 years: 1.68			
Boy	0 - 1 month: 0.19		birth -< 1 month: 0.29
	1 - 3 months: 0.28		1 -< 3 months: 0.33
	3 - 6 months: 0.35		3 -< 6 months: 0.39
	6 - 12 months: 0.42		6 -< 12 months: 0.45
	1 - 2 years: 0.48	-	1 -< 2 years: 0.53
	2 - 3 years: 0.58		2 -< 3 years: 0.62
	3 - 6 years: 0.69		3 -< 6 years: 0.76
	2 - 6 years: 0.69		6 -< 11 years: 1.09
	6 - 11 years: 0.93		11 -< 16 years: 1.61
	11 - 16 years: 1.41		16 -< 21 years: 1.94
16 - 18 years: 1.73			
Girl	0 - 1 month: 0.20		birth -< 1 month: 0.28
	1 - 3 months: 0.27		1 -< 3 months: 0.32
	3 - 6 months: 0.33		3 -< 6 months: 0.38
	6 - 12 months: 0.40		6 -< 12 months: 0.44
	1 - 2 years: 0.46		1 -< 2 years: 0.52
	2 - 3 years: 0.56		2 -< 3 years: 0.60?
	3 - 6 years: 0.68		3 -< 6 years: 0.75
	2 - 6 years: 0.62		6 -< 11 years: 1.08
	6 - 11 years: 0.93		11 -< 16 years: 1.57
	11 - 16 years: 1.39		16 -< 21 years: 1.73
16 - 18 years: 1.62			

1) Te Biesebeek, J. D., et al. "General Fact Sheet: General default parameters for estimating consumer exposure-Updated version 2014." RIVM rapport 090013003 (2014).

2) Nielsen, Elsa, and Pelle Thonning Olesen. Existing default values and recommendations for exposure assessment: Revision of the 2011 report, a Nordic exposure group project 2022. Nordic Council of Ministers, 2023.

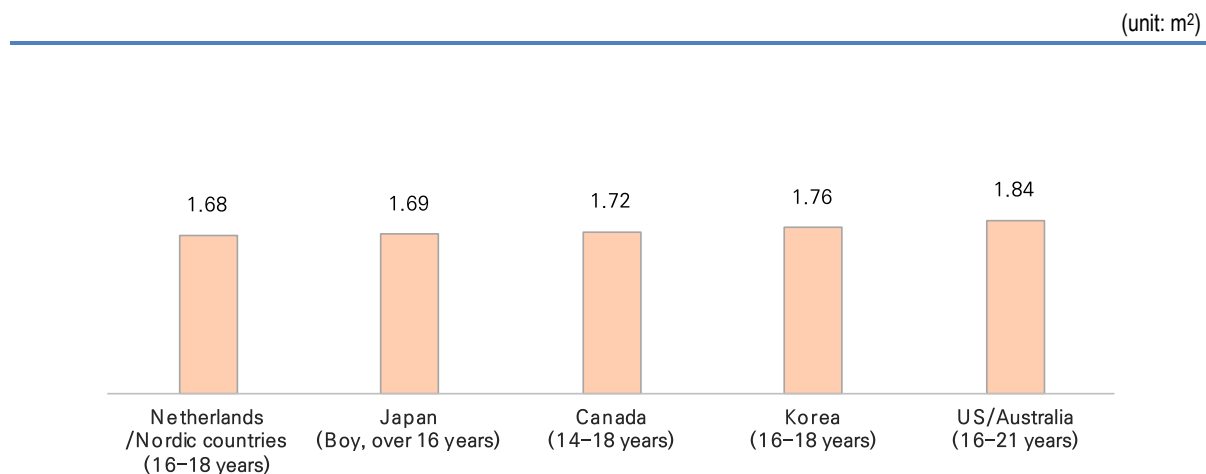
3) Health Canada, "Canadian exposure factors used in human health risk assessments," <https://www.canada.ca/en/health-canada/services/chemical-substances/fact-sheets/canadian-exposure-factors-human-health-risk-assessments.html>

4) US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.

5) Commonwealth of Australia. Australian exposure factor guidance, Guidelines for assessing human health risks from environmental hazards, 2012.

The graph below shows a comparison of the representative body surface area values for the oldest age group by country. Canada had the highest (1.87 m²), followed by the United States (1.84 m²) and Korea (1.76 m²).

Figure 1.3. Comparison of the Representative Body Surface Area Values for the Oldest Age Group by Country



* In cases where overall data was not available, boys' body surface area was used.

2) Body Part Surface Area

In Korea, the age-specific surface area percentages of each body part from the US-EPA (1985) were used to divide the total body surface area into the head, torso, arms, hands, legs, and feet. When dividing the legs into the thighs and calves, the percentages for Korean adults presented by Lee (2005) were applied.

Table 1.11. Surface Area of Body Parts – Mean Percent of Total Surface Area (Korea)

(unit: %)

Age	Head	Torso (trunk)	Arms		Hands	Legs		Feet
			Upper Arms	Lower Arms		Thighs	Calves	
0 -< 12 months	18.2	35.7	8.1	5.6	5.3	10.7	9.9	6.5
1 years	16.5	35.5	7.7	5.3	5.7	12	11	6.3
2 years	14.2	38.5	7.0?	4.8	5.3	12	11.1	7.1
3 - 5 years	13.7	31.7	8.4	5.7	5.9	14.2	13.1	7.3
6 - 10 years	12.6	34.7	7.5	5.1	5.0?	14.5	13.4	7.2
11 - 15 years	9.4	33.7	7.6	5.2	5.3	16.3	15	7.5
16 - 18 years	7.8	32.2	9.1	6.2	5.4	16.8	15.4	7.1

* Korean National Institute of Environmental Research (NIER). "Korean Exposure Factors Handbook for Children" (2019).

The Netherlands has used the percentages presented by the US-EPA (1985) for children under the age of 2 and the values from Boniol et al.(2008) for children over the age of 2. Nordic countries have applied the same values, as they determined that the average surface area values for certain body parts in the US-EPA (2011) data, such as reduction in head surface area between 1-2 years and 2-3 years of age, were unrealistic.

Table 1.12. Surface Area of Body Parts – Mean Percent of Total Surface Area (Netherlands)

(unit: %)						
Age	Head (incl. neck)	Torso (trunk) (excl. neck)	Arms (excl. hands)	Hands	Legs	Feet
Birth-<1 months ¹⁾	18.2	35.7	13.7	5.3	20.6	6.5
1-<3 months ¹⁾	18.2	35.7	13.7	5.3	20.6	6.5
3-<6 months ¹⁾	18.2	35.7	13.7	5.3	20.6	6.5
6-<12 months ¹⁾	18.2	35.7	13.7	5.3	20.6	6.5
1-<2 years ¹⁾	16.5	35.5	13.0	5.7	23.1	6.3
2-<3 years ²⁾	12.3	37.2	14.4	4.7	25.3	6.3
3-<6 years ³⁾	12.0	37.3	14.2	4.8	25.5	6.3
2-<6 years ²⁾	12.3	37.2	14.4	4.7	25.3	6.3
6-<11 years ⁴⁾	10.2	36.9	14.0	4.9	27.5	6.7
11-<16 years ⁵⁾	7.4	36.9	14.1	4.6	30.1	6.8
16-<18 year ⁶⁾	6.2	38.6	14.7	4.5	29.9	6.4

* Te Biesebeek, J. D., et al. "General Fact Sheet: General default parameters for estimating consumer exposure-Updated version 2014." RIVM rapport 090013003 (2014).

1) Mean percent of total surface area from (US-EPA 2011). Note that head includes neck.

2) Mean percent of total surface area of 2-year-old boys and girls (Boniol et al. 2008)

3) Average per cent of total surface area of 2 and 4-year-old boys and girls (Boniol et al. 2008)

4) Mean per cent of total surface area of 6-year-old boys and girls (Boniol et al. 2008)

5) Average per cent of total surface area of 10 and 12-year-old boys and girls (Boniol et al. 2008)

6) Mean per cent of total surface area of 16-year-old boys and girls (Boniol et al. 2008)

The United States has applied the below percentages. For children under the age of 2, the body surface area percentages of each body part from the US-EPA (1985) were applied, and for those aged 2 to 21 years, the values from Boniol et al. (2008) were used. Canada, the neighbouring country, has applied the same percentage values.

Table 1.13. Surface Area of Body Parts – Mean Percent of Total Surface Area (US)

(unit: %)						
Age	Head	Torso (trunk)	Arms	Hands	Legs	Feet
Birth-<1 month	18.2	35.7	13.7	5.3	20.6	6.5
1-<3 months	18.2	35.7	13.7	5.3	20.6	6.5
3-<6 months	18.2	35.7	13.7	5.3	20.6	6.5
6-<12 months	18.2	35.7	13.7	5.3	20.6	6.5
1-<2 years	16.5	35.5	13.0	5.7	23.1	6.3
2-<3 years	8.4	41.0	14.4	4.7	25.3	6.3
3-<6 years	8.0	41.2	14.0	4.9	25.7	6.4
6-<11 years	6.1	39.6	14.0	4.7	28.8	6.8
11-<16 years	4.6	39.6	14.3	4.5	30.4	6.6
16-<21 years	4.1	41.2	14.6	4.5	29.5	6.1

* US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.

Australia has applied the body surface area percentages and values for each body part from the US-EPA (1985). This is because these values provide the representative body surface area values for the widest range of body parts.

Table 1.14. Surface Area of Body Parts – Mean Percent of Total Surface Area (Australia)

	(unit: %)					
Age	Head	Torso (trunk)	Arms	Hands	Legs	Feet
Birth-<1 month	18.2	35.7	13.7	5.3	20.6	6.5
1-<3 months	18.2	35.7	13.7	5.3	20.6	6.5
3-<6 months	18.2	35.7	13.7	5.3	20.6	6.5
6-<12 months	18.2	35.7	13.7	5.3	20.6	6.5
1-<2 years	16.5	35.5	13.0?	5.7	23.1	6.3
2-<3 years	14.2	38.5	11.8	5.3	23.2	7.1
3-<6 years	13.7	31.7	14.2	5.9	27.3	7.3
6-<11 years	12.6	34.7	12.7	5.0	27.9	7.2
11-<16 years	9.4	33.7	12.9	5.3	31.3	7.5
16-<21 years	7.8	32.2	15.3	5.4	32.2	7.1

* Commonwealth of Australia. Australian exposure factor guidance, Guidelines for assessing human health risks from environmental hazards, 2012.

2-1) Head Surface Area

The head surface area was the largest in Asia, followed by Oceania, Europe and North America.

Table 1.15. Comparison of Head Surface Area by Country

					(unit: m ²)
Gender	Asia	Europe	North America		Oceania
	Korea ¹⁾	Netherlands ²⁾ Nordic countries ³⁾	Canada ⁴⁾	US ⁵⁾	Australia ⁶⁾
	Mean (recommended value)	P25 (recommended value)	Recommended value	Recommended value	Mean
All	0 -< 12 months: 0.083 1 - 2 years: 0.094 3 - 6 years: 0.112 7 - 9 years: 0.141 10 - 12 years: 0.146 13 - 15 years: 0.157 16 - 18 years: 0.137	0 - 1 month: 0.036 1 - 3 months: 0.051 3 - 6 months: 0.062 6 - 12 months: 0.075 1 - 2 years: 0.078 2 - 3 years: 0.070 3 - 6 years: 0.082 2 - 6 years: 0.077 6 - 11 years: 0.094 11 - 16 years: 0.105 16 - 18 years: 0.104	0 - 5 months: 0.064 6 - 11 months: 0.082 1 year: 0.087 2 - 3 years: 0.055 4 - 8 years: 0.061 9 - 13 years: 0.070 14 - 18 years: 0.074	0 -< 1 month: 0.053 1 -< 3 months: 0.06 3 -< 6 months: 0.069 6 -< 12 months: 0.082 1 -< 2 years: 0.087 2 -< 3 years: 0.051 3 -< 6 years: 0.061 6 -< 11 years: 0.066 11 -< 16 years: 0.073 16 -< 21 years: 0.075	0 -< 1 month: 0.05 1 -< 3 months: 0.06 3 -< 6 months: 0.07 6 -< 12 months: 0.08 1 -< 2 years: 0.09 2 -< 3 years: 0.09 3 -< 6 years: 0.1 6 -< 11 years: 0.14 11 -< 16 years: 0.15 16 -< 21 years: 0.14
Boy	0 -< 12 months: 0.086 1 - 2 years: 0.095 3 - 6 years: 0.113 7 - 9 years: 0.144 10 - 12 years: 0.148 13 - 15 years: 0.164 16 - 18 years: 0.144	-	-	-	-
Girl	0 -< 12 months: 0.081 1 - 2 years: 0.093 3 - 6 years: 0.110 7 - 9 years: 0.139 10 - 12 years: 0.145 13 - 15 years: 0.150 16 - 18 years: 0.129	-	-	-	-

2-2) Torso (trunk) Surface Area

The torso surface area was the largest in North America, followed by Europe, Oceania, and Asia, in the opposite order of the head surface area.

Table 1.16. Comparison of Torso (Trunk) Surface Area by Country

Gender	Asia	Europe	North America		Oceania
	Korea ¹⁾	Netherlands ²⁾ Nordic countries ³⁾	Canada ⁴⁾	US ⁵⁾	Australia ⁶⁾
	Mean (recommended value)	P25 (recommended value)	Recommended value	Recommended value	Mean
All	0 -< 12 months: 0.164 1 - 2 years: 0.229 3 - 6 years: 0.271 7 - 9 years: 0.389 10 - 12 years: 0.481 13 - 15 years: 0.564 16 - 18 years: 0.565	0 - 1 month: 0.071 1 - 3 months: 0.1 3 - 6 months: 0.121 6 - 12 months: 0.146 1 - 2 years: 0.167 2 - 3 years: 0.212 3 - 6 years: 0.257 2 - 6 years: 0.234 6 - 11 years: 0.343 11 - 16 years: 0.517 16 - 18 years: 0.648	0 - 5 months: 0.125 6 - 11 months: 0.161 1 year: 0.188 2 - 3 years: 0.267 4 - 8 years: 0.358 9 - 13 years: 0.531 14 - 18 years: 0.698	0 -< 1 month: 0.104 1 -< 3 months: 0.188 3 -< 6 months: 0.136 6 -< 12 months: 0.161 1 -< 2 years: 0.188 2 -< 3 years: 0.25 3 -< 6 years: 0.313 6 -< 11 years: 0.428 11 -< 16 years: 0.63 16 -< 21 years: 0.759	0 -< 1 month: 0.10 1 -< 3 months: 0.12 3 -< 6 months: 0.14 6 -< 12 months: 0.16 1 -< 2 years: 0.19 2 -< 3 years: 0.24 3 -< 6 years: 0.24 6 -< 11 years: 0.38 11 -< 16 years: 0.54 16 -< 21 years: 0.59
Boy	0 -< 12 months: 0.168 1 - 2 years: 0.232 3 - 6 years: 0.274 7 - 9 years: 0.396 10 - 12 years: 0.486 13 - 15 years: 0.589 16 - 18 years: 0.594	-	-	-	-
Girl	0 -< 12 months: 0.159 1 - 2 years: 0.226 3 - 6 years: 0.268 7 - 9 years: 0.382 10 - 12 years: 0.475 13 - 15 years: 0.536 16 - 18 years: 0.533	-	-	-	-

2-3) Arms Surface Area

The arms surface area was approximately 0.07 m² for children aged 1 to 2, increasing with age up to 0.28 m² for older children and adolescents.

Table 1.17. Comparison of Arms Surface Area by Country

Gender	(unit: m ²)				
	Asia	Europe	North America		Oceania
	Korea ¹⁾	Netherlands ²⁾ Nordic countries ³⁾	Canada ⁴⁾	US ⁵⁾	Australia ⁶⁾
	Mean (recommended value)	P25 (recommended value)	Recommended value	Recommended value	Mean
All	0 -< 12 months: 0.063 1 - 2 years: 0.076 3 - 6 years: 0.114 7 - 9 years: 0.141 10 - 12 years: 0.18 13 - 15 years: 0.214 16 - 18 years: 0.269	0 - 1 month: 0.027 1 - 3 months: 0.038 3 - 6 months: 0.047 6 - 12 months: 0.056 1 - 2 years: 0.061 2 - 3 years: 0.082 3 - 6 years: 0.098 2 - 6 years: 0.090 6 - 11 years: 0.130 11 - 16 years: 0.198 16 - 18 years: 0.246	0 - 5 months: 0.048 6 - 11 months: 0.062 1 year: 0.069 2 - 3 years: 0.094 4 - 8 years: 0.125 9 - 13 years: 0.190 14 - 18 years: 0.249	0 -< 1 month: 0.04 1 -< 3 months: 0.045 3 -< 6 months: 0.052 6 -< 12 months: 0.062 1 -< 2 years: 0.069 2 -< 3 years: 0.088 3 -< 6 years: 0.106 6 -< 11 years: 0.151 11 -< 16 years: 0.227 16 -< 21 years: 0.269	0 -< 1 month: 0.04 1 -< 3 months: 0.05 3 -< 6 months: 0.05 6 -< 12 months: 0.06 1 -< 2 years: 0.07 2 -< 3 years: 0.07 3 -< 6 years: 0.11 6 -< 11 years: 0.14 11 -< 16 years: 0.21 16 -< 21 years: 0.28
Boy	0 -< 12 months: 0.064 1 - 2 years: 0.077 3 - 6 years: 0.115 7 - 9 years: 0.144 10 - 12 years: 0.182 13 - 15 years: 0.224 16 - 18 years: 0.282	-	-	-	-
Girl	0 -< 12 months: 0.061 1 - 2 years: 0.075 3 - 6 years: 0.113 7 - 9 years: 0.139 10 - 12 years: 0.178 13 - 15 years: 0.204 16 - 18 years: 0.253	-	-	-	-

2-4) Hands Surface Area

The hands surface area was approximately 0.03 m² for children aged 1 to 2 years, increasing with age.

Table 1.18. Comparison of Hands Surface Area by Country

Gender					(unit: m ²)
	Asia	Europe	North America		Oceania
	Korea ¹⁾	Netherlands ²⁾ Nordic countries ³⁾	Canada ⁴⁾	US ⁵⁾	Australia ⁶⁾
	Mean (recommended value)	P25 (recommended value)	Recommended value	Recommended value	Mean
All	0 -< 12 months: 0.024 1 - 2 years: 0.034 3 - 6 years: 0.047 7 - 9 years: 0.056 10 - 12 years: 0.074 13 - 15 years: 0.089 16 - 18 years: 0.095	0 - 1 month: 0.011 1 - 3 months: 0.015 3 - 6 months: 0.018 6 - 12 months: 0.022 1 - 2 years: 0.027 2 - 3 years: 0.027 3 - 6 years: 0.033 2 - 6 years: 0.029 6 - 11 years: 0.046 11 - 16 years: 0.064 16 - 18 years: 0.075	0 - 5 months: 0.019 6 - 11 months: 0.024 1 year: 0.030 2 - 3 years: 0.031 4 - 8 years: 0.043 9 - 13 years: 0.061 14 - 18 years: 0.077	0 -< 1 month: 0.015 1 -< 3 months: 0.017 3 -< 6 months: 0.020? 6 -< 12 months: 0.024 1 -< 2 years: 0.03 2 -< 3 years: 0.028 3 -< 6 years: 0.037 6 -< 11 years: 0.051 11 -< 16 years: 0.072 16 -< 21 years: 0.083	0 -< 1 month: 0.02 1 -< 3 months: 0.02 3 -< 6 months: 0.02 6 -< 12 months: 0.02 1 -< 2 years: 0.03 2 -< 3 years: 0.03 3 -< 6 years: 0.05 6 -< 11 years: 0.05 11 -< 16 years: 0.08 16 -< 21 years: 0.10?
Boy	0 -< 12 months: 0.025 1 - 2 years: 0.034 3 - 6 years: 0.048 7 - 9 years: 0.057 10 - 12 years: 0.075 13 - 15 years: 0.093 16 - 18 years: 0.100?	-	-	-	-
Girl	0 -< 12 months: 0.024 1 - 2 years: 0.033 3 - 6 years: 0.047 7 - 9 years: 0.055 10 - 12 years: 0.073 13 - 15 years: 0.084 16 - 18 years: 0.089	-	-	-	-

2-5) Legs Surface Area

The representative legs surface area values in European countries were relatively smaller compared to those in other countries.

Table 1.19. Comparison of Legs Surface Area by Country

Gender	(unit: m ²)				
	Asia	Europe	North America		Oceania
	Korea ¹⁾	Netherlands ²⁾ Nordic countries ³⁾	Canada ⁴⁾	US ⁵⁾	Australia ⁶⁾
	Mean (recommended value)	P25 (recommended value)	Recommended value	Recommended value	Mean
All	0 -< 12 months: 0.094 1 - 2 years: 0.142 3 - 6 years: 0.229 7 - 9 years: 0.313 10 - 12 years: 0.429 13 - 15 years: 0.524 16 - 18 years: 0.565	0 - 1 month: 0.04 1 - 3 months: 0.058 3 - 6 months: 0.070 6 - 12 months: 0.084 1 - 2 years: 0.109 2 - 3 years: 0.144 3 - 6 years: 0.176 2 - 6 years: 0.159 6 - 11 years: 0.256 11 - 16 years: 0.421 16 - 18 years: 0.501	0 - 5 months: 0.072 6 - 11 months: 0.093 1 year: 0.122 2 - 3 years: 0.164 4 - 8 years: 0.245 9 - 13 years: 0.399 14 - 18 years: 0.514	0 -< 1 month: 0.06 1 -< 3 months: 0.068 3 -< 6 months: 0.078 6 -< 12 months: 0.093 1 -< 2 years: 0.122 2 -< 3 years: 0.154 3 -< 6 years: 0.195 6 -< 11 years: 0.311 11 -< 16 years: 0.483 16 -< 21 years: 0.543	0 -< 1 month: 0.06 1 -< 3 months: 0.07 3 -< 6 months: 0.08 6 -< 12 months: 0.09 1 -< 2 years: 0.12 2 -< 3 years: 0.14 3 -< 6 years: 0.21 6 -< 11 years: 0.30? 11 -< 16 years: 0.50? 16 -< 21 years: 0.59
Boy	0 -< 12 months: 0.097 1 - 2 years: 0.144 3 - 6 years: 0.231 7 - 9 years: 0.318 10 - 12 years: 0.433 13 - 15 years: 0.547 16 - 18 years: 0.594	-	-	-	-
Girl	0 -< 12 months: 0.092 1 - 2 years: 0.140? 3 - 6 years: 0.226 7 - 9 years: 0.307 10 - 12 years: 0.423 13 - 15 years: 0.498 16 - 18 years: 0.533	-	-	-	-

2-6) Feet Surface Area

The feet surface area was approximately 0.03 m² for children aged 1 to 2 years, increasing to 0.1 m² or more in children aged 16 and older.

Table 1.20. Comparison of Feet Surface Area by Country

Gender	(unit: m ²)				
	Asia	Europe	North America		Oceania
	Korea ¹⁾	Netherlands ²⁾ Nordic countries ³⁾	Canada ⁴⁾	US ⁵⁾	Australia ⁶⁾
	Mean (recommended value)	P25 (recommended value)	Recommended value	Recommended value	Mean
All	0 -< 12 months: 0.030 1 - 2 years: 0.042 3 - 6 years: 0.061 7 - 9 years: 0.081 10 - 12 years: 0.105 13 - 15 years: 0.126 16 - 18 years: 0.125	0 -< 1 month: 0.013 1 -< 3 months: 0.018 3 -< 6 months: 0.022 6 -< 12 months: 0.027 1 -< 2 years: 0.03 2 -< 3 years: 0.036 3 -< 6 years: 0.044 2 -< 6 years: 0.039 6 -< 11 years: 0.062 11 -< 16 years: 0.095 16 -< 18 years: 0.108	0 - 5 months: 0.023 6 - 11 months: 0.029 1 year: 0.033 2 - 3 years: 0.041 4 - 8 years: 0.059 9 - 13 years: 0.09 14 - 18 years: 0.108	0 -< 1 month: 0.019 1 -< 3 months: 0.021 3 -< 6 months: 0.025 6 -< 12 months: 0.029 1 -< 2 years: 0.033 2 -< 3 years: 0.038 3 -< 6 years: 0.049 6 -< 11 years: 0.073 11 -< 16 years: 0.105 16 -< 21 years: 0.112	0 -< 1 month: 0.02 1 -< 3 months: 0.02 3 -< 6 months: 0.03 6 -< 12 months: 0.03 1 -< 2 years: 0.03 2 -< 3 years: 0.04 3 -< 6 years: 0.06 6 -< 11 years: 0.08 11 -< 16 years: 0.12 16 -< 21 years: 0.13
Boy	0 -< 12 months: 0.031 1 - 2 years: 0.042 3 - 6 years: 0.061 7 - 9 years: 0.082 10 - 12 years: 0.106 13 - 15 years: 0.131 16 - 18 years: 0.131	-	-	-	-
Girl	0 -< 12 months: 0.029 1 - 2 years: 0.041 3 - 6 years: 0.06 7 - 9 years: 0.079 10 - 12 years: 0.104 13 - 15 years: 0.119 16 - 18 years: 0.118	-	-	-	-

Table 15 – Table 20

- 1) Korean National Institute of Environmental Research (NIER). "Korean exposure factors handbook for children." (2019).
- 2) Te Biesebeek, J. D., et al. "General Fact Sheet: General default parameters for estimating consumer exposure-Updated version 2014." RIVM rapport 090013003 (2014).
- 3) Nielsen, Elsa, and Pelle Thonning Olesen. Existing default values and recommendations for exposure assessment: Revision of the 2011 report, a Nordic exposure group project 2022. Nordic Council of Ministers, 2023.
- 4) Health Canada, "Canadian exposure factors used in human health risk assessments," <https://www.canada.ca/en/health-canada/services/chemical-substances/fact-sheets/canadian-exposure-factors-human-health-risk-assessments.html>
- 5) US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.
- 6) Commonwealth of Australia. Australian exposure factor guidance, Guidelines for assessing human health risks from environmental hazards, 2012.

References

Korea Ministry of Food and Drug Safety (2009), Investigation of body surface area measurement for risk evaluation

Lee, J.Y. (2005), Study on the body surface area of Korean adults Doctorate Dissertation, Seoul National University, <https://s-space.snu.ac.kr/handle/10371/22802>

Japan National Institute of Advanced Industrial Science and Technology (AIST) (2007), Exposure factors handbooks

Boniol, Mathieu, et al. (2008), "Proportion of skin surface area of children and young adults from 2 to 18 years old." , Journal of Investigative Dermatology, Volume 128, Issue 2Pages 461-464, <https://doi.org/10.1038/sj.jid.5701032>.

Environmental Health Standing Committee (enHealth) (2025), Guidelines for assessing human health risks from environmental hazards, Australian government , Department of Health, Disability and Ageing, <https://www.health.gov.au/resources/publications/enhealth-guidance-guidelines-for-assessing-human-health-risks-from-environmental-hazards>

Environmental Health Standing Committee (enHealth) (2012), Australian exposure factor guidance, <https://www.health.vic.gov.au/publications/the-australian-exposure-factor-guidance-handbook>.

Health Canada (1999), "Canadian exposure factors used in human health risk assessments.", Fact sheet series: Topics in risk assessment of substances under the Canadian Environmental Protection Act (CEPA), <https://www.canada.ca/en/health-canada/services/chemical-substances/fact-sheets/canadian-exposure-factors-human-health-risk-assessments.html>

Korean National Institute of Environmental Research (NIER) (2019), Korean exposure factors handbook for children.

Japan Ministry of Health, Labour and Welfare (2019), The National Health and Nutrition Survey (NHNS) Japan, https://www.nibn.go.jp/eiken/kenkounippon21/download_files/eiyouchousa/2019.pdf

Neuhauser, Hannelore, et al. (2013), "Referenzperzentile für anthropometrische Maßzahlen und Blutdruck aus der Studie zur Gesundheit von Kindern und Jugendlichen in Deutschland (KiGGS).", <https://edoc.rki.de/bitstream/handle/176904/3254/28jWMa04ZjppM.pdf>

Nielsen, Elsa, and Pelle Thonning Olesen (2023), Existing default values and recommendations for exposure assessment: Revision of the 2011 report, a Nordic exposure

group project 2022. Nordic Council of Ministers, <https://www.norden.org/en/publication/existing-default-values-and-recommendations-exposure-assessment-0>

Ocké, M. C., et al. (2008), Dutch national food consumption survey young children 2005/2006, RIVM report 350070001, Dutch National Institute for Public Health and the Environment (RIVM), <https://www.rivm.nl/en/dutch-national-food-consumption-survey/overview-surveys/young-children-2-6-years-2005-2006>

Perez, A., et al. (2008), "Report from the commission on dietary food additive intake in the European Union." *Contact Dermatitis* 58.1: 47-48.

Te Biesebeek, J. D., et al. (2014), General Fact Sheet: General default parameters for estimating consumer exposure-Updated version 2014, Dutch National Institute for Public Health and the Environment (RIVM) rapport 090013003, <https://www.rivm.nl/bibliotheek/rapporten/090013003.pdf>

US EPA (United States Environmental Protection Agency) (1985). "Development of statistical distributions or ranges of standard factors used in exposure assessments." (EPA600885010). <http://www.ntis.gov/search/product.aspx?ABBR=PB85242667> .

US EPA (United States Environmental Protection Agency) (2011), Exposure factors handbook: 2011 edition, <https://cfpub.epa.gov/ncea/efp/recordisplay.cfm?deid=236252>

2. Inhalation Rate

2.1. Overview

To estimate the amount of pollutants inhaled through the respiratory system, factors related to breathing must be considered. In this process, usually the inhalation rate, i.e. the volume of air inhaled in a certain time, is used.

Inhalation rate means the amount of air inhaled through breathing per unit of time. The daily inhalation rate (DIR) represents the amount of air breathed in throughout one day. DIR is mainly used in health and environmental studies to estimate exposure to airborne pollutants or harmful substances (e.g., dust, chemicals, toxic gases). The unit of measurement is m^3/day .

More physical activities lead to a higher volume of air being breathed in per unit of time, thereby raising the inhalation rate. Furthermore, children require more oxygen due to a higher metabolic rate relative to their body weight, which results in a higher inhalation rate compared to adults. Children's inhalation rates also vary significantly with age and activity level, more so than in adults.

Directly measuring the inhalation rate typically requires wearing specialized equipment, which can be impractical due to its weight, bulk, and high cost. Additionally, such equipment is generally not portable. Inhalation rate measurement devices should not be confused with portable air samplers, which collect air samples on a filter or cartridge. While they do not directly measure inhalation rate, they can help estimate chemical intake when combined with pump rate and sampling duration. Therefore, indirect measurement methods, such as those using heart rate, energy metabolic rate, or the doubly labeled water method, are primarily used.

Heart rate-based methods involve measuring heart rates at different exercise intensities and estimating the inhalation rate based on the correlation between heart rate and inhalation rate. The short-term inhalation rates at various exercise intensities can be applied to the 24-hour time-activity pattern to calculate the daily inhalation rate.

Energy metabolism rate-based methods involve measuring energy intake and estimating total daily energy expenditure (US-EPA, 2009). Alternatively, inhalation rates can be estimated using basal metabolic rate calculated based on body weight, and the energy expenditure associated with different activities measured based on time-activity patterns. (US EPA, 2006)

The doubly labelled water method (Stifelman, 2007) estimates inhalation rate by administering doubly labelled water ($^2\text{H}_2\text{O}$ and H_2^{18}O) to a participant and then collecting a urine sample after a set period to analyse the reduced isotope concentrations. (Since ^2H is excreted only in water and ^{18}O is excreted in both water and carbon dioxide, the excretion rates of the two elements are used to estimate carbon dioxide production, which is then used to calculate the inhalation rate.)

Methods for calculating the inhalation rate vary by country, including heart rate-based methods, energy metabolism rate-based methods, and the doubly labelled water method, making direct comparisons difficult.

The average daily dose (ADD) for inhalation exposure is calculated using parameters such as concentration (CA), inhalation rate (IR), exposure duration (ED), and other relevant factors. It is then normalized by body weight (BW) and averaging time (AT). Various methodologies exist depending on the specific scenario and chemical properties.

$$ADD = \frac{CA \times IR \times EF \times ED \times ET}{BW \times AT}$$

ADD	Average Daily Dose (mg/day-kg)
CA	Concentration of Agent (mg/m ³)
IR	Inhalation Rate (m ³ /hr)
ET	Exposure Time (hr/day)
EF	Exposure Frequency (day/year)
ED	Exposure Duration (year)
BW	Body Weight (kg)
AT	Averaging Time (day)

2.2. Status of Data by Country

The findings from the OECD Database on Children's Exposure Factors Development Project indicate that, among OECD member countries, seven, including Denmark, Japan, Korea, and the United States, have compiled representative inhalation rate values for children in their respective countries.

Inhalation rate is largely classified into long-term and short-term inhalation rates based on duration.

Long-term inhalation rate refers to the daily inhalation rate. Data is available from 10 countries, including Canada, Japan, Korea, Nordic countries, the United Kingdom, and the United States. The units of measurement are m³/day or m³/day-kg (when standardized by body weight).

Short-term inhalation rate refers to inhalation rate values based on activity level. Data is available from 10 countries, including Japan, Korea, the Netherlands, Nordic countries, the United Kingdom, and the United States. The data should be applied with care, as the classification of activity levels and units of measurement (m³/min, m³/hr, L/min, etc.) differ by country.

Japan provides daily inhalation rate data under two environmental conditions: standard temperature, pressure, dry (STPD) and body temperature, pressure, saturated with water vapor (BTPS).

Table 2.1. Status of Inhalation Rate Data by Country

Category	Korea	Japan	Nether lands	Nordic countries	UK	Canada	US
Long Term	0	0		0	0	0	0
Daily Inhalation Rate	0	0		0	0	0	0
Daily Inhalation Rate (btps)		0					
Daily Inhalation Rate (stpd)		0					
Short Term	0	0	0	0	0		0
During Activity (building with blocks)		0					
During Activity (light intensity)	0		0	0	0		0
During Activity (lying)		0					
During Activity (rest, sitting)	0		0		0		0

During Activity (sedentary/passive)				0	0		
During Activity (sitting)		0					
During Activity (sleep or nap)			0	0			0
During Activity (standing)		0					
During Activity (ball tossing)		0					
During Activity (climbing stairs)		0					
During Activity (high intensity)			0	0	0		0
During Activity (moderate intensity)	0			0	0		0
During Activity (running)		0					
During Activity (walking)		0					
During Activity (playing with plastic bricks)		0					

2.3. Comparison by Country

2.3.1. Long-term Daily Inhalation Rate

The table below provides the average daily inhalation rates by country. Although direct comparisons are difficult due to different categorizations of age groups by country, the daily inhalation rate for teenagers and younger was relatively higher in Korea, while Canada and the United States ranked higher in older age groups.

Korea used a regression equation correlating weight with heart rate at different activity levels to estimate inhalation rates for children aged 0-4 years (262 subjects). For children aged 5-18 years (5-11 subjects per age group, with 131 boys and 131 girls, totalling 262 subjects), oxygen consumption rates were measured under different exercise intensities (resting, walking, and running on a treadmill) to calculate the short-term inhalation rate (m³/hr). (Yoon et al. 2022). The results were then applied to the 24-hour time-activity pattern to calculate the daily inhalation rate. It has been found that as children's age increased, their daily inhalation rates also increased. For children aged 0-2 years, the daily inhalation rate was 9.49 m³/day, and for children aged 16-18 years, it was 14.98 m³/day.

Japan estimated inhalation rates based on body acceleration and heart rate data collected from children in the country (Kawahara, 2011). The estimated daily inhalation rate was 10.3 m³/day for children aged 5 years and 9.5 m³/day for children aged 6 years.

The inhalation rate data from the United States is based on four major, relatively recent studies. European data, on the other hand, is older, and some sources are uncertain. As a result, Nordic countries and the United Kingdom consider the United States data to be valid. For children under 1 month, the daily inhalation rate is 3.6 m³/day, and for children aged 16-21 years, it was 16.3 m³/day.

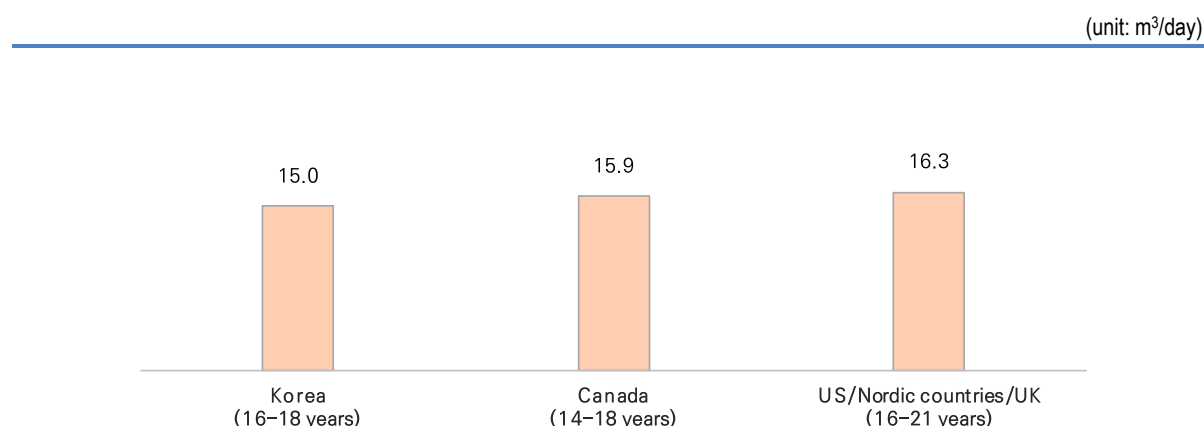
Canada also uses the long-term average inhalation rates from its neighbouring country, the United States, after adjusting for age groups.

Table 2.2. Comparison of Daily Average Inhalation Rate by Country (Asia), Unadjusted for Body Weight

(unit: m ³ /day)				
Gender	Asia		North America, Europe	
	Korea ¹⁾	Japan ²⁾	US ^{3)/Nordic countries^{4)/UK⁵⁾}}	Canada ⁶⁾
	Mean (recommended value)	Mean	Mean	Mean
All	0 - 2 years: 9.49 3 - 6 year: 10.38 7 - 9 years: 10.93 10 - 12 years: 12.74 13 - 15 years: 14.38 16 - 18 years: 14.98	5 years: 10.3 6 years: 9.5	< 1 month: 3.6 1 -< 3 months: 3.5 3 -< 6 months: 4.1 6 -< 12 months: 5.4 < 1 year: 5.4 1 -< 2 years: 8.0 2 -< 3 years: 8.9 3 -< 6 years: 10.1 6 -< 11 years: 12.0 11 -< 16 years: 15.2 16 -< 21 years: 16.3	0 - 5 months: 3.7 6 - 11 months: 5.4 1 year: 8.0 2 - 3 years: 9.2 4 - 8 years: 11.1 9 - 13 years: 13.9 14 - 18 years: 15.9

- 1) Korean National Institute of Environmental Research (NIER). "Korean exposure factors handbook for children." (2019).
- 2) Kawahara, Junko, et al. "Daily Inhalation Rate and Time-Activity/Location Pattern in Japanese Preschool Children." Risk Analysis: An International Journal 32.9 (2012): 1595-1604.
- 3) US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.
- 4) Nielsen, Elsa, and Pelle Thonning Olesen. Existing default values and recommendations for exposure assessment: Revision of the 2011 report, a Nordic exposure group project 2022. Nordic Council of Ministers, 2023.
- 5) Perez, A., et al. "Report from the commission on dietary food additive intake in the European Union." Contact Dermatitis 58.1 (2008): 47-48.
- 6) Health Canada, "Canadian exposure factors used in human health risk assessments," <https://www.canada.ca/en/health-canada/services/chemical-substances/fact-sheets/canadian-exposure-factors-human-health-risk-assessments.html>

The graph below shows a comparison of the representative daily inhalation rate values for the oldest age group by country. The United States had the highest (16.3 m³/day), followed by Canada (15.1 m³/day) and Korea (15.0 m³/day).

Figure 2.1. Comparison of the Representative Daily Inhalation Rate Values for the Oldest Age Group by Country

* Japan was excluded, as the oldest age group in Japan is 6 years old, which is lower compared to other countries.

2.3.2. Short-term Inhalation Rate

Since inhalation rates vary significantly with activity level, the data is presented by activity level.

The age group composition varies by country, and particularly for short-term inhalation rates, the classification of activity levels differs by country, making direct comparisons difficult. Therefore, the data is presented separately for each country, except for Table 2.3 and Table 2.4.

Table 2.3 compares children aged 5-6 years in Korea with children aged 6 years in Japan. (For Japan, L/min was converted to m³/hr.) Although overall comparisons are difficult due to differences in activity level classifications, the inhalation rate during sitting, which is the common parameter for both, was higher in Korean children than in their Japanese counterparts.

Table 2.3. Comparison of Short-Term Inhalation Rate by Country (Korea, Japan)

(unit: m ³ /hr)											
Country	Gender	Age Group	Mean								
			Rest, Sitting			Light Intensity			Moderate Intensity		
Korea ¹⁾	Boy	5-6 years	0.480			0.749			0.839		
	Girl	5-6 years	0.411			0.640			0.718		
Country	Gender	Age Group	Lying	Sitting	Standing	Playing With Plastic Bricks	Walking	Building With Blocks	Climbing Stairs	Ball Tossing	Running
Japan ²⁾	All	6 years	0.23	0.26	0.27	0.31	0.58	0.63	0.99	0.92	1.37

1) Korean National Institute of Environmental Research (NIER). "Korean exposure factors handbook for children." (2019).

2) Kawahara, Junko, et al. "Estimation of the respiratory ventilation rate of preschool children in daily life using accelerometers." Journal of the Air & Waste Management Association 61.1 (2011): 46-54.

Table 2.4 compares data from the Netherlands and the United States. (For the United States, m³/min was converted to m³/hr.) In younger age groups, the United States generally had higher inhalation rates, whereas, as the age range increased, the Netherlands had higher inhalation rates than the United States.

Table 2.4. Comparison of Short-Term Inhalation Rate by Country (Netherlands, US)

(unit: m ³ /hr)						
Country	Age Group	Mean				
		Sleep or Nap	Rest, Sitting / Sedentary Activity	Light Intensity	Moderate Intensity	High Intensity
Netherlands ¹⁾	1 -< 2 years	0.13	0.17	0.42	-	1.27
US ²⁾	1 -< 2 years	0.27	0.28	0.72	1.26	2.28
Netherlands	2 -< 3 years	0.15	0.19	0.49	-	1.42
US	2 -< 3 years	0.28	0.29	0.72	1.26	2.34
Netherlands	3 -< 6 years	0.17	0.22	0.57	-	1.58
US	3 -< 6 years	0.26	0.27	0.66	1.26	2.22
Netherlands	6 -< 11 years	0.22	0.29	0.76	-	1.92
US	6 -< 11 years	0.27	0.29	0.66	1.32	2.52
Netherlands	11 -< 16 years	0.32	0.42	1.13	-	2.53
US	11 -< 16 years	0.30	0.32	0.78	1.50	2.94
Netherlands	16 -< 18 years	0.38	0.5	1.36	-	2.87
US	16 -< 18 years	0.29	0.32	0.72	1.56	2.94

1) Te Biesebeek, J. D., et al. "General Fact Sheet: General default parameters for estimating consumer exposure-Updated version 2014." RIVM rapport 090013003 (2014).

2) US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.

1) Korea

In Korea, activity levels are classified into three categories: resting (e.g., sitting), light intensity activity, and moderate intensity activity. Short-term inhalation rates (m^3/hr) are presented by calculating the weighted averages for each gender, age group, and activity level based on the data measured in children of different age groups (NIER, 2014).

At moderate intensity, the inhalation rate was $0.839 \text{ m}^3/\text{hr}$ for boys aged 5-6 years, $1.755 \text{ m}^3/\text{hr}$ for boys aged 13-17 years, $0.718 \text{ m}^3/\text{hr}$ for girls aged 5-6 years, and $1.777 \text{ m}^3/\text{hr}$ for girls aged 13-17 years.

Table 2.5. Comparison of Short-Term Inhalation Rate by Country (Korea)

		(unit: m^3/hr)		
Gender	Age Group	Korea		
		Mean		
		Rest, Sitting	Light Intensity	Moderate Intensity
Boy	5 - 6 years	0.480?	0.749	0.839
	6 - 13 years	0.505	0.907	1.108
	13 - 17 years	0.621	1.355	1.755
Girl	5 - 6 years	0.411	0.640?	0.718
	6 - 13 years	0.452	0.807	0.982
	13 - 17 years	0.500?	1.249	1.777

* Korean National Institute of Environmental Research (NIER). "Korean exposure factors handbook for children." (2019).

2) Japan

In Japan, activity levels are classified into nine categories: lying, sitting, standing, playing with plastic bricks, walking, building with blocks, climbing stairs, ball tossing, and running. Inhalation rates were estimated based on body acceleration and heart rate data measured in children in the country (Kawahara, Junko, 2011).

For children aged 6 years, the average inhalation rate during walking was $9.7 \text{ L}/\text{min}$.

Table 2.6. Comparison of Short-Term Inhalation Rate by Country (Japan)

		(unit: L/min)								
Gender	Age	Japan								
		Mean								
		Lying	Sitting	Standing	Playing With Plastic Bricks	Walking	Building With Blocks	Climbing Stairs	Ball Tossing	Running
All	6 years	3.9	4.4	4.5	5.1	9.7	10.5	16.5	15.4	22.8

* Kawahara, Junko, et al. "Estimation of the respiratory ventilation rate of preschool children in daily life using accelerometers." Journal of the Air & Waste Management Association 61.1 (2011): 46-54.

3) The Netherlands

The Netherlands classifies activity levels into four categories: sleep or nap, resting (e.g., sitting), light intensity activity, and high intensity activity. Inhalation rates were calculated by applying the representative body weight for the country to the weight-inhalation rate relation equation (Freijer et al., 1997).

At moderate intensity, the inhalation rate for children under 1 month was 0.67 m³/hr, and for children aged 16-18 years, it was 2.87 m³/hr.

Table 2.7. Comparison of Short-Term Inhalation Rate by Country (Netherlands)

		(unit: m ³ /hr)			
Gender	Age Group	Netherlands			
		Mean			
		Sleep or Nap	Rest, Sitting	Light Intensity	Moderate Intensity
All	0 -< 1 month	0.05	0.07	0.16	0.67
	1 -< 3 months	0.08	0.1	0.25	0.9
	3 -< 6 months	0.09	0.12	0.31	1.03
	6 -< 12 months	0.11	0.15	0.36	1.16
	1 -< 2 years	0.13	0.17	0.42	1.27
	2 -< 3 years	0.15	0.19	0.49	1.42
	2 -< 6 years	0.16	0.21	0.53	1.51
	3 -< 6 years	0.17	0.22	0.57	1.58
	6 -< 11 years	0.22	0.29	0.76	1.92
	11 -< 16 years	0.32	0.42	1.13	2.53
16 -< 18 years	0.38	0.5	1.36	2.87	

* Te Biesebeek, J. D., et al. "General Fact Sheet: General default parameters for estimating consumer exposure-Updated version 2014." RIVM rapport 090013003 (2014).

* The inhalation rate calculation is based on Freijer et al. (1997) as used in ConsExpo (Delmaar et al. 2005)

4) Nordic Countries

Nordic countries use data from the United States (US-EPA, 2011) because European data is older than the US data, and some sources are uncertain. They classify activity levels into five categories: sleep or nap, sedentary activity, light intensity activity, moderate intensity activity, and high intensity activity.

At moderate intensity, the inhalation rate for children under 1 month was 0.014 m³/min, and for children aged 16-21 years, it was 0.026 m³/min.

Table 2.8. Comparison of Short-Term Inhalation Rate by Country (Nordic Countries)

		(unit: m ³ /min)				
Nordic countries Mean	Nordic countries Mean	Nordic countries				
		Mean				
		Sleep or Nap	Sleep or Nap	Sleep or Nap	Moderate Intensity	High Intensity
All	0 -< 1 year	0.003	0.0031	0.0076	0.014	0.026
	1 year	0.0045	0.0047	0.012	0.021	0.038
	2 years	0.0046	0.0048	0.012	0.021	0.039
	3 -< 6 years	0.0043	0.0045	0.011	0.021	0.037
	6 -< 11 years	0.0045	0.0048	0.011	0.022	0.042
	11 -< 16 years	0.005	0.0054	0.013	0.025	0.049
	16 -< 21 years	0.0049	0.0053	0.012	0.026	0.049

* Nielsen, Elsa, and Pelle Thonning Olesen. Existing default values and recommendations for exposure assessment: Revision of the 2011 report, a Nordic exposure group project 2022. Nordic Council of Ministers, 2023.

5) United Kingdom

The United Kingdom presented data in the European Centre for Ecotoxicology and Toxicology of Chemicals, ECETOC (2001). It was derived from the US data (US-EPA, 1997). ECETOC acknowledged that, while the data was based on US sources, it is considered representative of European contexts. Activity levels are classified into five categories: resting (e.g. sitting), sedentary activity, light intensity activity, moderate intensity activity, and high intensity activity.

At moderate intensity, the average inhalation rate for children was 1.2 m³/hr.

Table 2.9. Comparison of Short-Term Inhalation Rate by Country (UK)

		(unit: m ³ /hr)				
Gender	Age Group	UK				
		Mean				
		Rest, Sitting	Sedentary Activity	Light Intensity	Rest, Sitting	High Intensity
All	-	0.3	0.4	1.0	1.2	1.9

* Perez, A., et al. "Report from the commission on dietary food additive intake in the European Union." Contact Dermatitis 58.1 (2008): 47-48.

6) United States

In the United States, activity levels are classified into five categories: sleep or nap, sedentary activity, light intensity activity, moderate intensity activity, and high intensity activity. The representative values for the inhalation rate are derived from a compilation of data from four existing key studies.

At moderate intensity, the inhalation rate for children under 1 month was 0.014 m³/min, and for children aged 16-21 years, it was 0.026 m³/min.

Table 2.10. Comparison of Short-Term Inhalation Rate by Country (United States)

		(unit: m ³ /min)				
Gender	Age Group	United States				
		Mean				
		Sleep or Nap	Sedentary Activity	Light Intensity	Moderate Intensity	High Intensity
All	Birth -< 1 year	0.003	0.0031	0.0076	0.014	0.026
	1 -< 2 years	0.0045	0.0047	0.012	0.021	0.038
	2 -< 3 years	0.0046	0.0048	0.012	0.021	0.039
	3 -< 6 years	0.0043	0.0045	0.011	0.021	0.037
	6 -< 11 years	0.0045	0.0048	0.011	0.022	0.042
	11 -< 16 years	0.005	0.0054	0.013	0.025	0.049
	16 -< 21 years	0.0049	0.0053	0.012	0.026	0.049

* US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.

References

Freijer, J. I., et al. (1997), AirPex: air pollution exposure model, https://www.researchgate.net/publication/27453044_AirPEX_Air_Pollution_Exposure_Model

Health Canada (1999), "Canadian exposure factors used in human health risk assessments.", Fact sheet series: Topics in risk assessment of substances under the Canadian Environmental Protection Act (CEPA), <https://www.canada.ca/en/health-canada/services/chemical-substances/fact-sheets/canadian-exposure-factors-human-health-risk-assessments.html>

Kawahara, Junko, et al. (2012), "Daily Inhalation Rate and Time-Activity/Location Pattern in Japanese Preschool Children." *Risk Analysis: An International Journal* 32.9 : 1595-1604, <https://doi.org/10.1111/j.1539-6924.2011.01776.x>

Kawahara, Junko, et al. (2011), "Estimation of the respiratory ventilation rate of preschool children in daily life using accelerometers." *Journal of the Air & Waste Management Association* 61.1 : 46-54, <https://doi.org/10.3155/1047-3289.61.1.46>

Korean National Institute of Environmental Research (NIER) (2019), Korean exposure factors handbook for children.

Nielsen, Elsa, and Pelle Thonning Olesen (2023), Existing default values and recommendations for exposure assessment: Revision of the 2011 report, a Nordic exposure group project 2022. Nordic Council of Ministers, <https://www.norden.org/en/publication/existing-default-values-and-recommendations-exposure-assessment-0>

Perez, A., et al. (2008), "Report from the commission on dietary food additive intake in the European Union." *Contact Dermatitis* 58.1 : 47-48.

Stifelman, Marc (2077), "Using doubly-labeled water measurements of human energy expenditure to estimate inhalation rates." *Science of the total environment* 373.2-3 : 585-590.

Te Biesebeek, J. D., et al. (2014), "General Fact Sheet: General default parameters for estimating consumer exposure-Updated version 2014." RIVM rapport 090013003.

US EPA (US Environmental Protection Agency) (2011), Exposure factors handbook: 2011 edition.

Yoon, Chungsik, et al. (2022), "A study on the exposure factors used in the assessment of inhalation exposure to household chemicals." *Journal of Environmental Health Sciences* (2022): 195-205.

3. Food Intake

3.1. Overview

Food intake holds great significance for the exposure assessment of hazardous substances, as it is one of the key pathways of exposure to environmental pollutants (NIER, 2019). Even though the food supply in Western Europe and other regions is generally considered to be safe, contamination of foods may occur as a result of air, water, and soil pollution, or the intentional use of chemicals. Compared to adults, children, and adolescents have a higher food intake per body weight and may be more sensitive to physiological changes resulting from the ingredients they consume. For this reason, their intake requires thorough analysis.

Depending on whether analysis subjects have actually consumed the food or not, food intakes are categorized into “per capita intake” and “consumer-only intake.” The consumer-only intake rate is calculated by dividing the total intake by the number of respondents who consumed the items. The per capita intake rate includes individuals who reported no intake, resulting in a generally lower value compared to the consumer-only intake rate. In exposure assessment of hazardous substances, per capita intake is widely used as it includes all subjects regardless of actual food consumption.

The most universal method for investigating food intake is the 24-hour recall method, which requires subjects to recall and provide all food and beverage items they consumed in the last 24 hours. Other methods, such as food frequency questionnaires, where subjects select the frequency of consumption from a list of foods, and oral interviews, where the foods consumed are identified through conversation between the interviewer and the subjects, are also employed. It should be noted that when comparing intakes, the results may vary even for the consumption of the same foods, depending on the methods used for investigation.

$$ADD = \frac{C_{\text{medium}} \times \text{IngR} \times EF \times ED}{BW \times AT}$$

ADD	Average Daily Potential Dose (mg/day-kg)
C_{medium}	Concentration in medium (mg/L, mg/g)
IngR	Ingestion Rate (L/day, g/day)
EF	Exposure Frequency (day/year)
ED	Exposure Duration (years)
BW	Body Weight (kg)
AT	Averaging Time (days)

3.2. Status of Data by Country

The findings from the OECD Database on Children's Exposure Factors Development Project indicate that several OECD member countries have compiled the food intake data for children in their respective countries.

Table 3.1. Status of Food Intake Data by Country

Category		Korea	Japan	Denmark	Germany	Nether lands	Nordic countries	UK	Canada	US	Australia
Eating Factors	Eggs	0	0	0	0	0	0		0	0	0
	Fish / Shellfish	0	0	0	0	0	0		0	0	0
	Fruit	0	0	0	0	0	0		0	0	0
	Grain	0	0	0	0	0	0		0	0	0
	Meat	0	0	0	0	0	0		0	0	0
	Meat Alternatives								0		
	Nuts / Seed Products	0			0				0		
	Seaweeds		0								
	Seaweeds / Algae	0									
	Total Food				0					0	
	Vegetables	0	0	0	0	0	0		0	0	0
	Others				0						
Baby Food	Baby Food								0		
	Beverages	0	0	0	0	0	0				
	Dairy Products	0	0	0	0	0	0		0	0	0
	Drinking Water	0	0				0		0	0	0
	Energy			0			0				
	Fabricated Foods	0				0			0		
	Fats / Oils	0	0	0	0	0	0		0	0	
	Human Milk		0					0	0	0	
	Seasonings	0			0	0			0		
	Sugars / Sweeteners	0	0	0	0	0	0		0		
Others				0							

Comparing food intake across countries is crucial from many perspectives. Food intake is one of the most direct pathways through which the human body is exposed to certain ingredients or hazardous substances. Given that the types of foods consumed vary significantly by country due to differences in dietary culture, comparisons of food intakes should focus on similar food groups rather than the entire range of foods.

According to country-specific data, food intake data is primarily categorized into two groups: food consumption and beverage consumption. For eating factors, statistics on the intake of eggs, fish, fruits, grains, meat, and vegetables are available for all countries except the United Kingdom. However, data on seaweed is only available for Korea and Japan, highlighting the dietary cultural differences across countries. For drinking factors, dairy intake data is available for all countries except the United Kingdom, and data on fats and oils, as well as sugar and sweeteners, is also covered by a relatively large number of countries.

However, there are limitations to comparing food intake across countries based on the currently available data. While eating factors consist of 12 groups and drinking factors consist of 11, the types of

foods covered within each group vary significantly. For example, in the case of the fruit group, Korea provides intake data for 15 types of fruits, including apples, bananas, blueberries, and grapes, whereas Australia provides data for fruits as a whole regardless of type. In the grain group, Korea provides detailed intake data for 15 types of foods, including rice, noodles, bread, and cereal, whereas Australia, Denmark, and Nordic countries present only cereal intake, and the United States and Germany provide data for grains as a whole. As a result, direct comparisons of intake are difficult even within the same food group.

Depending on whether analysis subjects have actually consumed the food or not, food intakes are categorized into "per capita intake" and "consumer-only intake." When the scope of analysis is limited to consumers only rather than the entire population, the average intake tends to be higher. Therefore, even for data on the same food group, valid comparisons between countries cannot be made if the scope of analysis is not consistent. In particular, the intake statistics from, for example, Australia, Canada and Japan, do not clearly define the scope of analysis, making comparisons between countries virtually impossible.

Thus, this report does not provide or compare detailed data on food intake by country. The data on food intake by country can be found in the OECD Database on Children's Exposure Factors Development . While comparisons of food intake between countries are not provided, the current intake levels by age group within individual countries, as well as the types of food analysed in each country, can be reviewed.

While the status of the food intake data compiled in this project is limited to the data available during the time span of the project, the project also identified a regularly updated database on food consumption data in European Countries which can be accessed via <https://www.efsa.europa.eu/en/datareport/food-consumption-data> . This source also provides data for children's intake factors of the food categories covered by this project.

References

Korea

Korean National Institute of Environmental Research (NIER) (2019), "Korean exposure factors handbook for children."

Japan

Miyatake, Hirokazu, et al. (2020), "Estimation of internal dose from tap water after the Fukushima Daiichi Nuclear Power Station accident using newly obtained data." *Journal of Radiation Research*, Volume 61, Issue 2, March 2020, Pages 231–236, <https://doi.org/10.1093/jrr/rrz089>

Japan Ministry of Health, Labour and Welfare (2019), The National Health and Nutrition Survey (NHNS), https://www.nibn.go.jp/eiken/kenkounippon21/download_files/eiyouchousa/2019.pdf

Ministry of Health Law (2020), The National Health and Nutrition Survey (NHNS) Japan,

Ministry of Health Law (2021), The National Health and Nutrition Survey (NHNS) Japan,

Hirose et al. (2008), *Nihon bonyuhoikugakkaishi*, 2(1), 23-28

Denmark

Pedersen, A. N., et al.(2015), "Dietary habits in Denmark 2011-2013. Main results." (2015): 210-pp

Germany

German Federal institute for Risk Assessment (2017), KiESEL - The Children's Nutrition Survey to Record Food Consumption, <https://www.bfr.bund.de/en/research/research-fields/research-on-procuring-data-for-exposure-assessment/kiesel-childrens-nutrition-survey-to-record-food-consumption/>

Brettschneider A-K, Lage Barbosa C, Haftenberger M, Lehmann F, Mensink GB. (2021), Adherence to food-based dietary guidelines among adolescents in Germany according to socio-economic status and region: results from Eating Study as a KiGGS Module (EsKiMo) II. *Public Health Nutrition*. 2021;24(6):1216-1228. doi:10.1017/S136898002100001X

German Institute of Nutritional Behaviour, Results of the National Nutrition Survey II on food consumption and nutrient intake, <https://www.mri.bund.de/en/institutes/nutritional-behaviour/research-projects/nvsii/results-food-consumption-nutrient-intake/> (accessed June 2025).

Netherlands

National Institute for Public Health and the Environment (RIVM) (2023), Dutch National Food Consumption Survey 2019-2021, https://www.rivm.nl/publicaties/diet-of-dutch-results-of-dutch-national-food-consumption-survey-2019-2021-on-food#abstract_en

Nordic countries

Nielsen, Elsa, and Pelle Thonning Olesen (2023), Existing default values and recommendations for exposure assessment: Revision of the 2011 report, a Nordic exposure group project 2022. Nordic Council of Ministers, <https://www.norden.org/en/publication/existing-default-values-and-recommendations-exposure-assessment-0>

United Kingdom

ECETOC (2001), Exposure Factors Sourcebook for European Populations (with Focus on UK Data), Technical Report No. 79. Brussels, <https://www.ecetoc.org/wp-content/uploads/2014/08/ECETOC-TR-079.pdf>

Mills, Alison, and Hazel Tyler (1992), Food and nutrient intakes of British infants aged 6-12 months, <https://archive.org/details/foodnutrientinta0000mill>

Canada

Health Canada (1999), "Canadian exposure factors used in human health risk assessments.", Fact sheet series: Topics in risk assessment of substances under the Canadian Environmental Protection Act (CEPA), <https://www.canada.ca/en/health-canada/services/chemical-substances/fact-sheets/canadian-exposure-factors-human-health-risk-assessments.html>

Health Canada. 2015. Food Consumption Table derived from Statistics Canada, Canadian Community Health Survey, Cycle 2.2, Nutrition, <https://open.canada.ca/data/en/dataset/a9c18c37-b7b9-48ce-ac1d-b40a65bafa9e>

Health Canada (2018), Draft background document on default values for breast milk and formula intakes. Unpublished report. Ottawa (ON): Government of Canada.

United States

US EPA (2011), Exposure factors handbook: 2011 edition, <https://www.epa.gov/expobox/exposure-factors-handbook-2011-edition>

US EPA. "Update for Chapter 3 of the Exposure Factors Handbook. Ingestion of Water and Other Select Liquids." (2019), https://www.epa.gov/sites/default/files/2019-02/documents/efh_-_chapter_3_update.pdf

US EPA (2018a), Update for Chapter 9 of the Exposure Factors Handbook, Intake of Fruits and Vegetables, EPA/600/R-18/098F, https://www.epa.gov/sites/default/files/2018-08/documents/efh_-_chapter_9_update.pdf

Commonwealth of Australia (2012), Australian exposure factor guidance, Guidelines for assessing human health risks from environmental hazards.

US EPA (2018), Update for Chapter 12 of the Exposure Factors Handbook Intake of Grain Products, https://www.epa.gov/sites/default/files/2018-07/documents/efh_-_chapter_12_update.pdf

4. Time-Activity Patterns

4.1. Overview

It is beneficial in exposure assessments to understand the patterns of behaviour of individuals or groups. Certain types of activities may result in exposure to pollutants, and the type and quantity of pollutants encountered may vary depending on the type, location, and duration of the activity.

When calculating the average daily dose, data on time-activity patterns (TAP) is often used to determine ET (exposure time) and EF (exposure frequency). TAP represents the allocation of an individual's time and activities across different locations. As people move between microenvironments with varying pollutant concentrations, TAP information is crucial for estimating total human exposure. Exposure to environmental pollutants is equal to the concentration of pollutants multiplied by the duration spent in those locations. This equation is a general model that can be applied to various routes of exposure, including dermal, inhalation, and oral ingestion.

$$ADD = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT}$$

ADD	Average Daily Dose (mg/kg-day)
CA	Concentration of Agent (e.g., air, mg/m ³)
IR	Intake Rate (e.g., inhalation rate, m ³ /hr)
ET	Exposure Time (hr/day)
EF	Exposure Frequency (day/year)
ED	Exposure Duration (year)
BW	Body Weight (kg)
AT	Averaging Time (day)

Through the OECD Database on Children's Exposure Factors Development Project, activity time by location, behaviour frequency and duration have been collected from various countries.

As factors relating to activities vary depending on gender, age, location of residence, and culture, it is advisable to use data that reflects conditions closely matching the demographic characteristics of the subjects for more accurate exposure assessments.

4.2. Activity Time by Location

4.2.1. Status of Data by Country

It was found that among OECD member countries, Korea, Japan, Germany, Canada, and the United States have compiled data that can represent children's activity time by location.

Locations are generally categorized into indoors (house, school/kindergarten, other), transportation (in-vehicles), and outdoors. Most countries had data on time spent indoors, specifically in homes. Korea, Canada, and the United States provided separate data on time spent in transportation (in-vehicles).

Table 4.1. Status of Location-Based Activity Time Data by Country

Category			Korea	Japan	Germany	Nordic countries	UK	Canada	US	Australia
Indoors	House	Overall	0	0	0	0		0	0	0
		Weekday	0	0						
		Weekend	0	0						
	School ¹⁾	Overall	0							
		Weekday	0				0			
		Weekend	0							
	Others	Overall	0		0			0		
		Weekday	0							
		Weekend	0							
In-Vehicles	Overall	0					0	0		
	Weekday	0								
	Weekend	0								
Outdoors	Overall	0		0	0		0	0	0	
	Weekday	0	0			0				
	Weekend	0	0							

1) Childcare; Kindergarten or Daycare Center and School

4.2.2. Comparison by Country

In Korea, data for children aged 0–9 years have been collected from time-activity pattern logs, while data for children aged 10–18 years have been calculated by re-analyzing existing survey data (Time-Use Survey, Statistics Korea). Overall, Korean children spent more time in their homes on weekends than on weekdays. The time spent in homes was highest among children aged 0–9 years, particularly in winter, with an average of 21.03 hours. Weekday time spent in homes decreased with age.

In Japan, data has been derived from two separate surveys: one for the 10–19 age group and another for the 16–18 and 19–22 age groups. For children aged 10–19 years, the difference between weekday and weekend time spent in homes was smaller compared to Korea. For children aged 16–18 years, time spent outdoors was notably longer than in other countries on both weekdays and weekends, with 2.40 hours on weekdays and 2.64 hours on weekends.

In Germany, data for the age groups of 3–5, 6–8, 9–11, and 12–14 has been obtained through interview surveys, while data for the age groups under 7, 7–16, and 17–24 has been calculated using models. Time spent in homes and outdoors decreased, and time spent indoors (in places other than homes) increased with age. Moreover, German children generally spent more time outdoors and in transportation compared to children in other countries.

Canada has also used data from surveys conducted on its own population. As age increased, time spent in homes decreased, while time spent indoors (in places other than homes) and in transportation increased.

The United States used values reanalysed from existing national data (US EPA, 1996). It is noted that, due to activities that cannot be categorized as either indoors or outdoors, the total time spent indoors and outdoors may be less than 24 hours. Time spent in transportation (in-vehicles) represents the average for those who were actually in transportation (doers). For children aged 6–11, time spent outdoors increases, while in older age groups, it begins to decrease.

Nordic countries use data from the United States. This is because, although activity levels of Europeans and Americans may differ, the values recommended by the United States are based on various major studies and provide data on more activities compared to European data.

Australia also used data from the United States but uses its own data for time spent outdoors by certain age groups (under 1 year, 1–2 years, 2–3 years). The relevant values are provided in parentheses in Table 34. The Australian data (Brinkman et al., 1999) is based only on 14 waking hours for children (from 7:30 AM to 9:30 PM) and, as such, is not used for indoor activity time, but is used only for outdoor activity time for certain age groups.

Table 4.2. Comparison of Location-Based Activity Time by Country (1)

Country	Age Group (years)	Weekday/Weekend	Season	Participants	Indoor			Outdoor	In-Vehicles
					House	School	Others		
Korea ¹⁾	0 - 9	Weekday	Spring	531	16.91	5.13	0.62	0.40	0.93
			Summer	508	17.01	4.54	0.99	0.76	0.70
			Autumn	541	16.58	5.38	0.73	0.63	0.69
			Winter	500	16.95	5.47	0.55	0.31	0.72
		Weekend	Spring	531	20.58	0.16	1.26	0.84	1.16
			Summer	508	19.21	0.04	2.32	1.47	0.96
			Autumn	541	19.34	0.24	2.13	1.39	0.89
			Winter	500	21.03	0.33	1.14	0.63	0.87
Korea ¹⁾	10 - 12	Weekday	Spring + Autumn	1,434	13.68	8.40	0.59	1.33	
		Weekend		962	18.11	3.74	0.85	1.31	
	13 - 15	Weekday		1,476	11.94	10.07	0.57	1.42	
		Weekend		962	18.13	3.97	0.65	1.25	
	16 - 18	Weekday		1,232	10.47	11.25	0.72	1.55	
		Weekend		786	16.44	5.40	0.67	1.50	
Japan ²⁾	10 - 19	Weekday	October	-	13.50 (M)	-	-	-	-
					12.75 (F)	-	-	-	-
		Weekend			17.30 (M)	-	-	-	-
					17.00 (F)	-	-	-	-
Japan ³⁾	16 - 18	Weekday	-	342	-	-	-	2.40	-
		Weekend	May to June		-	-	-	2.64	-

1) Korean National Institute of Environmental Research (NIER). "Korean exposure factors handbook for children." (2019).

2) NHK Broadcasting Culture Research Institute "National Time Use Survey" (2020).

3) Shiotsu, Mika, et al. "Survey on human activity patterns according to time and place. Basic research on the exposure dose to indoor air pollutants-part 1." Journal of Architecture Planning and Environmental Engineering (1998): 45-52.

Table 4.3. Comparison of Location-Based Activity Time by Country (2)

Country	Age Group (years)	Weekday/Weekend	Season	Participants	(unit: hr)				
					Indoor			Outdoor	In-Vehicles
					House	School	Others		
Germany ¹⁾	3 - 5	Overall	-	383	16.32	3.05		3.98	
	6 - 8	Overall	-	419	15.58	4.07		3.93	
	9 - 11	Overall	-	414	15.23	5.13		3.62	
	16 - 18	Overall	-	454	15.00	5.60		3.38	
Germany ²⁾	< 7	Overall	-	513	17.60	-	-	-	
	7 - 16	Overall	-	1,264	14.80	-	-	-	
	17 - 24	Overall	-	840	12.60	-	-	-	
Canada ³⁾	< 1	Overall	Summer + Winter	161	21.38	1.17		0.95	
	1 - 4	Overall	Summer + Winter	269	17.73	3.67		1.82	
	5 - 11	Overall	Summer + Winter	428	17.12	4.27		1.80	
	12 - 19	Overall	Summer + Winter	330	16.67	4.98		1.48	
US ⁴⁾ (Nordic Countries/Australia)	1 -< 2	Overall	-	-	22.55			0.60(0.4 ⁵⁾)	
	2 -< 3	Overall	-	-	21.93			1.27(1.4 ⁵⁾)	
	3 -< 6	Overall	-	-	21.30			1.78(2 ⁵⁾)	
	6 -< 11	Overall	-	-	20.73			2.20	
	11 -< 16	Overall	-	-	21.00			1.67	
	16 -< 21	Overall	-	-	20.80			1.70	

1) Brasche, Sabine, and Wolfgang Bischof. "Daily time spent indoors in German homes-baseline data for the assessment of indoor exposure of German occupants." International journal of hygiene and environmental health 208.4 (2005): 247-253.

2) Conrad, Andre, et al. "The German Environmental Survey for Children (GerES IV): Reference values and distributions for time-location patterns of German children." International journal of hygiene and environmental health 216.1 (2013): 25-34.

3) Matz, Carlyn J., et al. "Effects of age, season, gender and urban-rural status on time-activity: Canadian Human Activity Pattern Survey 2 (CHAPS 2)." International journal of environmental research and public health 11.2 (2014): 2108-2124.

4) US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.

5) Commonwealth of Australia. Australian exposure factor guidance, Guidelines for assessing human health risks from environmental hazards, 2012.
For Australia, time spent outdoors for children <1, 1-2, and 2-3 years old, Australian data from Brinkman et al. (1999) are suggested

4.3. Behaviour Frequency and Duration

4.3.1. Status of Data by Country

Unlike adults, children often engage in behaviours like sucking their hands or objects. These behaviours can significantly impact their exposure to contaminants and are thus crucial in children's exposure assessments.

The frequency and duration of these behaviours are typically analysed through surveys or video recordings. It should be noted that surveys may produce subjective responses, depending on the respondent (e.g., parents or guardians). In the case of video recordings, the observer may operate the camera in person, or an observation camera may be installed. When the observer records in person, it ensures consistency in interpreting the children's behaviours, but the presence of the observer may influence the children's actions. Using an observation camera reduces the impact of others' presence, but children who are old enough to be aware of the camera may alter their behaviour and the camera's location or angle could hinder the accurate observation of children's behaviours.

This report presents data on the frequency and duration of hand-to-mouth and object-to-mouth behaviours. Additionally, some countries have provided data on the frequency and duration of other behaviours, such as hand-to-others, time spent bathing, showering, playing on the floor, and smartphone usage.

It was found that among OECD member countries, Korea, the Netherlands, Nordic countries, the United States, and Australia have compiled data on the frequency and duration of behaviours.

Table 4.4. Status of Behaviour Frequency and Duration Data by Country

Category		Korea	Netherlands	Nordic countries	US	Australia
Hand-to-mouth	Frequency	0		0	0	
	Duration	0	0		0	
Object-to-mouth	Frequency	0		0	0	
	Duration	0	0	0	0	0
Hand-to-others	Frequency				0	
	Duration				0	
Other activities ¹⁾	Frequency	0				0
	Duration	0			0	0

1) Bathing, Showering, Playing on The Floor, Using Smartphones

4.3.2. Comparison by Country

1) Hand-to-Mouth

In Korea, hand-to-mouth and object-to-mouth behaviours in children under 6 years old were observed through video recordings, with the frequency per hour (contacts/hr) and duration per contact (sec/contact) being recorded. The recordings took place in kindergartens and indoor spaces in homes (with one parent present), where children spend a significant amount of time. It appears that the presence of parents and teachers likely influenced the lower frequency of sucking behaviours compared to other countries. Additionally, the frequency and duration of hand-to-mouth behaviours decreased with age.

The Netherlands used data from Groot (1998), which observed children under 3 years old in the country and recorded the types and durations of objects brought to their mouths. Among the data, the average duration of hand-to-mouth behaviour was provided. For comparison, the table provides values converted from min/day in the original source to min/hr.

Nordic countries propose using data from the United States (US EPA, 2011) for the frequency of hand-to-mouth behaviour. This is because, although behaviour patterns may vary between European and American children, the data from the United States is based on more recent studies and European data is often limited in its use, as it typically provides only a single value for specific assessments.

The United States uses values from the study by Xue et al. (2007) for the frequency of hand-to-mouth behaviour. The study collected and analysed frequency data on hand-to-mouth behaviours to generate a frequency distribution. In general, the frequency of hand-to-mouth behaviour decreases with age, although there is a slight increase between the age groups of 2-3 years and 3-6 years.

Australia used the US representative value (US EPA, 2011) for the frequency of hand-to-mouth behaviour, while the duration of hand-to-mouth behaviour is based on the findings of a study conducted in the United Kingdom (UK DTI, 2002). The study observed mouthing behaviours in UK children with objects such as pacifiers, fingers, toys, and others, among which the data on fingers was used and averaged for the relevant age groups. For comparison, the table shows values converted from hr/day in the original source to min/hr.

Table 4.5. Comparison of Hand-to-Mouth Frequency and Duration by Country

Category	Korea ¹⁾	Netherlands ²⁾	US ^{3)/Nordic countries/Australia}	Australia ⁴⁾
Frequency (contacts/hr)	< 12 months: 2.68 1 - 2 years: 2.14 3 - 6 years: 1.42		[Indoor] 3 -< 6 months: 28 6 -< 12 months: 19 1 -< 2 years: 20 2 -< 3 years: 13 3 -< 6 years: 15 6 -< 11 years: 7 [Outdoor] 6 -< 12 months: 15 1 -< 2 years: 14 2 -< 3 years: 5 3 -< 6 years: 9 6 -< 11 years: 3	
Duration* (min/hr)	< 12 months: 2.73 1 - 2 years: 1.25 3 - 6 years: 0.20	3 - 6 months: 0.85 6 - 12 months: 0.31 12 - 18 months: 0.24 18 - 36 months: 0.26		1 -< 3 months: 0.75 3 -< 12 months: 1 1 -< 2 years: 0.75 2 -< 3 years: 1.25 3 -< 4 years: 1.5 4 -< 5 years: 0.75 5 -< 6 years: 1.75

1) Korean National Institute of Environmental Research (NIER). "Korean exposure factors handbook for children." (2019).

2) Groot, E. M. et al. "Mouthing behaviour of young children; An observational study (summary report)." RIVM report 613320 002. RIVM Bilthoven, The Netherlands, September 1998 (1998).

3) US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.

4) Commonwealth of Australia. Australian exposure factor guidance, Guidelines for assessing human health risks from environmental hazards, 2012.

* Note: Values for the Netherlands have been converted from min/day as reported in the original source (Groot, 1998) to min/hr for comparison purposes.

Values for the Australia have been converted from min/day as reported in the original source (US-EPA, 2011) to min/hr for comparison purposes.

2) Object-to-Mouth

In Korea, hand-to-mouth and object-to-mouth behaviours in children under 6 years old were observed through video recordings, with the frequency and duration being recorded. The recordings took place in kindergartens and indoor spaces in homes (with one parent present), where children spend a significant amount of time. It appears that the presence of parents and teachers likely influenced the lower frequency of sucking behaviours compared to other countries. Both the frequency (2.46 contacts/hr) and duration (1.23 min/hr) of object-to-mouth behaviour were highest in the 1-2 age group.

In the United States, the frequency of object-to-mouth behaviour is based on data derived from the study by Xue et al. (2010), while the duration is sourced from the studies by Juberg et al. (2001), Greene (2002), and Beamer et al. (2008). The frequency of object-to-mouth behaviour notably decreased after the 3-6 age group, both indoors and outdoors.

Table 4.6. Comparison Object-to-Mouth Frequency and Duration by Country

Category	Korea ¹⁾	US ^{2)/Nordic countries}
Frequency (contacts/hr)	< 12 months: 2.27 1 - 2 years: 2.46 3 - 6 years: 0.61	[Indoor] 3 -< 6 months: 11 6 -< 12 months: 20 1 -< 2 years: 14 2 -< 3 years: 9.9 3 -< 6 years: 10 6 -< 11 years: 1.1
		[Outdoor] 1 -< 2 years: 8.8 2 -< 3 years: 8.1 3 -< 6 years: 8.3 6 -< 11 years: 1.9
Duration (min/hr)	< 12 months: 0.92 1 - 2 years: 1.23 3 - 6 years: 0.17	3 -< 6 months: 11 6 -< 12 months: 9 1 -< 2 years: 7 2 -< 3 years: 10
		* Juberg et al., 2001; Greene, 2002; Beamer et al., 2008

1) Korean National Institute of Environmental Research (NIER). "Korean exposure factors handbook for children." (2019).

2) US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.

The Netherlands also has conducted studies to determine representative values for mouthing duration by object. However, since the values have been provided separately for each object, the country is not included in the cross-country comparison table in Table 37 and is presented separately. Nordic countries also use the same values as the Netherlands.

Table 4.7. Netherlands – Default Mouthing Times for Children

		(unit: min/day)			
Category	Age Group	Australia			
		Pacifier	Toy for mouthing ¹⁾	Other toy ²⁾	Non toy ³⁾
Duration	4.5 months	285	11	27	8
	7.5 months	82	21	63	23
	13.5 months	52	0	9	26
	18 months	62	0	3	6

* Bremmer, H. J., and M. P. Van Veen. "Children's toys fact sheet." (2002).

1) different kinds of teething rings, some rattles

2) cloth books, plastic books, cuddly toy

3) a piece of cloth, a piece of paper, a book for adults, flatware

Australia presents the representative average values on object-to-mouth time based on a UK Study conducted on its children (UK DTI, 2002). The duration for mouthing fingers was included in the cross-country comparison table in Table 37. However, since the durations for pacifiers, toys, and other objects were provided separately, they are not included in the comparison table but are presented separately in Table 4.8.

As age increased, the duration mouthing pacifiers and toys decreased. However, the duration mouthing fingers was the longest in the 5-6 age group, the oldest age group, with an average of 0.7 hours per day.

Table 4.8. Australia – Suggested Values for Mouthing Duration (Mean)

		(unit: hr/day)			
Category	Age Group	Australia			
		Pacifier	Fingers	Toys	Other objects
Duration	1 -< 3 months	0.8	0.3	0.003	0.1
	3 -< 12 months	0.5	0.4	0.5	0.3
	1 -< 2 years	0.7	0.3	0.2	0.3
	2 -< 3 years	0.5	0.5	0.2	0.4
	3 -< 4 years	0.8	0.6	0.2	0.3
	4 -< 5 years	0.3	0.3	0.05	0.2
	5 -< 6 years	0.005	0.7	0.03	0.2

* Commonwealth of Australia. Australian exposure factor guidance, Guidelines for assessing human health risks from environmental hazards, 2012.

References

Beamer, Paloma, et al. "Quantified activity pattern data from 6 to 27-month-old farmworker children for use in exposure assessment." *Environmental research* 108.2 (2008): 239-246.

Black, Kathleen, et al. "Children's mouthing and food-handling behaviour in an agricultural community on the US/Mexico border." *Journal of Exposure Science & Environmental Epidemiology* 15.3 (2005): 244-251.

Brasche, Sabine, and Wolfgang Bischof. "Daily time spent indoors in German homes-baseline data for the assessment of indoor exposure of German occupants." *International journal of hygiene and environmental health* 208.4 (2005): 247-253.

Bremmer, H. J., and M. P. Van Veen. "Children's toys fact sheet." (2002).

Commonwealth of Australia. *Australian exposure factor guidance, Guidelines for assessing human health risks from environmental hazards*, 2012.

Conrad, André, et al. "The German Environmental Survey for Children (GerES IV): Reference values and distributions for time-location patterns of German children." *International journal of hygiene and environmental health* 216.1 (2013): 25-34.

European Centre for Ecotoxicology and Toxicology of Chemicals. "Exposure Factors Sourcebook for European Populations (with Focus on UK Data)." (2001).

Groot, E. M. et al. "Mouthing behaviour of young children; An observational study (summary report)." RIVM report 613320 002. RIVM Bilthoven, The Netherlands, September 1998 (1998).

Korean National Institute of Environmental Research (NIER). "Korean exposure factors handbook for children." (2019).

Matz, Carlyn J., et al. "Effects of age, season, gender and urban-rural status on time-activity: Canadian Human Activity Pattern Survey 2 (CHAPS 2)." *International journal of environmental research and public health* 11.2 (2014): 2108-2124.

Matz, Carlyn J., et al. "Evaluation of daily time spent in transportation and traffic-influenced microenvironments by urban Canadians." *Air Quality, Atmosphere & Health* 11 (2018): 209-220.

NHK Broadcasting Culture Research Institute "National Time Use Survey" (2020).

Nielsen, Elsa, and Pelle Thonning Olesen. *Existing default values and recommendations for exposure assessment: Revision of the 2011 report, a Nordic exposure group project 2022*. Nordic Council of Ministers, 2023.

Korea Ministry of Environment (Korea ME), 2019. "Children's risk and exposure assessment methodology (CREAM)." <https://scienceon.kisti.re.kr/commons/util/originalView.do?cn=TRKO201900002702&dbt=TRKO&rn=>

Shiotsu, Mika, et al. "Survey on human activity patterns according to time and place. Basic research on the exposure dose to indoor air pollutants-part 1." *Journal of Architecture Planning and Environmental Engineering* (1998): 45-52.

US EPA (US Environmental Protection Agency). *Exposure factors handbook: 2011 edition*, 2011.

Wilson, Amanda M., et al. "Frequency of hand-to-head,-mouth,-eyes, and-nose contacts for adults and children during eating and non-eating macro-activities." *Journal of exposure science & environmental epidemiology* 31.1 (2021): 34-44.

Xue, Jianping, et al. "A meta - analysis of children's hand - to - mouth frequency data for estimating nondietary ingestion exposure." *Risk Analysis: An International Journal* 27.2 (2007): 411-420.

Xue, Jianping, et al. "A meta-analysis of children's object-to-mouth frequency data for estimating non-dietary ingestion exposure." *Journal of exposure science & environmental epidemiology* 20.6 (2010): 536-545.

5. Consumer Product Use Patterns

5.1. Overview

Children use various products in their daily lives, which can result in skin contact, inhalation, or intake during use. These products may contain contaminants or other substances that could potentially affect the human body, to which children can be exposed during use. This report focuses on the frequency, amount, and duration of use of consumer products, such as care products, cosmetics, and toys, to which children are easily likely to be exposed.

The types of consumer products used by children, along with additional related data, can be further explored in the referenced literature and supplementary materials. Notably, *Korea ME (2019)* and *Bremmer et al. (2016)* provide extensive data on consumer product use patterns. Since this project only highlights a subset of items investigated by the project-leading country, it is recommended to consult the listed references for a more comprehensive understanding of additional consumer product use patterns if further confirmation is needed.

5.2. Care Products and Cosmetics

5.2.1. Status of Data by Country

It has been found that data on care products and cosmetic use patterns were available for six OECD member countries, including Canada, France, Korea, the Netherlands, as well as Spain, Germany, and other European countries. Data availability by country is provided in Table 40, given the variety of detailed product types and the values provided (e.g., daily usage frequency, amount per use, and duration per use).

Korea has provided data on the frequency, amount, and duration of use for each product based on a survey from a study by the Korea Environmental Industry & Technology Institute (2018), which was conducted to determine exposure factors for children's product use.

France has sourced data from a study by Gomez-Berrada, Marie-Pierre, et al. (2017), which assessed the use and exposure to certain baby care products (e.g., shampoo, shower gel) among infants aged 0-23 months.

The Netherlands' data is derived from a study by Bremmer et al. (2006). The study used a mathematical model to calculate exposure and intake values for products across 35 major categories. The calculations were conducted using a computer program called ConsExpo (Consumer Exposure).

Nordic countries provided exposure values from their National Exposure Factor Handbook for cosmetics used by children, which are based on the Netherlands Children's Toys Fact Sheet (RIVM, 2002).

Switzerland has conducted a survey on the usage amounts, frequency, and application areas of household cleaning and personal hygiene products to assess the health risks associated with the chemicals they contain. The survey included data for children aged under 12 years old, which was used for this report. (Garcia-Hidalgo, Elena, et al., 2017)

Germany, Spain, and other European countries presented values from the study by Gomez-Berrada, Marie-Pierre, et al. (2017). The study compiled usage data for family-use cosmetics across ten categories (e.g., shampoo, shower gel, soap) and conducted consumption and exposure assessments.

Canada has provided data sourced from 18 different studies, including the Gomez-Berrada, Marie-Pierre, et al. (2017) used in France.

Table 5.1. Status of Care Product Data by Country

Category	Sub-category	Korea			France			Netherlands			Nordic countries			Switzerland			Spain, Germany, and other countries			Canada		
		Frequency	Amount	Duration	Frequency	Amount	Duration	Frequency	Amount	Duration	Frequency	Amount	Duration	Frequency	Amount	Duration	Frequency	Amount	Duration	Frequency	Amount	Duration
Toiletries	Shampoo	0	0	0	0	0								0			0			0	0	
	Conditioner													0						0	0	
	Soap	0		0													0					
	Body Wash/Shower Gel	0	0	0	0	0								0			0			0	0	
	Bubble Bath													0								
	Facial Cleanser				0	0								0			0					
	Toothbrush	0		0																		
	Toothpaste							0	0					0						0	0	
	Hand Soap	0	0	0										0						0	0	
	Hand Sanitizer																			0	0	
Skin Care	Hand Cream													0								
	Lotion	0	0											0						0	0	
	Cream				0	0								0			0			0	0	
	Balm																0					
	Oil	0	0																	0	0	
	Suncream/Spray	0	0																	0	0	
	Baby Powder	0	0																	0	0	
	Foundation													0								
Make-Up	Powder																			0	0	
	Blusher										0	0										
	Shadow	0									0	0								0		
	Lip Care/Lip Balm	0															0			0		
	Lipstick										0	0										
	Make-Up Remover													0								
	Nail Polish	0		0							0	0								0	0	
	Cotton Swab, Cotton Bud	0		0																		
Others	Wet Tissue	0	0											0						0	0	
	Wet Tissue (Oral Cleaning)	0		0																		
	Disposable Diaper	0		0																		

5.2.2. Comparison by Country

Comparison tables have been prepared, primarily covering products for which data from various countries is available. These include shampoo, body wash/shower gel, lotion, and wet tissues.

1) Shampoo

Overall, the amount of shampoo used increased with age. In terms of frequency, children in Korea had higher usage frequency than children in Canada at similar age groups.

Table 5.2. Comparison of Shampoo by Country

Country	Age Group (years)	Gender	Season	Amount		Duration min/event	Frequency event/day
				g/event(g/use)	g/day		
Korea ¹⁾	0 - 2	Boy	Summer + Winter	0.55	-	5.39	0.93
		Girl	Summer + Winter	0.55	-	5.57	0.94
	3 - 6	Boy	Summer + Winter	0.66	-	6.55	0.93
		Girl	Summer + Winter	0.68	-	6.78	0.91
	7 - 9	Boy	Summer + Winter	0.66	-	7.32	0.88
		Girl	Summer + Winter	0.71	-	7.82	0.90
10 - 12	Boy	Summer + Winter	0.69	-	7.25	0.91	
	Girl	Summer + Winter	0.84	-	7.65	0.92	
France ²⁾	0 – 23 months	All	-	3.90	2.90	-	0.80
Switzerland ³⁾	0 - 5	Boy	-	3.00	1.30	-	-
		Girl	-	4.00	1.60	-	-
	6 - 12	Boy	-	4.40	1.90	-	-
		Girl	-	7.40	3.10	-	-
Spain, Germany, and others ⁴⁾	0 - 3	Boy	-	8.40	5.90	-	-
	4 - 12	Girl	-	11.30	10.00	-	-
Canada	0 - 5 months	All	-	3.90 ⁵⁾	-	-	0.64 ⁹⁾
	6 - 11 months	All	-	5.60 ⁶⁾	-	-	0.64 ⁹⁾
	1	All	-	6.10 ⁶⁾	-	-	0.64 ⁹⁾
	2 - 3	All	-	7.90 ⁶⁾	-	-	0.65 ⁶⁾
	4 - 8	All	-	9.70 ⁶⁾	-	-	0.64 ⁶⁾
	9 - 13	All	-	7.50 ⁷⁾	-	-	0.70 ¹⁰⁾
	14 - 18	All	-	10.40 ⁷⁾	-	-	0.70 ¹⁰⁾

1) Korea Ministry of Environment (Korea ME), 2019. "Children's risk and exposure assessment methodology (CREAM)."

<https://scienceon.kisti.re.kr/commons/util/originalView.do?cn=TRKO201900002702&dbt=TRKO&rn=>

2) Gomez-Berrada, Marie-Pierre, et al. "Consumption and exposure assessment to cosmetic products for children under 2 years old." Food and Chemical Toxicology 105 (2017): 151-160.

3) Garcia-Hidalgo, Elena, et al. "Use-patterns of personal care and household cleaning products in Switzerland." Food and chemical toxicology 99 (2017): 24-39.

4) Gomez-Berrada, M. P., et al. "Exposure assessment of family cosmetic products dedicated to babies, children and adults." Food and Chemical Toxicology 103 (2017): 56-65.

5) Gomez-Berrada, Marie-Pierre, et al. "Consumption and exposure assessment to cosmetic products for children under 2 years old." Food and Chemical Toxicology 105 (2017): 151-160.

6) Gomez-Berrada, Marie-Pierre, et al. "Retrospective exposure data for baby and children care products: an analysis of 48 clinical studies." Food and chemical toxicology 57 (2013): 185-194.

7) Ficheux, A. S., et al. "Consumption of cosmetic products by the French population second part: amount data." Food and Chemical Toxicology 90 (2016): 130-141.

8) Loretz, L. J., et al. "Exposure data for cosmetic products: facial cleanser, hair conditioner, and eye shadow." Food and chemical Toxicology 46.5 (2008): 1516-1524.

9) Ficheux, A. S., et al. "Consumption of cosmetic products by the French population. First part: frequency data." Food and Chemical Toxicology 78 (2015): 159-169.

10) Wu, Bennett, et al. "Usage pattern of personal care products in California households." *Food and chemical toxicology* 48.11 (2010): 3109-3119.

2) Body Wash/Shower Gel

The amount of body wash and shower gel used, and their duration tended to increase with age, but in Canada, the amount used remained consistent across all age groups.

Table 5.3. Comparison of Body Wash/Shower Gel by Country

Country	Age Group (years)	Gender	Season	Amount		Duration min/event	Frequency event/day
				g/event(g/use)	g/day		
Korea ¹⁾	0 - 2	Boy	Summer + Winter	0.96	-	10.88	0.94
		Girl	Summer + Winter	0.93	-	10.68	0.95
	3 - 6	Boy	Summer + Winter	1.05	-	11.93	0.95
		Girl	Summer + Winter	1.08	-	12.11	0.93
	7 - 9	Boy	Summer + Winter	1.14	-	12.94	0.91
		Girl	Summer + Winter	1.14	-	13.24	0.93
	10 - 12	Boy	Summer + Winter	1.18	-	13.28	0.88
		Girl	Summer + Winter	1.23	-	13.40	0.91
France ²⁾	0 - 23 months	All	-	6.0	4.4	-	0.8
Switzerland ³⁾	0 - 5	Boy	-	6.7	2.4	-	-
		Girl	-	5.2	2.7	-	-
	6 - 12	Boy	-	9.3	6.0	-	-
		Girl	-	10.9	5.1	-	-
Spain, Germany, and others ⁴⁾	Shower Gel	0 - 3	All	-	17.5	13.0	-
		4 - 12	All	-	31.1	17.4	-
	Emollient Bath	0 - 3	All	-	9.7	12.2	-
		4 - 12	All	-	9.7	13.4	-
Canada ⁵⁾	0 - 5 months	All	-	6.0	-	-	-
	6 - 11 months	All	-	6.0	-	-	-
	1	All	-	6.0	-	-	-
	2 - 3	All	-	6.0	-	-	-

1) Korea Ministry of Environment (Korea ME), 2019. "Children's risk and exposure assessment methodology (CREAM)."

<https://scienceon.kisti.re.kr/commons/util/originalView.do?cn=TRKO201900002702&dbt=TRKO&rn=>

2) Gomez-Berrada, Marie-Pierre, et al. "Consumption and exposure assessment to cosmetic products for children under 2 years old." Food and Chemical Toxicology 105 (2017): 151-160.

3) Garcia-Hidalgo, Elena, et al. "Use-patterns of personal care and household cleaning products in Switzerland." Food and chemical toxicology 99 (2017): 24-39.

4) Gomez-Berrada, M. P., et al. "Exposure assessment of family cosmetic products dedicated to babies, children and adults." Food and Chemical Toxicology 103 (2017): 56-65.

5) Gomez-Berrada, Marie-Pierre, et al. "Consumption and exposure assessment to cosmetic products for children under 2 years old." Food and Chemical Toxicology 105 (2017): 151-160.

6) Ficheux, A. S., et al. "Consumption of cosmetic products by the French population. First part: frequency data." Food and Chemical Toxicology 78 (2015): 159-169.

3) Lotion

In Korea, there was no noticeable difference in the amount of lotion used between genders, whereas in Switzerland, girls used more lotion than boys.

Table 5.4. Comparison of Lotion by Country

Country	Age Group (years)	Gender	Season	Amount		Frequency
				g/day	event/day	event/day
Korea ¹⁾	0 - 2	Boy	Summer + Winter	1.25	-	1.53
		Girl	Summer + Winter	1.20	-	1.55
	3 - 6	Boy	Summer + Winter	1.22	-	1.53
		Girl	Summer + Winter	1.23	-	1.56
	7 - 9	Boy	Summer + Winter	1.21	-	1.48
		Girl	Summer + Winter	1.19	-	1.55
	10 - 12	Boy	Summer + Winter	1.18	-	1.47
		Girl	Summer + Winter	1.24	-	1.55
Switzerland ²⁾	0 - 5	Boy	-	6.5	3.4	-
		Girl	-	9.7	7.0	-
	6 - 12	Boy	-	9.1	2.5	-
		Girl	-	11.1	3.1	-
Canada	0 - 5 months	All	-	2.1 ³⁾	-	0.8 ⁵⁾
	6 - 11 months	All	-	2.7 ³⁾	-	0.8 ⁵⁾
	1	All	-	3.2 ³⁾	-	0.8 ⁵⁾
	2 - 3	All	-	4.1 ⁴⁾	-	0.8 ⁵⁾
	4 - 8	All	-	5.2 ³⁾	-	0.8 ⁶⁾
	9 - 13	All	-	7.7 ³⁾	-	0.8 ⁶⁾
	14 - 18	All	-	10.0 ⁴⁾	-	0.8 ⁶⁾

1) Korea Ministry of Environment (Korea ME), 2019. "Children's risk and exposure assessment methodology (CREAM)."

<https://scienceon.kisti.re.kr/commons/util/originalView.do?cn=TRKO201900002702&dbt=TRKO&rn=>

2) Garcia-Hidalgo, Elena, et al. "Use-patterns of personal care and household cleaning products in Switzerland." Food and chemical toxicology 99 (2017): 24-39.

3) Surface area adjustment based on other age groups

4) Ficheux, A. S., et al. "Consumption of cosmetic products by the French population. First part: frequency data." Food and Chemical Toxicology 78 (2015): 159-169.

5) Ficheux, A. S., et al. "Consumption of cosmetic products by the French population second part: amount data." Food and Chemical Toxicology 90 (2016): 130-141.

6) Wu, Bennett, et al. "Usage pattern of personal care products in California households." Food and chemical toxicology 48.11 (2010): 3109-3119.

4) Wet Tissues

The use of wet tissues generally decreased with age across all countries.

Table 5.5. Comparison of Wet Tissues by Country

Country	Age Group (years)	Gender	Season	Amount				Frequency	
				ea/event	g/use	g/day	g/wipe	event/day	wipe/day
Korea ¹⁾	0 - 2	Boy	Summer + Winter	9.97	-	-	-	6.57	-
		Girl	Summer + Winter	10.14	-	-	-	6.70	-
	3 - 6	Boy	Summer + Winter	9.18	-	-	-	3.45	-
		Girl	Summer + Winter	9.08	-	-	-	3.44	-
	7 - 9	Boy	Summer + Winter	8.55	-	-	-	2.13	-
		Girl	Summer + Winter	8.78	-	-	-	2.27	-
	10 - 12	Boy	Summer + Winter	8.64	-	-	-	1.99	-
		Girl	Summer + Winter	8.59	-	-	-	2.21	-
Switzerland ²⁾	0 - 5	Boy	-	-	1.9	3.5	-	-	-
		Girl	-	-	2.6	4.6	-	-	-
	6 - 12	Boy	-	-	2.4	1.1	-	-	-
		Girl	-	-	1.8	0.2	-	-	-
Canada	0 - 5 months	All	-	-	-	-	0.7 ³⁾	-	11.2 ⁴⁾
	6 - 11 months	All	-	-	-	-	0.7 ³⁾	-	11.2 ⁴⁾
	1	All	-	-	-	-	0.7 ³⁾	-	10.8 ⁴⁾
	2 - 3	All	-	-	-	-	0.7 ³⁾	-	9.81 ⁴⁾
	14 - 18	All	-	-	-	-	0.3 ³⁾	-	1.5 ⁵⁾

1) Korea Ministry of Environment (Korea ME), 2019. "Children's risk and exposure assessment methodology (CREAM)."

<https://scienceon.kisti.re.kr/commons/util/originalView.do?cn=TRKO201900002702&dbt=TRKO&rn=>

2) Garcia-Hidalgo, Elena, et al. "Use-patterns of personal care and household cleaning products in Switzerland." Food and chemical toxicology 99 (2017): 24-39.

3) Ficheux, A. S., et al. "Consumption of cosmetic products by the French population second part: amount data." Food and Chemical Toxicology 90 (2016): 130-141.

4) Dey, Swatee, et al. "Probabilistic Monte Carlo estimation for quantitative exposure assessment of lotion transfer via baby wipes usage." Regulatory Toxicology and Pharmacology 79 (2016): 54-63.

5) Ficheux, A. S., et al. "Consumption of cosmetic products by the French population. First part: frequency data." Food and Chemical Toxicology 78 (2015): 159-169.

5.3. Toy Products

5.3.1. Status of Data by Country

Data on the usage patterns of toy products is available for Australia, Korea, the Netherlands, Nordic countries, and the United States, among OECD member countries. Data availability for each country is shown in Table 45, categorized by product types and the values provided (e.g., usage frequency, duration).

SKorea has provided data on the frequency, amount, and duration of use for each product based on a survey from a study by the Korea Environmental Industry & Technology Institute (2018), which was conducted to determine exposure factors for children's product use.

The Netherlands has provided exposure factors for major children's toys in the Children's Toys Fact Sheet (Bremmer, H.J. and M.P. Van Veen, 2002). The relevant values were calculated using a mathematical model, with more details in the OECD Database on Children's Exposure Factors . Nordic countries also use this data for certain products in their National Exposure Factor Handbooks.

In the United States, data on the usage duration (sucking duration) of certain products, such as pacifiers, teethers, and soft plastic items, is available from a study by Greene (2002) conducted on children in the country.

Australia provides representative values for object-to-mouth time for pacifiers, fingers, toys, and other objects, based on a UK study (UK DTI 2002) conducted on the country's children, among which the data for pacifiers presented as the usage time for toy products.

Table 5.6. Status of Toy Products Data by Country

Category	Korea		Netherlands		Nordic countries		US		Australia	
	Frequency	Duration	Frequency	Duration	Frequency	Duration	Frequency	Duration	Frequency	Duration
Toy	Baby Bottle (Feeding)	0	0							
	Pacifier	0	0		0	0		0		0
	Teether	0	0		0				0	
	Plastic Toy (Soft Plastic Toy)								0	
	Rattle	0	0							
	Roly-Poly Toy	0	0							
	Modelling Clay	0	0	0	0	0	0			
	Slime	0	0							
	Soap Bubble Toy	0	0							
	Indoor Playing Mats	0	0							
	Outdoor Playing Mats	0	0							
	Indoor Swimming Pool	0	0							
Stationery	Automatic Pencil, Propelling Pencil, And Pencil	0	0							
	Eraser	0								
	Pen	0	0	0	0					
	Marker	0	0							
	Crayon	0	0							
	Colored Pencil	0	0							
	Glue (Stick and Liquid)	0								
Sticker	0	0								
Others ¹⁾			0	0	0	0	0	0		
Non toy ²⁾				0						

1) Paint from a toy car, piece of chalk, face paint, finger paint etc.

2) A piece of cloth, a piece of paper, a book for adults, flatware

5.3.2. Comparison by Country

A comparison table has been prepared, primarily covering products for which data from various countries is available, including pacifiers, teethingers, and children's clay.

1) Pacifier

In Australia, the usage duration for pacifiers was found to be shorter compared to the Netherlands and Nordic countries, reflecting a generally lower daily exposure across various age groups.

Table 5.7. Comparison of Pacifiers by Country

Country	Age Group (years)	Gender	Season	Frequency	Duration	
				event/day	min/day	min/event
Korea ¹⁾	0 - 2	Boy	Summer + Winter	2.84	-	17.33
		Girl	Summer + Winter	2.77	-	17.83
Netherlands ²⁾	3 - 6 months (4.5 months)	All	-	-	285	-
	6 - 12 months (7.5 months)	All	-	-	82	-
	12 - 18 months (13.5 months)	All	-	-	52	-
	18 - 36 months (18 months)	All	-	-	62	-
Nordic countries ³⁾	3 - 6 months (4.5 months)	All	-	-	285	-
	6 - 12 months (7.5 months)	All	-	-	82	-
	12 - 18 months (13.5 months)	All	-	-	52	-
	18 - 36 months (18 months)	All	-	-	62	-
US ⁴⁾	3 -< 12 months	All	-	-	81.6	-
	12 -< 24 months	All	-	-	62.4	-
	24 -< 36 months	All	-	-	43.2	-
Australia ⁵⁾	1 -< 3 months	All	-	-	48.0	-
	3 -< 12 months	All	-	-	30.0	-
	1 -< 2 years	All	-	-	42.0	-
	2 -< 3 years	All	-	-	30.0	-
	3 -< 4 years	All	-	-	48.0	-
	4 -< 5 years	All	-	-	18.0	-
	5 -< 6 years	All	-	-	0.6	-

1) Korea Ministry of Environment (Korea ME), 2019. "Children's risk and exposure assessment methodology (CREAM)."

<https://scienceon.kisti.re.kr/commons/util/originalView.do?cn=TRKO201900002702&dbt=TRKO&m=>

2) Bremmer, H. J., and M. P. Van Veen. "Children's toys fact sheet." (2002).

3) Nielsen, Elsa, and Pelle Thonning Olesen. Existing default values and recommendations for exposure assessment: Revision of the 2011 report, a Nordic exposure group project 2022. Nordic Council of Ministers, 2023. (Converted from min/hr to min/day for comparison)

4) US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.

5) Commonwealth of Australia. Australian exposure factor guidance, Guidelines for assessing human health risks from environmental hazards, 2012. (Converted from hr/day to min/day for comparison)

2) Teether

In Korea, the usage duration for teethers per occasion was longer for girls (9.0 min/event) than for boys (8.8 min/event), indicating a slight gender-based difference in teether usage patterns. Additionally, when compared to the US, where the usage duration is consistently reported as 0.0 min/event across all age groups (12–24 months to 24–36 months), Korean children exhibit significantly higher teether usage durations, highlighting a notable cultural or behavioural difference.

Table 5.8. Comparison of Teethers by Country

Country	Age Group (years)	Gender	Season	Frequency	Duration	
				event/day	min/event	min/hr
Korea ¹⁾	0 - 2	Boy	Summer + Winter	2.14	8.88	-
		Girl	Summer + Winter	2.15	9.08	-
US ²⁾	3 -< 12 months	All	-	-	-	0.2
	12 -< 24 months	All	-	-	-	0.0
	24 -< 36 months	All	-	-	-	0.0

1) Korea Ministry of Environment (Korea ME), 2019. "Children's risk and exposure assessment methodology (CREAM)."

<https://scienceon.kisti.re.kr/commons/util/originalView.do?cn=TRKO201900002702&dbt=TRKO&m=>

2) US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.

3) Children's Clay

In Korea, while there was little difference in the frequency of clay toy usage across age groups (ranging from 0.17 to 0.20 events/day), the usage duration per occasion tended to increase with age, rising from 16.36 min/event (0–2 years) to 29.54 min/event (10–12 years). In comparison, the Netherlands and Nordic countries show a much higher frequency of clay toy usage (e.g., 52.0 contacts/year in the Netherlands for the 4.5–5 age group) and a longer duration (60.0 min/event), suggesting that Korean children may engage less frequently but for comparable or slightly shorter durations per occasion depending on age.

Table 5.9. Comparison of Clay by Country

Country	Age Group (years)	Gender	Season	Frequency		Duration	
				events/day	contacts/year	min	min/event
Korea ¹⁾	0 - 2	Boy	Summer + Winter	0.19	-	-	16.36
		Girl	Summer + Winter	0.20	-	-	16.29
	3 - 6	Boy	Summer + Winter	0.18	-	-	24.01
		Girl	Summer + Winter	0.18	-	-	24.41
	7 - 9	Boy	Summer + Winter	0.17	-	-	28.21
		Girl	Summer + Winter	0.18	-	-	28.90
	10 - 12	Boy	Summer + Winter	0.13	-	-	28.41
		Girl	Summer + Winter	0.14	-	-	29.54
Netherlands ²⁾ /Nordic countries ³⁾	4.5	All	-	-	52.0	60.0	-

1) Korea Ministry of Environment (Korea ME), 2019. "Children's risk and exposure assessment methodology (CREAM)."

<https://scienceon.kisti.re.kr/commons/util/originalView.do?cn=TRKO201900002702&dbt=TRKO&m=>

2) Bremmer, H. J., and M. P. Van Veen. "Children's toys fact sheet." (2002).

3) Nielsen, Elsa, and Pelle Thonning Olesen. Existing default values and recommendations for exposure assessment: Revision of the 2011 report, a Nordic exposure group project 2022. Nordic Council of Ministers, 2023.

References

- Bremmer, H. J., and M. P. Van Veen. "Children's toys fact sheet." (2002).
- Bremmer, H. J., L. C. H. Prud'Homme de Lodder, and J. G. M. Van Engelen. "Cosmetics Fact Sheet. To assess the risks for the consumer. Updated version for ConsExpo 4." (2006).
- Bremmer, H. J., and M. P. Van Veen. "Children's toys fact sheet." (2002).
- Nielsen, Elsa, and Pelle Thonning Olesen. Existing default values and recommendations for exposure assessment: Revision of the 2011 report, a Nordic exposure group project 2022. Nordic Council of Ministers, 2023.
- Dey, Swatee, et al. "Probabilistic Monte Carlo estimation for quantitative exposure assessment of lotion transfer via baby wipes usage." *Regulatory Toxicology and Pharmacology* 79 (2016): 54-63.
- Gomez-Berrada, M. P., et al. "Exposure assessment of family cosmetic products dedicated to babies, children and adults." *Food and Chemical Toxicology* 103 (2017): 56-65.
- Garcia-Hidalgo, Elena, et al. "Use-patterns of personal care and household cleaning products in Switzerland." *Food and chemical toxicology* 99 (2017): 24-39.
- Gomez-Berrada, Marie-Pierre, et al. "Consumption and exposure assessment to cosmetic products for children under 2 years old." *Food and Chemical Toxicology* 105 (2017): 151-160.
- Anderson, Elizabeth L., et al. "Assessment of health risk from historical use of cosmetic talcum powder." *Risk Analysis* 37.5 (2017): 918-929.
- Bánsághi, Száva, et al. "Critical reliability issues of common type alcohol-based handrub dispensers." *Antimicrobial Resistance & Infection Control* 9 (2020): 1-13.
- Bennett, Deborah H., et al. "Usage pattern of personal care products in California households." *Food and chemical toxicology* 48.11 (2010): 3109-3119.
- Cosmetic, Toiletry, and Fragrance Association. "Summary for the Results of Surveys of the amount and Frequency of use of cosmetic products by Women." Report prepared by Environ Corporation, Washington, DC. Washington (DC): CTFA (1983).
- Dey, Swatee, et al. "Probabilistic Monte Carlo estimation for quantitative exposure assessment of lotion transfer via baby wipes usage." *Regulatory Toxicology and Pharmacology* 79 (2016): 54-63.
- Ficheux, A. S., et al. "Consumption of cosmetic products by the French population second part: amount data." *Food and Chemical Toxicology* 90 (2016): 130-141.
- Ficheux, A. S., et al. "Consumption of cosmetic products by the French population. First part: frequency data." *Food and Chemical Toxicology* 78 (2015): 159-169.
- Ficheux, A. S., et al. "Probabilistic assessment of exposure to nail cosmetics in French consumers." *Food and Chemical Toxicology* 66 (2014): 36-43.

Gomez-Berrada, Marie-Pierre, et al. "Retrospective exposure data for baby and children care products: an analysis of 48 clinical studies." *Food and chemical toxicology* 57 (2013): 185-194.

Greene, M. A. "Mouthing times among young children from observational data." US Consumer Product Safety Commission: Bethesda, MD, USA (2002).

Health Canada. 2021. Screening assessment talc.. Ottawa (ON): Government of Canada. (professional judgement and labels, use daily)

Hendriks, H. S., et al. "Beoordeling van gezondheidsrisico's bij gebruik van ethanol bevattende handgel." (2021).

Korea Ministry of Environment (Korea ME), 2019. "Children's risk and exposure assessment methodology (CREAM)."

<https://scienceon.kisti.re.kr/commons/util/originalView.do?cn=TRKO201900002702&dbt=TRKO&rn=>

Loretz, Linda, et al. "Exposure data for personal care products: hairspray, spray perfume, liquid foundation, shampoo, body wash, and solid antiperspirant." *Food and Chemical Toxicology* 44.12 (2006): 2008-2018.

Loretz, L. J., et al. "Exposure data for cosmetic products: facial cleanser, hair conditioner, and eye shadow." *Food and chemical Toxicology* 46.5 (2008): 1516-1524.

Custom tabulation of grooming products data from the Canadian Health Measures Survey Cycle 2

Strittholt, C. A., et al. "A randomized clinical study to assess ingestion of dentifrice by children." *Regulatory Toxicology and Pharmacology* 75 (2016): 66-71.

Beamer, Paloma, et al. "Quantified activity pattern data from 6 to 27-month-old farmworker children for use in exposure assessment." *Environmental research* 108.2 (2008): 239-246.

US EPA (US Environmental Protection Agency). *Exposure factors handbook: 2011 edition*, 2011.

Commonwealth of Australia. *Australian exposure factor guidance, Guidelines for assessing human health risks from environmental hazards*, 2012.

6. Soil and Dust Ingestion

6.1. Overview

Soil and dust ingestion must be considered in exposure assessments because they are one of the main routes through which harmful substances in the environment may enter the human body. Soil and dust may contain heavy metals and organic chemicals, such as lead, cadmium, and dioxins, which, if directly ingested, can accumulate in the human body and cause chronic health effects. The significance of soil and dust ingestion is particularly evident in children. In addition to soil and dust ingestion, incidental water ingestion should also be considered in exposure assessments. Comprehensive analysis is required, as health impacts can vary by country. Therefore, this chapter provides exposure factors related to soil and dust, incidental water ingestion during swimming, and adherence of solids to the skin.

Children are at greater risk of oral exposure to soil and dust than adults, given their physiological and behavioural characteristics. They are more likely to directly ingest soil and dust by frequently playing on the floor and engaging in hand-to-mouth behaviours. These behavioural characteristics serve as direct pathways for ingestion, increasing the likelihood that harmful substances in soil and dust will be absorbed into the body. Because children's immune and nervous systems are still developing and are more sensitive than those of adults, they are also more likely to be affected by harmful substances if they accumulate in their bodies.

Comparing exposure factors for soil and dust across countries can serve as a mean for understanding the level of environmental pollution and the public health status of each nation. However, considering the differences in climate, industrial structure, economic conditions, and geographic and social characteristics, it is difficult to generalise the situation in each country based solely on comparisons of soil and dust ingestion. Additionally, it should be noted that there may be limitations in making accurate comparisons, as measurement methods and sampling criteria for soil and dust-related data may vary between countries.

The most common method for measuring soil and dust ingestion is the tracer element method. This method employs a specific element or substance as a tracer to indirectly estimate the amount of soil and dust absorbed by the human body. Other methods, such as bio-kinetic model comparisons and activity pattern analysis, are also used. Therefore, it is important to give due consideration to the measurement methods selected when comparing data.

6.2. Status of Data by Country

Countries that have provided representative values for soil and dust ingestion include Australia, Germany, Japan, Korea, the United States, and among OECD member countries.

Both the United States and Australia have also provided estimates for the amount of water unintentionally ingested while swimming, and the United States has provided representative values for the amount of solids adhered to the skin during different activities.

Table 6.1. Status of Data on Ingestion of Soil and Dust by Country

Category		Korea	Japan	Germany	Netherlands	Nordic countries	Canada	US	Australia
Ingestion	Soil and Dust	0		0	0	0	0	0	
	Soil	0	0	0		0	0	0	
	Dust	0			0	0	0	0	
	Water (during swimming)							0	0
Adherence (of solid/soil) to Skin								0	0

6.3. Comparison by Country

6.3.1. Soil and dust

The soil and dust ingestion amounts presented in Table 50 below are estimates based on the amount of excreted tracer substances in children from each country, measured using the tracer element method.

In Korea, soil and dust ingestion amounts for children aged 0-6 years were estimated by analysing the content of tracer substances in faces. The average soil ingestion for Korean children aged 0-6 years was 35 mg/day, while the average dust ingestion was 35 mg/day, resulting in a total of 70 mg/day for soil and dust combined.

In Japan, the estimated soil ingestion was 43.5 mg/day. Although direct comparison is difficult due to differences in age group categorization, it is higher than that of other countries.

Germany had the highest soil and dust ingestion value for children aged 1–2 years at 100 mg/day, which was also higher than the values reported for similar age groups in other countries. However, for other age groups, the values were generally lower than those in other countries. With regard to soil ingestion, data categorized by particle size were also provided; according to the German data, the mean intake of soil particles <500 µm was consistently higher than that of fine particles <63 µm.

In the Netherlands, soil and dust ingestion for children aged 2-4 years was estimated to be 56 mg/day.

In the United States, soil and dust ingestion values were recommended based on a compilation of several major studies. The highest soil and dust ingestion value, 90 mg/day, was observed for children aged 1-2. For children aged 1-6 years, the recommended soil and dust ingestion was 80 mg/day, with 40 mg/day for soil and 40 mg/day for dust. These values are slightly higher than the estimated values for Korean children aged 0-6 years.

Nordic countries also recommend US values as the default, as they are based on more recent research compared to European studies and separately account for soil and dust ingestion for various age groups.

Canada has provided values calculated using a model from one of the major studies (Wilson et al., 2013) adopted by the United States, with coefficients adjusted to reflect Canadian conditions. Soil ingestion was considered non-existent for infants aged 0-5 months, as they were assumed to be in contact primarily with soft surfaces. Both soil and dust ingestion amounts were relatively low compared to other countries, with dust ingestion being particularly low, ranging from 2.1 mg/day to 35.0 mg/day.

Table 6.2. Comparison of Soil and Dust by Country (Mean)

(unit: mg/day)						
Category	Korea ¹⁾	Japan ²⁾	Germany ³⁾	Netherlands ⁴⁾	Nordic Country ⁵⁾ US ⁶⁾	Canada ⁷⁾
Soil and Dust	0 - 6 years: 70		< 1 year: 22 1 - 2 years: 100 2 - 7 years: 35 7 - 12 years: 57	2 - 4 years: 56	< 6 months: 40 6 -< 12 months: 70 1 -< 2 years: 90 2 -< 6 years: 60 1 -< 6 years: 80 6 -< 12 years: 60 12 - adult: 30	
Soil	0 - 6 years: 35	child: 43.5	(Fraction < 500 µm) < 1 year: 22 1 - 2 years: 100 2 - 7 years: 35 7 - 12 years: 57 all: 53 (Fraction < 63 µm) < 1 year: 16 1 - 2 years: 48 2 - 7 years: 20 7 - 12 years: 42 all: 31		< 6 months: 20 6 -< 12 months: 30 1 -< 2 years: 40 2 -< 6 years: 30 1 -< 6 years: 40 6 -< 12 years: 30 12 - adult: 10	0 - 5 months: - 6 - 11 months: 7.3 1 year: 8.8 2 - 3 years: 6.2 4 - 8 years: 8.7 9 - 13 years: 6.9 14 - 18 years: 1.4
Dust	0 - 6 years: 35				< 6 months: 20 6 -< 12 months: 40 1 -< 2 years: 50 2 -< 6 years: 30 1 -< 6 years: 40 6 -< 12 years: 30 12 - adult: 20	0 - 5 months: 21.6 6 - 11 months: 27 1 year: 35.0 2 - 3 years: 21.4 4 - 8 years: 24.4 9 - 13 years: 23.8 14 - 18 years: 2.1

1) Korean National Institute of Environmental Research (NIER). "Korean exposure factors handbook for children." (2019).

2) AIST, Exposure factors handbooks (2007)

3) Bothe, M. (2004). Quantifizierung der Ingestion von Boden durch Kinder. Germany: Dresden.

4) Clausing, P., B. Brunekreef, and J. H. Van Wijnen. "A method for estimating soil ingestion by children." International archives of occupational and environmental health 59 (1987): 73-82.

5) Existing default values and recommendations for exposure assessment: Revision of the 2011 report, a Nordic exposure group project 2022.

6) Exposure Factors Handbook Chapter 5 (Update): Soil and Dust Ingestion." Washington, DC 20460 (2017).

7) Canadian exposure factors used in human health risk assessments

<https://www.canada.ca/en/health-canada/services/chemical-substances/fact-sheets/canadian-exposure-factors-human-health-risk-assessments.html>

6.3.2. Incidental Water Ingestion During Swimming

Alongside soil and dust ingestion, the United States proposes representative values for the amount of water unintentionally ingested while swimming that can be used in exposure assessments. The values showed 38 ml/hr for ages 6-11, 44 ml/hr for 11-16, and 33 ml/hr for ages 16-21.

Australia uses a value of 50 ml/hr for the amount of water unintentionally ingested while swimming in exposure assessments for children aged 15 and under, which is rounded from the US average of 49 ml/hr for both boys and girls (US-EPA, 1989).

Table 6.3. Incidental Water Ingestion During Swimming: U.S., Australia

(unit: ml/hr)		
Category	US ¹⁾	Australia ²⁾
Amount of water	6 -< 11 year: 38	-<15: ~50
	11 -< 16 years: 44	
	16 -< 21 years: 33	

1) US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.

2) Commonwealth of Australia. Australian exposure factor guidance, Guidelines for assessing human health risks from environmental hazards, 2012.

6.3.3. Adherence of Solids(soil) to the Skin

The United States has presented representative values for the amount of solids adhered to the skin, categorized by activity type. The values are geometric means, derived from measurements of the amount of soil adhered to the skin after each activity.

Table 6.4. Adherence to Skin (US)

(unit: mg/cm ²)						
Category	Age Group	Mean				
		Arms	Face	Feet	Hands	Legs
In Residence	0 - 3 years	0.0041	-	0.01	0.011	0.35
In Daycare	1 - 6.5 years	0.024	-	0.071	0.099	0.2
While Playing in Sediment	7 - 12 years	0.17	0.04	21	0.49	0.7
While Playing in Mud	9 - 14 years	11	-	15	47	23
During Outdoor Sports	13 - 15 years	0.011	0.012	-	0.11	0.31
During Activities with Soil	16 - 35 years	0.046	0.054	0.02	0.17	0.051
During Indoor Sports	over 8 years	0.019	-	0.0022	0.0063	0.002

* US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.

References

Korean National Institute of Environmental Research (NIER). "Korean exposure factors handbook for children." (2019).

AIST, Exposure factors handbooks (2007)

Bothe, M. "Quantification of ingestion of soil by children; Quantifizierung der Ingestion von Boden durch Kinder." (2004).

Clausing, P., B. Brunekreef, and J. H. Van Wijnen. "A method for estimating soil ingestion by children." *International archives of occupational and environmental health* 59 (1987): 73-82.

Oomen, Agnes Guadalupe, et al. "Exposure to chemicals via house dust." RIVM report 609021064 (2008).

Nielsen, Elsa, and Pelle Thonning Olesen. Existing default values and recommendations for exposure assessment: Revision of the 2011 report, a Nordic exposure group project 2022. Nordic Council of Ministers, 2023.

Health Canada. "Canadian exposure factors used in human health risk assessments." <https://www.canada.ca/en/health-canada/services/chemical-substances/fact-sheets/canadian-exposure-factors-human-health-risk-assessments.html>

Wilson, Ross, et al. "Revisiting dust and soil ingestion rates based on hand-to-mouth transfer." *Human and Ecological Risk Assessment: An International Journal* 19.1 (2013): 158-188.

EPA, US. "Exposure Factors Handbook Chapter 5 (Update): Soil and Dust Ingestion." Washington, DC 20460 (2017).

US EPA (US Environmental Protection Agency). Exposure factors handbook: 2011 edition, 2011.

7. Life Expectancy

7.1. Overview

Life expectancy is considered in exposure factor assessments to accurately predict and manage the health impacts of exposure to harmful substances. As life expectancy refers to the average time an individual can expect to live under specific environmental conditions, it serves as a crucial variable in assessing the cumulative damage that may occur during the exposure period. It's important to note that life expectancy may vary depending on the time of the investigation, and data from the World Health Organization can be consulted for more accurate and up-to-date information.

Some countries provide the years of life remaining until death at a specific age to assess lifetime cumulative exposure. In this report, the remaining years of life until death at birth (0 year), or life expectancy, were compared for the purpose of comparing exposure factors in children across countries.

During the lifetime of individuals exposed to harmful substances, these substances often accumulate or have long-term effects. Toxins such as radiation or carcinogens may not cause immediate effects, but prolonged exposure can lead to cancer or chronic diseases. Without considering life expectancy, it may be difficult to accurately assess these long-term health impacts.

Life expectancy is a critical factor in calculating dose estimates for exposure factors when dose estimates are calculated by averaging total exposure over an individual's lifetime. Since total exposure is divided by life expectancy, a shorter life expectancy yields a higher exposure amount per unit time, which in turn increases the relative risk of developing cancer or other chronic diseases. Conversely, a longer life expectancy yields a lower exposure concentration per unit time for the same exposure amount, thus reducing the relative risk.

As such, considering life expectancy in exposure assessments enables risk evaluations that take an individual's entire lifespan into account. It also serves as a crucial adjustment variable, particularly when comparing exposure risks between groups with differing life expectancies.

7.2. Status of Data and Comparison by Country

The World Health Organisation (WHO) provides data on life expectancy at birth by country for countries around the world. In every country, women had a longer life expectancy than men, with Ukraine showing the widest gap. While the reference year varies by country, the most recent data dates to 2021.

Although this report does not cover the life expectancy figures for all countries listed by the WHO, more detailed information is available from the WHO.

Table 7.1. Life Expectancy at Birth by Country (WHO)

Continent	Country	Gender		
		All	Male	Female
(unit: years)				
Asia	Korea	83.80	80.71	86.66
	Japan	84.46	81.71	87.16
	China	77.62	74.95	80.52
	Cambodia	68.92	66.35	71.45
	India	67.31	65.77	69.02
	Singapore	83.86	81.58	86.25
	Viet Nam	73.80	69.73	77.96
Europe	Austria	80.99	78.66	83.30
	Belgium	81.51	79.29	83.69
	Denmark	81.18	79.46	82.90
	Finland	81.53	79.01	84.06
	France	81.92	79.08	84.69
	Greece	79.60	77.26	81.95
	Germany	80.49	78.15	82.86
	Hungary	74.40	70.94	77.83
	Italy	82.20	79.98	84.33
	Netherlands	81.12	79.58	82.65
	Norway	82.88	81.50	84.25
	Poland	75.40	71.55	79.40
	Portugal	81.18	78.27	83.88
	Romania	72.76	69.21	76.52
	Serbia	72.81	69.99	75.62
	Slovakia	74.51	71.13	78.01
	Slovenia	80.41	77.54	83.39
	Spain	82.66	79.99	85.30
	Sweden	82.66	81.02	84.31
	Switzerland	83.33	81.48	85.11
Ukraine	70.91	66.33	75.34	
UK of Great Britain and Northern Ireland	80.10	78.27	81.93	
North America	Canada	81.58	79.37	83.81
	United States	76.37	73.72	79.15
Oceania	Australia	83.10	81.31	84.90
	New Zealand	82.20	80.36	84.01
Africa	Central African Republic	52.31	49.57	55.38
	Egypt	69.11	66.69	71.71
	Kenya	66.76	64.40	69.22
	Nigeria	63.40	62.07	64.78
	South Africa	61.50	58.90	64.02
South America	Argentina	74.57	71.59	77.58
	Brazil	72.39	69.04	75.85
	Mexico	70.83	67.20	74.69
	Uruguay	74.98	71.25	78.74

References

WHO, World Health Organization 2025 data.who.int, Life expectancy at birth (years) [Indicator].
<https://data.who.int/indicators/i/A21CFC2/90E2E48> (Accessed on 9 October 2025)

Annex A.

This Guidance Document is accompanied by:

<https://www.oecd.org/content/dam/oecd/en/topics/policy-sub-issues/testing-of-chemicals/oecd-database-on-childrens-exposure-factors.xlsx>