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Assessment of regional exposure factors associated with soil impact in cities of the Arctic region

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ABSTRACT

BACKGROUND: Unfavorable climatic conditions determine the interaction between people and soil in northern territories, differing from those in southern regions of Russia. When assessing risks, standard exposure factors (EFs) must be adjusted to reflect regional characteristics.

AIM: To study regional EFs used to assess health risk from exposure to chemical soil pollutants in urban areas of the Arctic zone.

MATERIAL AND METHODS: A cross-sectional study was carried out by questioning 752 children aged 1–6 years, 1027 children aged 7–17 years, and 323 adults aged 18 years and older, all living in the cities of the Arctic zone of the Russian Federation. Physiological and behavioral EFs related to soil exposure were studied. The median (Me), relative frequencies, and 95% confidence intervals were used to describe the data. To test the null hypotheses, the nonparametric Kruskal–Wallis test, Wilcoxon two-sample test, and χ-square test were used.

RESULTS: Children aged 1–6 years spent an average of 10 more days in the city compared to children aged 7–17 years and adults (p <0.001). Children aged 1–6 years also spent 3.2 times more days playing on soil/sand (Me=48 days) and 1.3 times more time playing daily (Me=50 min/day) than children aged 7–17 years (p <0.001). Adults spent 1.7 times more days on land from May to October (Me=50 days) and worked with soil 2.2 times more time daily (130 min/day) than children aged 7–17 years (p <0.001). Average daily doses for oral exposure to soil chemicals, calculated using regional EFs, are 2–10 times higher in children from the Arkhangelsk agglomeration and 5 and 1.2 times lower in adults compared to doses calculated using WHO and US EPA recommended EFs values.

CONCLUSION: Differences were revealed in quantitative and categorical values of most regional EFs associated with the soil ingress in the body across different age groups. Using the characteristic regional exposure factors of specific population allows for improving the accuracy and reliability of the assessed risk to public health.

Keywords: exposure factors; chemical contaminants; health risk assessment; soil.

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Оценка региональных факторов экспозиции, связанных с воздействием почвы в городах Арктического региона

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АННОТАЦИЯ

Обоснование. Неблагоприятные климатические условия определяют особенности взаимодействия человека с почвой на северных территориях, которые отличаются от южных регионов России. При оценке риска стандартные факторы экспозиции необходимо корректировать с учётом региональных особенностей.

Цель. Изучить региональные факторы экспозиции, используемые для расчёта риска здоровью при воздействии химических веществ, загрязняющих почву в городах Арктической зоны.

Материал и методы. Выполнено поперечное исследование путём анкетирования 752 детей в возрастной группе от 1 до 6 лет, 1027 детей — от 7 до 17 лет и 323 взрослых 18 лет и старше, проживающих в городах Арктической зоны Российской Федерации. Изучены физиологические и поведенческие факторы экспозиции, связанные с воздействием почвы на организм человека. Для описания данных использованы медиана (Me), относительные частоты, 95% доверительные интервалы. Для проверки нулевых гипотез применяли непараметрические критерии: критерий Краскела–Уоллиса, двухвыборочный критерий Вилкоксона, критерий хи-квадрат.

Результаты. Продолжительность пребывания в городах у детей в возрасте 1–6 лет (Me=325 дней) на 10 дней больше, чем у детей 7–17 лет и взрослых (p <0,001). У детей в возрасте 1–6 лет длительность игры на земле/песке с мая по октябрь (Me=48 дней) и время игры (Me=50 мин/день) в 3,2 и 1,3 раза соответственно выше, чем у детей 7–17 лет (p <0,001). У взрослого населения время пребывания на земельном участке с мая по октябрь (Me=50 дней) и длительность работы с почвой (130 мин/день) в 1,7 и 2,2 раза соответственно выше, чем у детей 7–17 лет (p <0,001). Значения среднесуточных доз при пероральном воздействии химических веществ, загрязняющих почву и рассчитанных с использованием региональных факторов экспозиции, у детей Архангельской агломерации в 2–10 раз выше, а у взрослых — в 5 и 1,2 раза ниже по сравнению с дозами, рассчитанными с использованием значений факторов экспозиции, рекомендованных ВОЗ и US EPA.

Заключение. Выявлены различия в количественных и категориальных значениях большинства региональных факторов экспозиции, связанных с поступлением почвы в организм населения разных возрастных групп. Использование региональных данных о факторах экспозиции, характерных для отдельной популяции, позволяет увеличить точность и надёжность оцениваемого риска для здоровья населения.

Ключевые слова: факторы экспозиции; химические вещества; оценка риска для здоровья; почва.

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北极地区城市土壤暴露相关区域性因素的评估

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摘要

背景。不利的气候条件决定了北极地区人与土壤相互作用的特殊性，这种情况与俄罗斯南方地区存在显著差异。在健康风险评估中，需要根据区域特点调整标准暴露因素。

研究目的。研究北极地区城市土壤污染物对健康风险评估中所用区域性暴露因素的影响。

材料与方法。采用横断面调查方法，对俄罗斯北极地区城市居民进行问卷调查。研究共涉及2102名参与者，包括1至6岁儿童752人、7至17岁儿童1027人及18岁及以上成年人323人。分析涵盖了与土壤暴露相关的生理和行为因素。描述性统计数据采用中位数（Ｍｅ）、相对频率及95%置信区间。假设检验采用非参数方法，包括克拉斯卡尔-沃利斯检验、两样本Wilcoxon检验和卡方检验。

结果。1至6岁儿童在城市的平均停留时间（Ｍｅ=325天）比7至17岁儿童和成年人多10天（$p < 0.001$）。1至6岁儿童在5月至10月期间的土壤/沙地游戏天数（Ｍｅ=48天）和每日游戏时间（Ｍｅ=50分钟/天）分别是7至17岁儿童的3.2倍和1.3倍（$p < 0.001$）。成年居民在5月至10月期间的土地停留天数（Ｍｅ=50天）和土壤工作时间（130分钟/天）分别是7至17岁儿童的1.7倍和2.2倍（$p < 0.001$）。基于区域性暴露因素计算的土壤污染化学物质经口暴露的日均剂量显示：阿尔汉格尔斯克地区儿童的剂量比基于WHO和美国EPA推荐暴露因素计算的剂量高2至10倍；成年人的剂量则分别低5倍和1.2倍。

结论。研究发现，不同年龄组人群的区域性暴露因素在数量和类别上存在显著差异。基于具体人群的区域数据调整暴露因素，可显著提高健康风险评估的准确性和可靠性。

关键词：暴露因素；化学物质；健康风险评估；土壤。

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BACKGROUND

Assessment of population health risks from environmental chemical exposure is widely recognized as an interdisciplinary field in modern science and practice. It prioritizes accuracy of risk levels, scientific validity, and the effectiveness of regulatory decisions based on such assessments [1]. A critical phase of risk assessment involves evaluating exposure factors (EFs). This phase quantifies the exposure of human body to pollutants through contact with various environmental media (air, water, soil, food) [2, 3]. Exposure and risk calculations utilize factors reflecting physiological parameters, human activities, lifestyle, and behavioral patterns. These incorporate region-specific characteristics of studied population groups [3].

Extensive international research has established national and international EF databases for health risk assessment. A significant body of reference data on various EFs can be found in U.S. Environmental Protection Agency (US EPA) guidelines which are regularly updated with data from population surveys [4–7]. European guidance covers EFs for 30 EU countries and the UK [8]. Australia's national EF guidelines have been developed for population health risk assessment [9].

In Russia, studies assessing regional EFs through population surveys have been conducted in Moscow, Lipetsk, Ryazan, Novodvinsk, and other cities. These studies sometimes revealed regional EFs to be lower than reference values [10].

Inaccurate EF values increase uncertainty and may distort calculated health risks. Therefore, recommended EFs constitute reference data requiring adjustments for regional specificity.

Soil is a critical environmental medium influencing human health and living conditions. Soil pollutants may enter and adversely affect the body via direct contact (hand-digging soil, barefoot walking, soil ingestion, hand-to-mouth transfer, sandbox play, etc.) and media indirectly contacting soil (water, air) [11–15].

This research targets three major industrial cities in the Arkhangelsk agglomeration (Arkhangelsk, Severodvinsk, Novodvinsk), located within the Arctic zone.[1] The harsh Arctic climate (cold; high winds; elevated humidity; short daylight hours; persistent snow cover ⩾6 months) dictates fundamentally different soil-contact behaviors than those observed in Russian southern regions [16]. Therefore, investigating soil-attributed EFs in the Arctic zone cities remains relevant.

The work aimed to investigate regional EFs across different age groups, enabling accurate health risk assessment for soil-borne chemical exposures in the Arctic zone cities.

[1] Decree of the President of the Russian Federation No. 296 dated May 02, 2014 On the Land Territories of the Arctic Zone of the Russian Federation (as amended on March 05, 2020). Available at http://www.consultant.ru/document/cons_doc_LAW_162553/942772dce30cfa36b671bcf19ca928e4d698a928. Accessed on September 17, 2023.

METHODS

Regional soil EFs were assessed through a population survey across the Arkhangelsk agglomeration in a cross-sectional study. The survey included 2102 participants: 752 children aged 1–6 years, 1027 children aged 7–17 years, and 323 adults (⩾18 years). Children were surveyed at preschools and schools, while adults were surveyed at workplaces (companies and enterprises). Data on regional EFs for children aged 1–6 years were obtained from their parents. The response rate was 87%. A modified questionnaire developed by the Federal State Budgetary Institution Center for Strategic Planning and Management of Biomedical Health Risks of the Ministry of Health of the Russian Federation, which covered the following information: body weight (kg), body surface area (m^2), exposure duration (outdoor time, min/day; soil/sand play, days/year; soil-contact during play, min/day; land plot staying, days/year; soil-handling duration during plot activities, min/day; urban stay during the year, days/year). Additional data obtained during the survey included months of starting and finishing soil/sand play, child behaviors (hand/toy mouthing during play, soil/sand ingestion, consumption of soil/sand-contaminated vegetables and berries, and habits of post-exposure handwashing, washing homegrown vegetables and berries, glove use (rubber or cotton) during soil handling). The study was approved by the Ethics Committee of the Federal State Budgetary Educational Institution of Higher Education Northern State Medical University (Arkhangelsk) of the Ministry of Health of the Russian Federation (Protocol of the Ethics Committee No. 1 dated November 02, 2016).

Comparative analysis of EFs across age groups was performed for the population of the Arkhangelsk agglomeration. Regional EF values were compared against standard EF values recommended by WHO [17] and other countries (USA, Australia, Canada, Japan) [4–7, 9, 18, 19]. Considering that multiple EFs are used to calculate chemical dose load assessment, we conducted comparative analysis of doses for 10 soil-contaminating chemicals (copper, chromium, zinc, nickel, manganese, lead, mercury, cadmium, cobalt, and arsenic) via oral exposure. Dose calculations utilized both regional and standard EF values [17].

Quantitative variables were described using medians (Me) with 95% confidence intervals (95% CI) for Me. As quantitative data distribution significantly deviated from normal, group comparisons employed the Kruskal–Wallis test, while pairwise comparisons used the Wilcoxon rank-sum test. Categorical data were presented as absolute numbers, relative frequencies, and 95% CIs. The chi-square test (χ^2) was used to test null hypotheses between categorical variables. A p-value of 0.05 served as the critical significance threshold. Statistical analysis was performed using STATA 18.0 software.

To compare exposure levels of soil-contaminating chemicals, average daily lead doses were calculated using regional

EF values and standards from WHO and US EPA, using the following formula [17]:

$$I=Cs\times FI\times ET\times CF_2\times IRa\times ED/(BWI=\times AT\times 365),$$

where I is soil intake (mg/(kg×day)); Cs is soil concentration (mg/kg); FI is contaminated soil fraction (per unit value); ET is exposure time (hr/day); CF_2 is conversion factor (ET/24 day/hr); IRa is intake rate (mg/day); ED is exposure duration (years); BW is body weight (kg); AT is exposure averaging time (years).

RESULTS

Analysis of survey results revealed differences in quantitative and categorical values of most EFs across age groups (Tables 1, 2). At the median level, children's body weight in 1–6 year and 7–17 year age groups was 3.8-fold and 1.5-fold lower than that of adults, respectively (p <0.001). Median values of body surface area for 7–17-year-old children and adults were 1.9-fold and 2.4-fold greater than for 1–6-year-old children, respectively (p <0.001).

Urban stay duration among 1–6-year-old children (Me=325 days) exceeded that of 7–17-year-old children and adults (Me=315 days for both groups) by 10 days; p <0.001. Adults showed the longest outdoor exposure duration (Me=300 days), which was 1.7–2.0 times higher than that of children.

Soil and sand play duration from May through October for 1–6-year-old children (Me=48 days) was 3.2-fold greater than for 7–17-year-old children (Me=15 days). The mean daily soil and sand play time for 1–6-year-old children exceeded that of 7–17-year-old children by 10 min/day (Me=50 min/day vs. Me=40 min/day, respectively).

Time spent at land plots (dacha), beaches, and other urban/suburban sites (with adults/children contacting soil) from May to October was 20 days longer for adults (Me=50 days) than children aged 7–17 (Me=30 days); p <0.001. Adults' median soil-handling duration (130 min/day) was 2.2 times higher than that of children aged 7–17.

Categorical EF analysis revealed 92.2% of surveyed children and adults left Arkhangelsk agglomeration urban areas annually. The highest proportions initiating sand/soil play at sandpits in May were children aged 1–6 (45.6%) and 7–17 (51.6%). Over half of preschoolers ended sand/soil play in sandpits in November (51.6%), whereas most school-aged children ended play in September (41.4%).

Analysis of soil ingestion facilitators in the studied age groups showed 15% of children aged 1-6 put hands/toys in their mouths during play or consumed soil-contaminated berries and vegetables. Less than 5% of preschoolers ingested sand (put sand into their mouths) during soil/sand play. However, 99.8% of surveyed children aged 1–6 cleaned their hands after walks outside (handwashing with water or wet wipes).

Among children aged 7–17, 8.8% of respondents put hands/toys in their mouths during soil/sand play. Approximately 6% of schoolchildren consumed soil-contaminated vegetables and berries. The majority of respondents aged 7–17 (98.8%) cleaned hands after walks outside (handwashing with water or wet wipes); 75.0% used rubber/cotton gloves (mittens) when contacting soil. A total of 91.5% of children in this age group visited beaches or urban/suburban areas with soil/sand contact from May to October.

Among adult respondents, 85.9% owned land plots (dachas) within urban/suburban areas, cultivating vegetables and berries for consumption. Approximately 90% visited beaches or other urban/suburban areas with soil/sand contact from May to October. Among adults, 98.7% cleaned hands post-soil contact (handwashing with water or wet wipes), 86.4% washed homegrown berries and vegetables before consumption, and 84.8% used rubber/cotton gloves (mittens) during soil work (see Table 2).

Average daily lead dose assessment from oral soil intake revealed that for children aged 1–6, doses calculated with regional EFs were 2.0 times lower and 2.5 times higher than doses calculated using WHO- and US EPA-recommended standard EFs, respectively. Respective adult doses exceeded those calculated using WHO- and US EPA-recommended standard EFs by 5.0-fold and 28.5-fold. Average daily doses of soil contaminants for children aged 1–6 calculated using WHO-recommended EFs exceeded those calculated using US EPA-recommended EFs by 4-fold, while adult doses were 6-fold higher (Fig. 1).

DISCUSSION

Comparative assessment of questionnaire results across cities in the Arkhangelsk agglomeration revealed statistically significant differences in most quantitative EFs across age groups. Regional EFs were compared with standard values recommended by the US EPA [4–7] and Australian guidelines [9]. Comparison of pediatric population EFs with those established for Canada [18], Japan [19], Europe [8], and WHO recommendations [17] proved challenging due to differing age groups. Median-level comparison of regional EFs with standard values demonstrated that surveyed children's body weight in the 1–6 year group in Arkhangelsk agglomeration cities (18 kg) exceeded values recommended by US EPA (16 kg), WHO (15 kg), and Australian guidelines (17 kg). Children aged 7–17 years in our study had a median weight of 45 kg, which was 9 kg below US EPA and Australian national guidelines (both 54 kg) but 3 kg above WHO's recommendation (42 kg). Adult respondents' body weight (68 kg) exceeded Japan's recommended value (58.4 kg) by 9.6 kg but remained below WHO (70 kg), Canadian (77.5 kg), Australian (78 kg), US EPA (80 kg), and European (73.5 kg) national guidelines.

Body surface area values for children in the studied cities were 0.7 m^2 (ages 1–6) and 1.4 m^2 (ages 7–17), showing minor deviations from the values recommended by US EPA (0.6 m^2 and 1.5 m^2), WHO (0.5 m^2 and 1.3 m^2), and Australian

Table 1. Characteristics of quantitative exposure factors among the population of the cities of the Arkhangelsk agglomeration (according to the survey)

Factors	Units	1–6-year-old children (group 1)			7–17-year-old children (group 2)			Adults (group 3)			p
		Me	95% CI for Me		Me	95% CI for Me		Me	95% CI for Me		
			lower	upper		lower	upper		lower	upper	
Body weight	kg	18.0	17.5	18.0	45.0	43.0	46.0	68.0	66.0	70.0	p^a <0.001
Body surface area	m^2	0.7	0.7	0.8	1.4	1.4	1.4	1.8	1.7	1.8	p^a <0.001
Exposure duration											
Urban stay	days/year	325	320	330	315	309	315	315	305	315	p^a <0.001
Outdoor stay	min/day	150	150	150	180	150	180	300	270	330	p^a <0.001
Soil/sand play	days/year	48	42	50	15	12	16	–	–	–	p^b <0.001
Soil/sand play duration	min/day	50	45	60	40	40	50	–	–	–	p^b =0.001
Land plot stay	days/year	–	–	–	30	30	30	50	40	50	p^b <0.001
Soil-handling duration	min/day	–	–	–	60	60	70	130	120	130	p^b <0.001

Note. Me — median; p^a — comparison of median values by the Kruskal–Wallis test; p^b — comparison of median values by the Wilcoxon test; «–» — no data because survey was not conducted.

guidelines (0.6 m^2 and 1.6 m^2). Among adults, body surface area in the studied cities was 1.8 m^2 — matching WHO (1.8 m^2) and US EPA (1.8 m^2) standards — with slight variations from Japanese (1.6 m^2), Australian (2.0 m^2), Canadian, and European guidelines (1.9 m^2).

Outdoor exposure duration for children aged 1–6 years in the studied cities averaged 150 min/day, which was 1.4 times lower than US EPA standard values (207 min/day) but 1.4 times higher than Australian ones (104 min/day). Children aged 7–17 years spent 180 min/day outdoors, which was 1.6 times higher than values recommended by Australian guidelines (112 min/day) and 10 minutes below US EPA recommendations (190 min/day). Adults' outdoor duration (300 min/day) was 1.6 times below standard values recommended by WHO (480 min/day) but 2.0–8.6 times higher than Canadian (35 min/day), Australian (180 min/day), American (144 min/day), Japanese (72 min/day), and European (120 min/day) norms.

Indoor exposure for children aged 1–6 years totaled 840 min/day in the studied cities, which was 1.2 times lower than Australian and US EPA standard values (~1000 min/day). Children aged 7–17 years spent 900 min/day indoors, which was 28 minutes above Australian and US EPA recommendations (872 min/day). Adults' indoor duration (720 min/day) was 1.3–1.7 times below recommended values.

WHO-established soil ingestion rates are 200 mg/day for children aged 1–6 years and 100 mg/day for children aged 7–17 years, respectively 4-fold and 2-fold higher than US EPA recommendations for these age groups (50 mg/day). The highest adult soil ingestion rates are recommended by WHO (100 mg/day) and Australian guidelines (50 mg/day), with Japan setting a rate of 47.7 mg/day, while the lowest

Table 2. Characteristics of categorical exposure factors among the population of the cities of the Arkhangelsk agglomeration (according to the survey)

Факторы	1–6-year-old children (group 1)			7–17-year-old children (group 2)			Adults (group 3)			p
	abs.	%	95% CI	abs.	%	95% CI	abs.	%	95% CI	
Month of the soil play start										χ^2=46,9 p <0,001
April	258	34.7	31.4–38.2	71	18.5	14.9–22.7	–	–	–	
May	339	45.6	42.1–49.2	198	51.6	46.6–56.5	–	–	–	
June	119	16.0	13.5–18.8	99	25.8	21.6–30.4	–	–	–	
July	13	1.8	1.0–3.0	15	3.9	2.4–6.4	–	–	–	
August	14	1.9	1.1–3.2	1	0.3	0.04–1.8	–	–	–	

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End of the Table 2

Факторы	1–6-year-old children (group 1)			7–17-year-old children (group 2)			Adults (group 3)			p
	abs.	%	95% CI	abs.	%	95% CI	abs.	%	95% CI	
Month of the soil play end										χ^2=115,0 *p* <0,001
August	32	4.4	3.1–6.1	38	9.9	7.3–13.3	–	–	–	
September	133	18.1	15.5–21.1	159	41.4	36.6–46.4	–	–	–	
October	194	26.4	23.4–29.7	101	26.3	22.1–30.9	–	–	–	
November	375	51.1	47.5–54.7	86	22.4	18.5–26.8	–	–	–	
Leaving the city										χ^2=31,3 *p* <0,001
Yes	642	88.3	85.8–90.5	968	95.5	94.0–96.6	293	90.7	87.0–93.4	
No	85	11.7	9.5–14.2	46	4.5	3.4–6.0	30	9.3	6.6–13.0	
Factors contributing to soil intake										
Put hands or toys in their mouth when playing with sand or soil										χ^2=10,2 *p* <0,001
Yes	116	15.5	13.1–18.3	35	8.8	6.4–12.0	–	–	–	
No	633	84.5	81.7–86.9	363	91.2	88.0–93.6	–	–	–	
Ingest (put) sand in their mouth while playing with sand or soil										χ^2=11,4 *p* <0,001
Yes	33	4.4	3.1–6.1	3	0.8	0.2–2.3	–	–	–	
No	716	95.6	93.9–96.9	395	99.3	97.7–99.8	–	–	–	
Put soil-contaminated vegetables and berries into their mouths										χ^2=22,4 *p* <0,001
Yes	112	15.0	12.6–17.7	22	5.5	3.7–8.3	–	–	–	
No	636	85.0	82.3–87.4	376	94.5	91.7–96.3	–	–	–	
Cleaning hands after walks										χ^2=41,8 *p* <0,001
Wash with water	733	99.7	98.9–99.9	973	94.8	93.3–96.0	317	98.1	95.9–99.2	
Wipe hands with wet wipes	1	0.1	0.02–1.00	41	4.0	3.0–5.4	2	0.6	0.2–2.4	
Do not clean hands	1	0.1	0.02–1.00	12	1.2	0.7–2.0	4	1.2	0.5–3.3	
Wash vegetables and berries grown at their land plot (dacha) before eating										χ^2=13,3 *p* <0,001
Yes	–	–	–	578	93.5	91.3–95.2	279	86.4	82.2–89.7	
No	–	–	–	40	6.5	4.8–8.7	44	13.6	10.3–17.8	
Use gloves (mittens) when contacting soil										χ^2=12,2 *p* <0,001
Yes	–	–	–	461	75.0	71.4–78.2	274	84.8	80.5–88.4	
No	–	–	–	154	25.0	21.8–28.6	49	15.2	11.6–19.5	
Have a land plot (dacha) where they grow vegetables and berries for consumption										–
Yes	–	–	–	–	–	–	268	85.9	81.6–89.4	
No	–	–	–	–	–	–	44	14.1	10.6–18.4	
Visited the beach or other places where contacted soil/sand										χ^2=4,2 *p*=0,040
Yes	–	–	–	571.0	91.5	89.0–93.5	282.0	87.3	83.2–90.5	
No	–	–	–	53.0	8.5	6.5–11.0	41.0	12.7	9.5–16.8	

Note."–", data is missing because the survey was not conducted.

is in Europe (1 mg/day). Canadian and American adult soil ingestion rates are identical, i.e. 20 mg/day.

Identified variations in exposure factor values affect chemical dose burdens from oral soil intake.

Differences in average daily lead doses calculated using regional EFs and WHO recommendations result from variations in body weight and soil contact duration: 0.83 hr/day vs. 1 hr/day for children aged 1–6 years during sand/soil play, and 2.2 hr/day vs. 1 hr/day for adults during soil-handling activities. Differences between average daily lead doses calculated using regional EFs/WHO recommendations and US EPA values result from differing soil ingestion rates (mg/day) and respondents' body weights.

This study has certain limitations. First, population surveys took place during the cold season, potentially influencing outcomes. Second, adult respondents (⩾18 years) were predominantly female (70%). Exposure factor data for children aged 1–6 years were obtained through parent interviews (primarily mothers). Third, the majority of respondents (70%) were Arkhangelsk residents, precluding extrapolation across all Russian Arctic territories due to climatic variations.

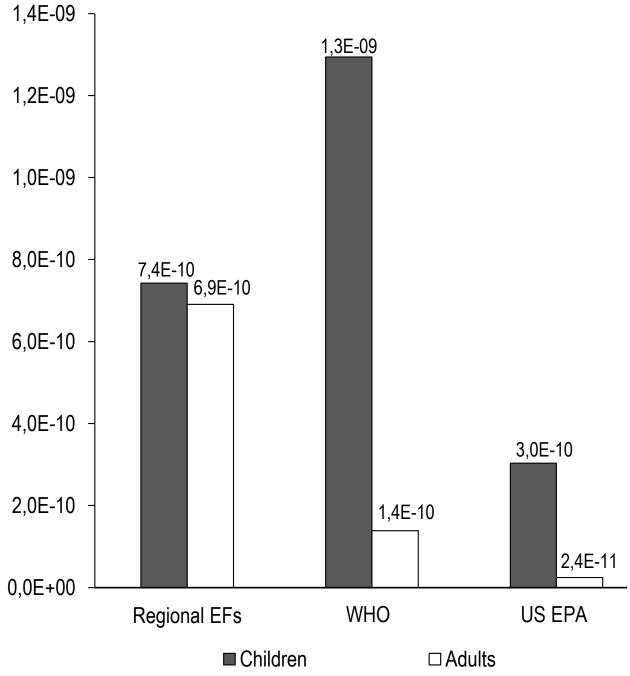

Fig. 1. Comparison of average daily doses of lead for children and adults through oral intake from soil, mg/(kg×day): EFs — exposure factors.

CONCLUSION

Statistically significant differences were identified in quantitative and categorical values of most regional EFs related to soil ingestion across different age groups. Differences between regional and recommended (standard) EF values (body weight, body surface area, outdoor duration, indoor duration) affect chemical exposure doses from oral soil intake; this necessitates adjustment in health risk assessments for the studied population. To reduce risk assessment uncertainties, regional EFs must be investigated whose differences may be attributed to climatic/geographic conditions, outdoor time duration, and soil chemical contaminant exposure duration.

Using region-specific EF data characteristic of local populations enhances health risk assessment accuracy and reliability. Consequently, studies to collect EF data across Russian regions and establish a national EF database should be arranged.

ADDITIONAL INFORMATION

Authors' contribution. A.N. Deryabin — made a significant contribution to the concept and design of the study, collected, analyzed and interpreted data, prepared tables, the first draft of the article, worked to improve it; T.N. Unguryanu — significantly revised the article on the importance of intellectual content, approved the final version for submission to the editor. All authors confirm that their authorship meets the international ICMJE criteria (all authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work).

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Consent for publication. The patients who participated in the study signed an informed consent to participate in the study and publish medical data.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

Вклад авторов. А.Н. Дерябин — существенный вклад в концепцию и дизайн исследования, сбор, анализ и интерпретацию данных, подготовил таблицы, первый вариант статьи; Т.Н. Унгуряну — вклад в концепцию и дизайн исследования, существенно переработала статью на предмет важности интеллектуального содержания, утвердила окончательный вариант рукописи для направления в редакцию. Все авторы подтверждают соответствие своего авторства международным критериям ICMJE (все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией).

Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

Информированное согласие на участие в исследовании. Все участники до включения в исследование добровольно подписали форму информированного согласия, утверждённую в составе протокола исследования этическим комитетом.

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