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Dental caries in 12-year-olds in the Russian Arctic: A systematic review and metaanalysis

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ABSTRACT

BACKGROUND: The health of Russian Arctic residents has recently received special attention; however, information on the dental health of children in this region remains limited.

AIM: To perform a systematic search and qualitative synthesis of scientific data on the prevalence and severity of dental caries in 12-year-olds in the Russian Arctic published in Russian and English over the last 25 years.

MATERIALS AND METHODS: The scientific data were identified, selected, and presented according to the PRISMA 2020 guidelines. The literature search on the prevalence and severity of dental caries in 12-year-olds in Arctic and Subarctic Russia was performed using eLIBRARY.RU for publications in Russian and PubMed for publications in English, for the period from 1998 to 2023. Furthermore, information was gathered from national dental examination reports.

RESULTS: The initial search yielded 279 publications. Following screening and eligibility assessment using inclusion and exclusion criteria, 14 publications were selected for qualitative synthesis. According to the metaanalysis, the newly arrived residents in Salekhard had the highest prevalence and severity of dental caries among 12-year-olds, accounting for 98.33% (95% confidence interval [CI]: 95.04–99.97) and 7.82%, respectively. The lowest prevalence and severity of dental caries were observed in Segezha (Republic of Karelia): 54.98% (95% CI: 48.21–61.65) and 1.81%, respectively. The weighted prevalence based on systematic sampling was 79.33% (95% CI: 74.70–83.62). In the majority of cities where the assessment was performed at least twice, the prevalence of dental caries decreased over time; however, there were no significant differences.

CONCLUSION: The study found that dental caries were more severe in 12-year-olds in the Russian Arctic than in other northern countries; however, the prevalence decreased over time without achieving statistical significance.

Keywords: dental caries; children; Arctic; systematic review; metaanalysis.

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Кариес зубов у 12-летних детей Арктической зоны Российской Федерации: систематический обзор и метаанализ

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АННОТАЦИЯ

Обоснование. Здоровью жителей Арктической зоны Российской Федерации (АЗРФ) в последнее время уделяется повышенное внимание, однако о стоматологическом здоровье детей этого региона информации по-прежнему недостаточно.

Цель исследования — провести систематический поиск и качественный синтез научной информации о распространённости и интенсивности кариеса у детей 12 лет в АЗРФ, опубликованной на русском и английском языках за 25 лет.

Материалы и методы. Поиск, отбор и представление научной информации проведены в соответствии с рекомендациями PRISMA-2020. Поиск источников, представляющих распространённость и интенсивность кариеса среди 12-летних детей арктической и субарктической территорий России, осуществлён на платформах eLIBRARY.RU для русскоязычной и PubMed — для англоязычной литературы за период 1998–2023 гг. Кроме того, в качестве источников информации использованы отчёты национальных стоматологических обследований.

Результаты. В результате первичного поиска идентифицировано 279 источников. После скрининга и оценки публикаций на приемлемость с помощью критериев включения и исключения отобрано 14 публикаций для качественного синтеза. В результате метаанализа максимальная распространённость и интенсивность кариеса среди 12-летних детей отмечены в г. Салехарде у пришлого населения, что составило 98,33% (95% доверительный интервал (ДИ): 95,04–99,97) и 7,82% соответственно. Самый низкие показатели зарегистрированы в г. Сегеже Республики Карелии — 54,98% (95% ДИ: 48,21–61,65) и 1,81% соответственно. Взвешенная распространённость по результатам систематического отбора составила 79,33% (95% ДИ: 74,70–83,62). В большинстве населённых пунктов, где исследования проводились минимум в два момента времени, отмечена тенденция к уменьшению распространённости кариеса, однако статистически значимых различий не выявлено.

Заключение. В сравнении с другими северными странами отмечен более высокий уровень активности кариозного процесса у 12-летних детей АЗРФ, однако распространённость имеет тенденцию к снижению, не достигая уровня статистической значимости.

Ключевые слова: кариес; дети; арктическая зона; систематический обзор; метаанализ.

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INTRODUCTION

Protecting and improving children's health is one of Russia's top healthcare priorities. Increased responsiveness in children is due to immature organs and systems of the body, as well as metabolic characteristics. The Russian Arctic is characterized by extreme natural, climatic, economic, and geographical conditions. This region has recently become the object of special attention. After signing the RF Presidential Decree No. 645 of October 26, 2020, On the Russian Arctic Development Strategy and National Security Protection till 2035, ¹the development of the Russian Arctic has received exceptional importance, becoming one of the priorities of national strategy. As of 2020, the total population of the Russian Arctic was 2,431.5 thousand people [2], with a significant proportion of children, who are one of the most vulnerable groups. Providing medical care and implementing health promotion and disease prevention programs in this region is difficult due to the remoteness of populated areas, complex transportation systems, and diminished traditional use of natural resources [3].

The availability of dental care, including preventive care, in remote areas is crucial in the Russian Arctic. More than half of Russia's indigenous small-numbered peoples of the North live in the Russian Arctic [4]. Due to ongoing globalization and economic transformation processes, the Arctic region experiences many changes, notably in the diet of indigenous and newly arrived populations. In recent years, there has been a decrease in meat-processing and dairy industries and agricultural lands in the Russian Arctic, and imported processed foods and fast-acting carbohydrates have grown prevalent in the diet of local residents [5]. This can have a negative impact on children's health, particularly their dental health. Somatic health parameters in the Russian Arctic are also below the national average [6, 7].

The analysis of data on dental health and factors affecting oral health plays a significant role in assessing the general health of children. When examining the prevalence and severity of dental caries, 12-year-olds are a preferred age group to analyze and compare across countries and regions. This is because the emergence of secondary teeth ends by the age of twelve. As a result, this age group must have the lowest prevalence of dental caries. Furthermore, preventive interventions at all levels should strive to increase the number of 12-year-olds without dental caries. For example, in 2006, the proportion of 12-year-olds without dental caries in Nordic nations such as Finland, Norway, and Sweden was 38%–58% [8]. In 2018, after implementing the national dental caries prevention policy, the proportion of 12-year-olds without

dental caries in Greenland was 54.6% [9]. Notably, in emerging countries with socioeconomic indicators similar to those in Russia, this value did not exceed 15% [10].

To assess the efficacy of existing and proposed measures aimed at decreasing the prevalence of dental caries in children, regular dental examinations using international standardized criteria are required. Noncompliance with this requirement limits the comparability of findings obtained in different regions and/or at different times. Moreover, the obtained findings must be systematized on a regular basis in order to synthesize data obtained in a region and uncover patterns. Such analysis better represents the current situation in a region and enables for adjustments to treatment and prevention strategies as needed. However, we were unable to find systematic data on dental health in children in the Russian Arctic in the literature.

STUDY AIM: To perform a systematic review and qualitative synthesis of literature data on the prevalence and severity of dental caries, as well as a meta-analysis of the prevalence of dental caries in 12-year-olds, in the Russian Arctic over the last 25 years.

MATERIALS AND METHODS:

The literature search was performed in the eLIBRARY.RU and PubMed databases. The analysis included English- and Russian-language papers published between 1998 and 2023. The search covered studies published during the last 25 years. The systematic review was performed according to PRISMA-2020 guidelines, based on the established criteria, which included a mandatory requirement for children's age (12 years) and the study region (Russian Arctic). The study describes and assesses the prevalence and severity of dental caries.

Two pediatric dentists independently reviewed the databases and extracted relevant publications. In the event of a disagreement, a third reviewer was involved.

The search in the eLIBRARY.RU database was performed as follows:

- Subject: dental caries, children, Far North, Arctic, Russian Arctic;
- Scope: publication title, abstract, keywords, full text;
- Publication type: journal articles;
- Parameters: morphology-based search;
- Publication years: 1998–2023.

As of December 2023, 273 publications were identified in the eLIBRARY.RU database using these search criteria (Fig. 1). After screening, 263 publications were excluded.

The following search terms were used for the PubMed database: *Caries AND (Arctic OR North) AND Russia AND Child**. Four relevant publications were identified. Two of them were excluded after screening. The remaining two were included in the review.

¹ RF Presidential Decree No. 645 of October 26, 2020, On the Russian Arctic Development Strategy and National Security Protection till 2035. Available at: <http://www.kremlin.ru/acts/bank/45972>

Exclusion criteria:

- Systematic reviews;
- Studies assessing children with somatic diseases;
- Studies assessing children under or over the age of 12;
- Non-reviewed manuscripts;
- Studies with no data on the prevalence and/or severity of dental caries;
- Studies assessing children outside the Russian Arctic.

The final review included only original studies published as full-text articles in peer-reviewed journals. All selected publications met the search conditions.

In accordance with PRISMA-2020 guidelines, the review additionally included reports on nationwide epidemiological studies performed in Russia, published in 2009 and 2019 [12, 13]. Fig. 1 shows a diagram of publication selection for the review.

The meta-analysis only included publications with data on the number of examined 12-year-olds and the number of study subjects with confirmed dental caries.

In cases where the number of children with dental caries was not specified, but data on the prevalence were available, the authors calculated the number of examined children prior to including these parameters in the meta-analysis. Studies without available data for these calculations were excluded.

The prevalence of dental caries for all studies is presented as a percentage, and the severity of dental caries based on the DMF index (the sum of decayed [D], missing [M], and filled [F] teeth) and its components is presented as arithmetic means. During the meta-analysis, the prevalence was calculated with 95 confidence intervals (CI) using the Freeman–Tukey test [14]. To assess the heterogeneity of findings of individual studies, I^2 was calculated, which shows the proportion of general variability caused by heterogeneity among studies rather than being random. The meta-analysis was performed using the random effect approach [15]. A forest plot with a weighted prevalence of dental caries and 95% CI is used as a graphic representation of the results.

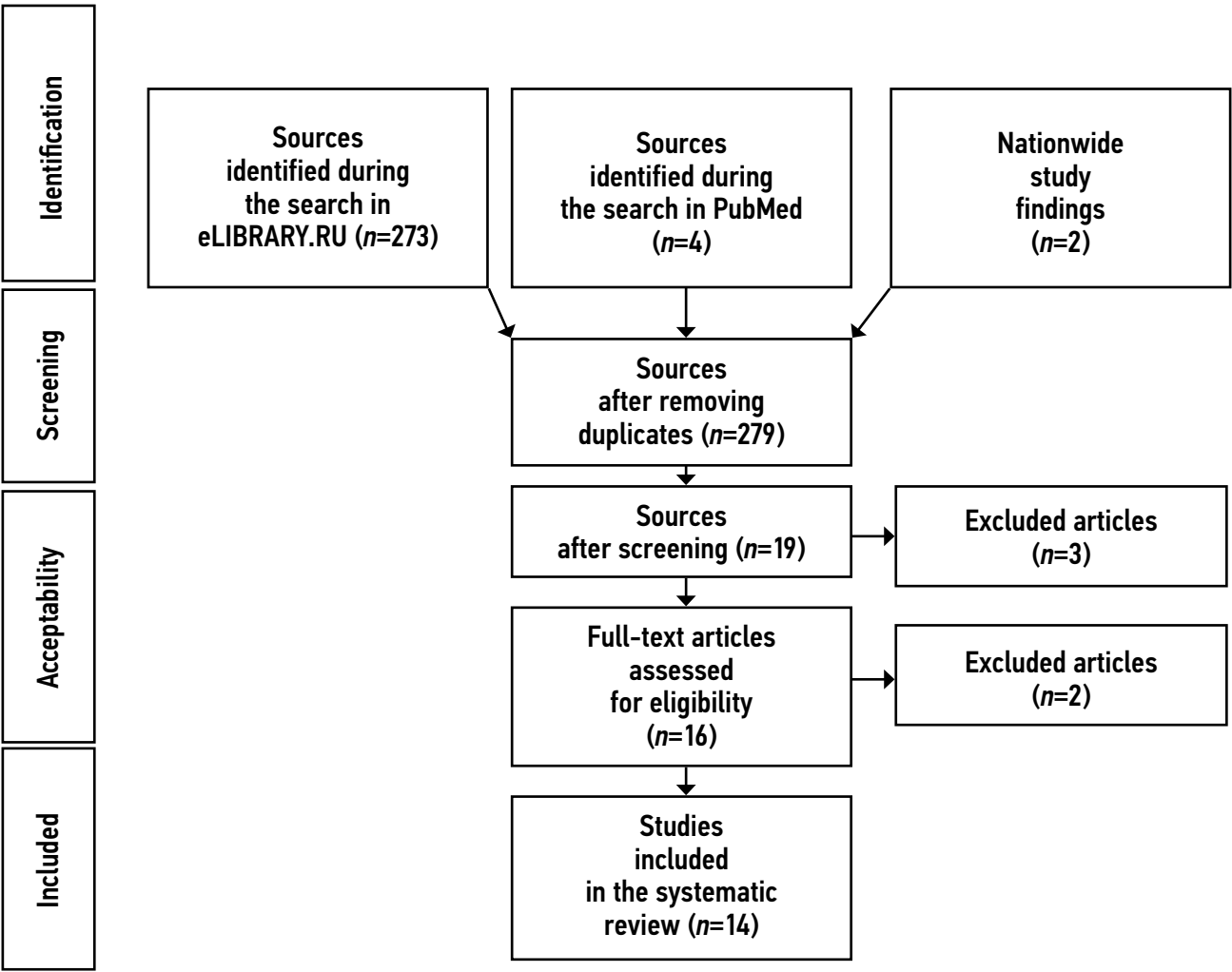


Fig. 1. Diagram of publication selection for the systematic review.

RESULTS

For the period between 1998 and 2023, the scientific literature contains data on the prevalence of dental caries for 7 of the 9 constituent entities that make up the Russian Arctic. Ten of the fourteen studies were cross-sectional observational studies. One study was a cross-sectional continuous study [16], and two studies provided insufficient information on the methodology [17, 18]. All studies calculated prevalence as a percentage with a 95% CI. The severity of dental caries was presented as a mean DMF index. One study used a median [19]. Data published in 1999, 2009, and 2019 were obtained during nationwide cross-sectional dental studies performed in 1996–1998, 2007–2008, and 2015–2016. During these and eight other studies, children were examined according to World Health Organization (WHO) guidelines using a standard chart [20] to ensure internal and external validity of examination findings. Three other studies provided insufficient information on the data collection method [17, 21, 22]. In one study, data were stratified by gender, place of residence, and ethnicity [23]. The sample size in the studies varied from 14 to 808, with a total of 5,376 children examined.

Five of the fourteen selected studies did not specify the exact number of participating 12-year-olds [17, 18, 22, 24, 25]. As a result, these publications were not included in the meta-analysis due to the lack of data for calculations. Some studies provided no data on the severity of dental caries by components [18, 16, 21, 24, 26], reducing their usefulness in assessing the situation. All of these considerations emphasize the importance of uniform data representation to ensure study comparability and subsequent quantitative synthesis.

The highest prevalence of dental caries was observed in Tazovsky settlement and among newly arrived residents of Salekhard (Yamalo-Nenets Autonomous Okrug): 99.0% and 98.6%, respectively. The lowest prevalence of dental caries was observed in Segezha (Republic of Karelia) and Murmansk: 55.0% and 58.0%, respectively.

High prevalence and severity of dental caries in children were reported among the indigenous population of the Russian Arctic in the Republic of Sakha (Yakutia) [25, 26]. In the Nenets, the prevalence and severity of dental caries in children were low to moderate [16, 23]. Indigenous small-numbered peoples of the North have a high proportion of the missing teeth (M) component of the DMF index in children. It reached 23% ($M = 1.14$) in the Evens in the Republic of Sakha (Yakutia) and 12.3% ($M = 0.54$) in the Yakut; in the Nenets, the mean number of missing teeth was 0.07, or 1.5% of the DMF index.

In the Novaya Zemlya urban district, the DMF index in children was lower (1.72) than in other studied regions of the Russian Arctic; however, the DMF index in newly arrived residents of Salekhard reached 7.82. Appendix 1

presents detailed data on the prevalence and severity of dental caries in 12-year-olds in the Russian Arctic [12, 13, 16–19, 21–28].

Data from at least several years were available for 8 populated areas. In all these areas, except for Norilsk, the prevalence of dental caries in 2019 was lower than in 2009. However, the CIs for the prevalence overlapped in all cases, making it hard to determine whether this decrease was significant. Moreover, the mean DMF index in 2019 was lower than in 2009 in all populated areas, except for Noyabrsk. Interestingly, in the majority of populated areas, the proportion of the decayed teeth (D) component of the DMF index decreased by 2019. However, in Onega, this component increased from 21.1% to 64.5%, indicating a possible reduction in the availability of dental care.

Fig. 2 presents the results of quantitative synthesis of individual studies as a forest plot. The weighted prevalence of dental caries in 12-year-olds was 79.3% (95% CI: 74.7–83.6). I^2 was 86%, indicating high heterogeneity of the results of individual studies.

No research have been published in the last 25 years on the prevalence and severity of dental caries in the Arctic region of the Chukotka Autonomous Okrug and the Komi Republic (Fig. 3).

DISCUSSION

The quantitative analysis found no significant decrease in the prevalence of dental caries (Fig. 2); however, it gradually diminishes with time. Individual constituent entities of the Russian Federation show a more pronounced decrease in the DMF index, which can be explained by several factors.

For example, in Murmansk, the prevalence of dental caries in 12-year-olds has decreased by 21% over the last 10 years (probably due to decentralized dental care). The majority of therapeutic and preventive interventions in the city are provided in pediatric dentistry departments and dental offices in some educational institutions. Moreover, periodic preventive examinations are performed in schools according to a schedule [29].

The situation with dental care is similar in the Vyngapurovski district of Noyabrsk (Yamalo-Nenets Autonomous Okrug), with a population of less than 6.5 thousand people. According to the Russian Federal State Statistics Service, the number of dentists in the Yamalo-Nenets Autonomous Okrug has increased by 15% in the last 5 years [30]; a renovated children's outpatient clinic and school dental office are now open. Prior to 2017, this region most likely focused on therapeutic rather than preventive activities.

The lowest prevalence of dental caries in children was reported in Segezha. On the one hand, this may be attributed to optimal fluoride levels in water in the Segezha district

(0.9 mg/L) [12] due to an aluminum plant located 20 km away from the city [31]. On the other hand, the decayed teeth (D) component of the DMF index predominates in children, which may be due to an insufficient number of pediatric dentists and the absence of dental hygienists in public healthcare institutions [32, 33].

Norilsk has copper and nickel ore production and processing facilities. Despite optimal fluoride levels in water (0.5–0.7 mg/L) [13], industrial complexes release harmful emissions into the environment, primarily sulfur dioxide and nitrogen dioxide. Their toxic effects

may disrupt tissue differentiation of tooth buds and jaw ossification [34], leading to no decrease in the prevalence of dental caries in children. At the same time, the city has a well-developed pediatric health checkup system, as demonstrated by the prevalence of the filled teeth (F) component in the DMF index.

The Nenets who live in the Nenets Autonomous Okrug primarily have a settled way of life and work in the oil industry. During the years of epidemiological studies, industry personnel had periodic health checkups. The Red Chum program was implemented for medical

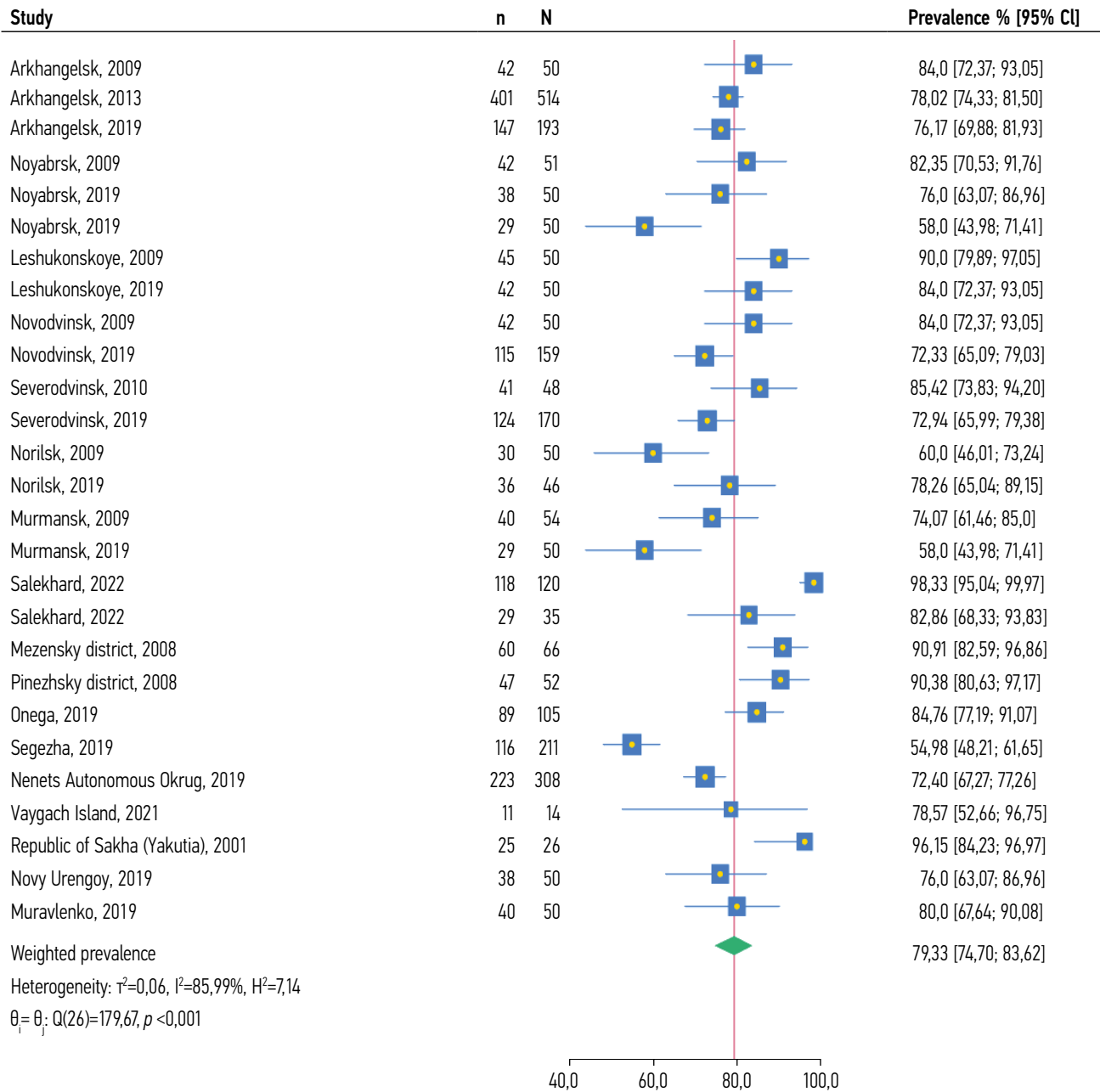


Fig. 2. Meta-analysis of dental caries prevalence studies in 12-year-olds in the Russian Arctic in 1998–2023: n, number of examined children with dental caries; N, number of examined children; CI, confidence interval.

examination, treatment, and personal hygiene education in nomadic Nenets [35].

The modest severity of dental caries among 12-year-olds in the Novaya Zemlya urban district (Arkhangelsk region) can be attributed to the fact that during the epidemiological study, the majority of the population was newly arrived and resided in the archipelago for several months to five years [24].

Overall, the prevalence and severity of dental caries were fairly modest. This is explained by the fact that the negative effect of candy consumption is still insufficient to cause severe demineralization of the enamel of newly erupted secondary teeth in 12-year-olds. Some regions of the Russian Arctic have also seen an improvement in dental care quality as a result of greater dentist availability and preventive efforts. However, regular monitoring of the prevalence and severity of dental caries in children, particularly in the Russian Arctic, according

to international standards and criteria remains critical for the development of the Arctic region.

Notably, the majority of children examined in this study reside in the Arkhangelsk region (Arkhangelsk and Severodvinsk). This is due to a well-developed maxillofacial disease monitoring system, as evidenced by numerous studies performed in this region. The Nenets Autonomous Okrug ranks second in terms of published studies. Therefore, it is reasonable to assume that the qualitative and quantitative analysis findings primarily represent these two constituent entities. Moreover, two other constituent entities with territories that make up the Russian Arctic were not included in the review due to the absence of data, highlighting the necessity for research in Chukotka and the Komi Republic (Fig. 3).

The majority of studies after 2010 were performed in compliance with WHO recommendations, increasing the internal and external validity of both individual studies and the meta-analysis as a whole.



- | | | |
|---|---|--|
| 1. Murmansk (Murmansk region) | 11. Muravlenko (Yamalo-Nenets Autonomous Okrug) | 19. Noyabrsk (Yamalo-Nenets Autonomous Okrug) |
| 2. Segezha (Republic of Karelia) | 12. Naryn-Mar (Nenets Autonomous Okrug) | 20. Taimyr Dolgano-Nenets municipal district (Krasnoyarsk Territory) |
| 3. Onega (Arkhangelsk region) | 13. Vaygach Island (Nenets Autonomous Okrug) | 21. Eveno-Bytantaysky district (Republic of Sakha (Yakutia)) |
| 4. Severodvinsk (Arkhangelsk region) | 14. Novaya Zemlya urban district (Arkhangelsk region) | 22. Verkhoyansky district (Republic of Sakha (Yakutia)) |
| 5. Arkhangelsk (Arkhangelsk region) | 15. Salekhard (Yamalo-Nenets Autonomous Okrug) | 23. Abyysky district (Republic of Sakha (Yakutia)) |
| 6. Novodvinsk (Arkhangelsk region) | 16. Tazovsky (Yamalo-Nenets Autonomous Okrug) | 24. Srednekolymsky district (Republic of Sakha (Yakutia)) |
| 7. Leshukonskoye (Arkhangelsk region) | 17. Norilsk (Krasnoyarsk Territory) | |
| 8. Mezensky district (Arkhangelsk region) | 18. Novy Urengoy (Yamalo-Nenets Autonomous Okrug) | |
| 9. Karpogory (Arkhangelsk region) | | |
| 10. Pinezhsky district (Arkhangelsk region) | | |

Fig. 3. Russian Arctic territories where dental caries prevalence studies in 12-year-olds were performed in 1998–2023.

Study limitations. The limitations of this study include the following: low-quality methodology descriptions in some studies performed in compliance with WHO recommendations, which reduces the validity of findings; no data distribution by gender and age in some studies, which limited the number of publications included in the quantitative synthesis; and the lack of data for some constituent entities that make up the Russian Arctic.

A considerable number of studies excluded from the meta-analysis due to insufficient information highlights the necessity for uniform data representation for dental caries studies.

CONCLUSION

The review of studies performed in the Russian Arctic over the last 25 years indicates that the prevalence and severity of dental caries in 12-year-olds in this region remain high compared to Nordic nations. Despite preventive measures implemented in the region, additional efforts are needed to further reduce the prevalence and severity of dental caries in all constituent entities. These include a broader range of preventive measures, better

access to dental care and dental hygienists, regular health checkups, and the development of individualized prevention programs for pediatric patients.

ADDITIONAL INFORMATION



Supplement 1. Prevalence and experience of dental caries among 12-years-old children in Arctic Russia.

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