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Human helminth infections above latitude 60°N: reports published 2001 -2024

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Abstract

This article surveys reports of human helminth infection from geographical regions above latitude 60ºN published in the period 2001-2024. We take a global approach encompassing the Americas and Eurasia. The helminth genera thus described herein include nematode (*Trichinella*, *Toxocara*, *Anisakis*, *Pseudoterranova*), cestode (*Echinococcus*, *Dibothriocephalus*) and trematode (*Opisthorchis*, *Trichobilharzia*). The primary reports identified infections principally by serology (community-based or individual, including imported cases) and outbreaks. There were also articles reporting national data compiled from official sources. Despite successful local control programmes, these pathogens pose an ongoing risk to human health in this region

Keywords: *Trichinella*; *Toxocara*; Anisakid, *Echinococcus*; *Dibothriocephalus*; *Opisthorchis*; Alaska; Canada; Greenland; Russian Federation.

Introduction

This article surveys reports of human infection with parasitic helminths in the global Arctic and sub-Arctic region, northwards from a latitude of approximately 60ºN, published in the period 2001-2024. We use 60°N to focus on the northernmost part of the inhabited world as it has relatively sparse literature compared to other regions of the world.

Previous review articles in the literature have concentrated on particular helminth genus or geographical region, for example: trichinellosis (Ozeretskovskaya et al., 2005; Oksanen et al., 2022); *Echinococcus* (Davidson et al., 2016); *Dibothriocephalus* (Kralova-Hromadova et al., 2021; Kuchta et al., 2023); the Americas (Jenkins et al., 2013). Those articles have also incorporated historical perspectives. Generally, there has been a decline in human helminth infections in this region during the twentieth century, due to public health campaigns and specific control and monitoring programmes. These include for *E. granulosus* in Iceland (Saarma et al., 2023) and Finland (Hirvelä-Koski et al., 2007; Oksanen and Lavikainen, 2015) and *E. multilocularis* surveillance in Nordic countries (Wahlström et al., 2015).

Here, by applying a 21st-century timeframe and a global lens, we concentrate on more recent reports to highlight the ongoing risk of human infection.

Methods

Search terms comprising genus name and geographical region e.g., ["*Trichinella*" AND "Human" AND "Greenland"] were searched on Pubmed, Web of Science and Google Scholar for publications dated from 2001 onwards. There were no language restrictions. Excluded: articles in which the source of infection was identified or suspected by those publications' authors as below 60°N.

Results

Of the articles identified for inclusion herein, the majority (n= 27) were primary reports of helminth infection that were either fully accessible to us online or in a few cases only the Abstract. There were a smaller number of publications that compiled national sources of data and/or unpublished reports for which the primary data were not readily attainable.

The helminth genera comprised nematodes *Trichinella*, *Toxocara*, *Anisakis*, *Pseudoterranova*, cestodes *Echinococcus*, *Dibothriocephalus* and trematode *Opisthorchis*, *Trichobilharzia*. All are zoonotic and, with the exception of *Trichobilharzia*, are acquired by ingestion of infective helminth propagules from undercooked game (mammal or fish) or by exposure to materials contaminated by animal faeces (Benesh et al., 2021). The identified articles concentrated on a single genus or considered up to three genera.

Geographic locations in the Americas were in Alaska, Canada and Greenland (Kalaallit Nunaat), and in Eurasia were in Iceland, Norway, Finland and Russian Federation (Figure 1). In the primary reports, infections were identified by serology in community surveys (Table 1) or in individual cases (sometimes with parasitological or molecular demonstration), or as part of outbreaks (principally of *Trichinella*, Table 2).

The highest number of articles were on *Trichinella*, followed by *Toxocara* and *Echinococcus*. Articles on the trematodes *Opisthorchis* and *Trichobilharzia* referred only to Eurasia, whereas the other genera were represented by articles referring to both Eurasia and the Americas.

In the following sections, each genus is considered in turn, with a brief description of propagule infection followed by the reports according to geographical setting.

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Nematodes

***Trichinella* spp.**

Consumption of inadequately cooked game meat containing parasite larvae can lead to diarrhoea, fever, myalgia, facial oedema, eosinophilia, and elevated levels of muscle enzymes. The predominant regional taxon of this genus is encapsulated *T. nativa*, viable at low (frozen) temperatures (Pozio, 2016).

Americas. A serosurvey among bird-hunting populations of southern Alaska sampled in 2007-08 found 5% seropositivity, although no specific source of infection was proposed (Miernyk et al., 2019). However, outbreaks of trichinellosis related to the consumption of walrus (*Odobenus rosmarus*) were identified in 2016 and 2017 in the Norton Sound area of western Alaska. In the 2016 outbreak, five members of the same family were affected; the following year an outbreak was suspected in a separate community, involving five neighbours who had shared walrus meat. In both outbreaks, the incriminated meat was not available for testing, but stored (frozen) meat from the household of the 2017 outbreak was identified by PCR to contain *T. nativa* (Springer et al., 2017).

A study in 2004, part of a Canadian health survey in the northern Quebec region of Nunavik, reported a seroprevalence of ≤1% for the 14 sites as a whole (Messier et al., 2012). In contrast, a study conducted in 2007 and 2008 across coastal regions further north in Nunavut as part of the International Polar Year Inuit Health Survey, reported a combined seroprevalence of 18.6% from >30 communities; these remote far northern study populations were reached by sea or air (Goyette et al., 2014). An analysis of Canadian hospital admissions between 2001-2005 revealed that there was a much higher incidence in Nunavut and Nunavik together than in the rest of Canada combined (Gilbert et al., 2010).

Outbreak clusters in northern Canada reported since 2001 have been associated with coastal communities. In 1997, the implementation of a novel control programme including

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PCR identification of *T. nativa* in walrus meat samples and community engagement prevented a larger outbreak in Puvirnituq and Inukjuak (west coast of Nunavik) (Proulx et al., 2002). In 1999 seven individuals, who had eaten raw walrus meat a few weeks previously, presented at a health centre in Qikiqtarjuag (eastern coast of Nunavut) with symptoms including diarrhoea, abdominal pain, rash and swelling. All were found to have high levels of anti-*Trichinella* antibodies and eosinophilia (Serhir *et al*., 2001). In 2009, a cluster in a group of sailors returning to France after exploring the Northwest passage on two different boats was considered to be most likely caused by consumption of frozen meat of grizzly bear (*Ursus arctos*) around Cambridge Bay (Iqaluktuuttiaq), Victoria Island, Nunavut. Prior to definite diagnosis, two of the sailors while still on-board experienced influenza-like symptoms (Houzé et al., 2009). In 2013, another outbreak in Inukjuak involved 18 individuals across 15 different households, notable as most of the cases were adult women and also as the investigators were not able to identify a specific event or food source as a cause, although distributed meat of polar bear (*Ursus maritimus*) was considered the most likely (Ducrocq et al., 2020).

A seroprevalence study comparing samples from various settlements predominantly in western Greenland archived between 1979-1981 and 1998-2004 identified (i) game meat consumption as the main risk factor for infection and (ii) a declining trend in seropositivity between the two time periods, likely due to the increased consumption of industrially produced food (Møller, 2007). A seroprevalence of 1.1% was found from a 2001 survey among children under 14 years of age in western Greenlandic settlements (Møller et al., 2007). Similarly, a 2004 sampling among game hunting communities in eastern Greenland revealed an increase in seropositivity according to age, 1.4% vs. 7.5% in participants aged under or over 40 respectively; seroprevalence for the ⩾60 years age group alone was 12%. 'Occupation hunter/fisherman' and 'polar bear meat consumption' were identified as

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significant risk factors (Møller et al., 2010).

As elsewhere in the Americas, outbreak clusters have been recognised in Greenland in recent decades. In 2001 a cluster associated with consumption of game meat, suspected to be walrus, was identified near Aasiaat in west Greenland. Serological confirmation by ELISA and western blot was achieved in four of the six cases initially; one of the two seronegative cases sero-converted when tested a year later, the authors considered this due to new infection (Møller et al., 2005). In a later outbreak, three travellers returning to France in 2016 presented at a Paris hospital with symptoms including myalgia, diarrhoea, with elevated eosinophilia and creatinine kinase levels. They had consumed meat of polar bear in eastern Greenland a few weeks before; trichinellosis was confirmed by ELISA and western blotting (Dupouy-Camet et al., 2016).

Eurasia. In the Russian Federation, sampling in 2007 from Viljujsk city, Sakha/Yakutia, north-eastern Siberia, reported 4.4.% seroprevalence by ELISA (Magnaval et al., 2011). From sampling in two coastal settlements in Chukotka on the Arctic coast of the Bering Sea in 2010 and 2011, 24.3% seroprevalence was found by ELISA using in-house generated *T. nativa* excretory–secretory antigen, with important sources of infection being meat of walrus and seal (*Phoca*) (Uspensky et al., 2019). A serosurvey in 2018 in rural areas of Central Sakha/Yakutia used commercial ELISA kit to detect 2.2% seroprevalence; the authors also assessed IgG against *E. granulosus* and *T. canis*, as described in the sections below. However, in that study, none of the three helminths had correlations with possible exposure variables identified (Nakhodkin et al., 2019).

A listing of outbreaks within the Russian Federation between 1996-2002, compiled from official sources, cites an outbreak involving 10 cases in Yamal-Nenets in north-western Siberia caused by consumption of the meat of the brown bear (*Ursus arctos*) (Ozeretskovskaya et al., 2005).

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***Toxocara* spp.**

Ingestion of embryonated eggs in material contaminated with dog or cat faeces results in the release of larvae that migrate in the human body, consequently, toxocariasis comprising several pictures (covert toxocariasis, visceral larva migrans, ocular or neurological toxocariasis) may occur.

Americas. The Canadian studies of Messier et al. and Goyette et al. described above reported 3.9% and 1.7% seroprevalence respectively for human toxocariasis using a commercial ELISA (Messier et al., 2012; Goyette et al., 2014). Decrease in seropositivity associates with northerly latitude in Canada (Bradbury and Panicker, 2020).

Eurasia. Anti-*Toxocara* IgG4 seroprevalences of 17.5% and 8.0% in parents and offspring respectively were found as part of a Norwegian inter-generational study (overall 11.7%), identifying positive associations with allergic symptoms among the offspring. The authors described a soluble worm somatic antigen preparation for use in the ELISA (Jõgi et al., 2018).

Seroprevalence has been reported from Sakha/Yakutia (Russian Federation). In a 2007 sampling, seroprevalence by western blot of 4.4% was reported in a Northwestern area (Magnaval et al., 2011), although none was found in other settlements of the Far North (Magnaval et al., 2016). In line with this, a sampling in in 2007-8 revealed 3% seroprevalence by commercial ELISA, among the lowest in the geographical range (south to north) of Russian regions examined (Akhmadishina et al., 2020), and a 2018 sampling identified 1.1% seroprevalence (Nakhodkin et al., 2019).

Anisakids

Larvae of anisakid species such as *Anisakis simplex* and *Pseudoterranova decipiens* in muscle of undercooked marine fish are released by human stomach enzymes, leading to gastric or intestinal infection. Both locally acquired (Norway Iceland, Greenland) and

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imported cases (from Alaska) have been reported.

Americas. The study of western Greenlandic settlements mentioned above for *Trichinella* also reported the first human arctic IgG against Anisakidae (Møller et al., 2007). In imported cases, anisakiasis was detected histologically within an inguinal hernia in a patient who had consumed raw salmon from a stream on a recent fishing trip to Alaska (Hope et al., 2020). The first documented imported cases in Austria occurred in two travellers returning from an Alaskan fishing trip where they had consumed cold smoked salmon. Diagnosis was by specific antibody detection, the morphological and molecular identification of *A. simplex s. str*. larvae in the consumed salmon and of *Anisakis* DNA in the resected ileum of one of the patients (Auer et al., 2007).

Eurasia. In Norway, a chronic infection was identified by decreased *A. simplex* IgE serology following resection of an occluding duodenal tumour, and suggestive identification of a tubular sclerotic structure 1-2 mm in diameter. The authors reported the patient's history of consumption of prepared saltwater fish (Eskesen et al., 2001).

Between 2004-2020 in Iceland, 16 human cases of *P. decipiens* and two of *A. simplex* were identified in this island nation (Skírnisson, 2022). Among these, *P. decipiens* larvae were found in the throats of patients a few days after consumption of inadequately cooked catfish (Skírnisson, 2006).

Cestodes

Echinococcus spp.

Transmission is by ingestion of eggs in material contaminated with canid faeces (leading to hydatid cyst), or following contact with foxes (alveolar echinococcosis, AE).

Americas. Two documented human cases of *E. granulosus* cystic echinococcosis (CE) in Alaska were reported as having unusually severe presentations (Castrodale et al., 2002). The 2007-08 sampling mentioned above (Miernyk et al., 2019) reported 1.8% and 0.1%

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seroprevalences for *E. granulosus* and *E. multilocularis* respectively.

The Canadian studies of Messier et al. and Goyette et al. described above reported 8.3% and 6.3% seroprevalence respectively for *E. granulosus* only (Messier et al., 2012; Goyette et al., 2014). Analyses of Canadian hospital admissions have also been undertaken. One study of the years 2001-2005 revealed the incidence for echinococcosis increased with northerly latitude, the highest being from above 55ºN. The type of echinococcosis (CE or AE) was not specified (Gilbert et al., 2010). A different analysis for year range 2000–2020 also found that Northwest Territories, Nunavut and Yukon together (all above 60°N) had a much higher risk of echinococcosis (RR 17.1; 95% CI: 8.7–33.7) compared to more southerly Atlantic provinces, with Northwest Territories having the highest national risk and increase (6.3 to 9.1 cases/million) but decreases in Nunavut and Yukon (8.6 to 2.6 and 5.3 to 5.1 respectively/million). The number of identified cases of *E. granulosus* and *E. multilocularis* for Canada as a whole were given by those authors, but not specified geographically for each province (Khalid et al., 2024).

Eurasia. Sampling in 2012 in the Russian Federation identified 1.3 % seroprevalence of AE in a study of two villages in the Verkhoyansk district (Far North Sakha/Yakutia) by ELISA using commercial soluble extract of *E. granulosus* protoscoleces and a second-tier western blot using *E. multilocularis* whole larval extract for AE discrimination (Magnaval et al., 2016). A 2018 sampling in the same region reported 4.4% seroprevalence (Nakhodkin et al., 2019).

***Dibothriocephalus* spp.**

Following ingestion of the plerocercoid from undercooked fish, adult worms may grow to several metres in length within the human host.

Americas. A report of traveller returning to Austria, who passed a 75 cm tapeworm segment in stool, was suspected to have been infected during a Alaskan fishing tour 14

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months earlier. The otherwise asymptomatic patient, without weight loss, anaemia or eosinophilia, was treated successfully with a single dose of praziquantel (Stadlbauer et al., 2005).

Eurasia. A report of molecular typing of *D. latus* DNA included an infection from a Finnish patient, who reported having eaten a local fish meal in the southern coastal locality of Kotka (Wicht et al., 2010).

An analysis of official reports and Russian-language sources revealed information according to region. North-western Russia: in Karelia nearly 300 cases between 2011-2013; in Arkhangelsk a decrease in incidence/100,000 from 6.99 to 2.74 between 2006-17. Ural district: in Khanty-Mansi region 210 cases between 2020-2022. Siberia: incidence/100,000 in Evenk (548.8) and Taymyr Dolgano-Nenets (343.7) administrative regions were the highest nationally. Far East: in Sakha/Yakutia decrease in incidence to 112.2/100,000 by 2016 (Kuchta et al., 2023). Molecular analysis of an adult worm expelled from a patient in the St Petersburg area allowed the identification of repetitive elements in the *D. latus* genome (Usmanova and Kazakov, 2010).

Trematode

***Opisthorchis* spp.**

Following ingestion of metacercaria from undercooked fish, adult worms live in human bile ducts, significantly increasing risk of cholangiocarcinoma in chronic infection.

Eurasia. Infection with *O. felineus* is endemic in many parts of Russian Federation, principally in Western Siberia. An analysis of official sources for 2011-2013 revealed the highest incidence in Khanty-Mansi and Yamal-Nenets regions (599.7 and 261.9 cases respectively/100,000/year). Approximately 30,000 new cases were diagnosed each year nationally (Fedorova et al., 2017).

A familial outbreak in Israel was traced to imported fish eaten 10 days earlier that had

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been originally bought in Nizhnevartovsk, Khanty-Mansi region. Diagnosis was confirmed by identification of worm ova in patient stool, and presumed to be *O. felineus* due to high levels of endemicity in the region of origin (Yossepowitch et al., 2004).

***Trichobilharzia* spp.**

These members of the Schistosomatidae family infect humans through skin penetration by the cercariae which emerge from the intermediate snail host. Cercarial dermatitis ('swimmers itch') is caused by zoonotic schistosomes which do not develop fully in humans. Following infection, a pruritic dermal maculopapular response develops.

Eurasia. In Iceland, outbreaks of cercarial dermatitis after infection by bird schistosome cercariae have been reported since 2000 (Skírnisson et al., 2009). Two outbreaks occurred in a touristic geothermally-heated brook in Landmannalaugar in the southern interior of the island in 2003 and 2004. The authors state that these were caused by increased numbers of *Trichobilharzia* schistosomes deriving from mallard (*Anas platyrhynchos*) ducklings and developing in *Radix peregra* snails (Skírnisson and Kolarova, 2005).

In a compilation of reports from Norway between 2001-2009, cercarial dermatitis was recorded in dozens of lakes throughout the length of that country (Soleng and Mehl, 2011). The authors of that study identified *Trichobilharzia franki* cercariae shed from a *R. auricularia* snail in a sampling in 2008.

Discussion

The prevalence of neglected infectious diseases in Arctic and sub-Arctic communities may not always have been well considered in global disease burdens, due to factors such as the geographical and societal remoteness of such populations (Hotez, 2010).

Our intention here was to survey recent literature for a broad range of human helminths (nematode, cestode and trematode) to encompass the inhabited global region above 60°N. From fully accessible (online) primary reports, we could extract details including locations,

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sampling, and diagnostic tests. However, this was not always possible, as some articles referred to compiled national data (Ozeretskovskaya et al., 2005; Gilbert et al., 2010; Fedorova et al., 2017; Khalid et al., 2020; Skírnisson, 2022; Kuchta et al., 2023) or only the abstract was accessible to us (for example, Auer et al, 2007; Skírnisson 2006).

Many of these studies used commercial ELISA tests to identify IgG. Some authors acknowledged the possible limitations of the commercial ELISAs, such as used for *Trichinella*, including lack of specificity, and confounding longevity of IgG, as caveats (Messier et al., 2012, Goyette et al., 2014). For *Toxocara*, ELISA or western-blot using *T. canis* excretory-secretory antigens do not discriminate between infection due to *T. canis* and that due to *T. cati*. Such considerations may also skew associations with risk factors. Therefore, the identification and characterisation of outbreak clusters becomes of particular interest. Those described here principally relate to trichinellosis, for which the most literature was readily accessible, predominantly from the Americas. These demonstrate that transmission to humans is ongoing and therefore almost certainly under-reported due the isolation of hunting communities or mild or unrecognised symptoms.

Among reports in returning travellers, infections originated in the Americas (Alaska, Canada, Greenland). These articles reinforce the importance of travel history including food consumption, which may otherwise lead to mis-diagnosis and delay appropriate treatment.

The helminths described in the current article are all zoonoses, which (with the exception of *Trichobilharzia*) require human exposure to undercooked game, or to materials contaminated by animal faeces. Thus not only prevalence in the sylvatic environment but also human lifestyle are crucial for transmission. For example, in stark contrast to the increase in trichinellosis and echinococcosis with northerly latitude in Canada (Gilbert et al., 2010, Khalid et al., 2024), anti-*Toxocara* IgG seroprevalence showed the opposite trend in that country (Bradbury and Panicker, 2020) and in Russian Federation (Akhmadishina et al.,

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2020), likely due to unfavourable environmental conditions for persistence of the mature infective embryonated egg and contact with humans.

Control programmes for *E. granulosus* (CE) have been successful in Iceland leading to eradication by 1979 (Saarma et al., 2023) and in human food-chain reindeer in Finland (Hirvelä-Koski et al., 2007; Oksanen and Lavikainen, 2015). For *E. multilocularis* (AE), surveillance in Nordic countries has been in place since its identification in a fox in Denmark in 2000 (Wahlström et al., 2015). In this control context, the Nunavik Trichinellosis Prevention Program, implemented in the 1997 outbreak in Nunavik in northern Quebec (Proulx et al., 2002), succeeded in preventing any further local walrus-acquired outbreaks for more than decade, despite the ongoing identification of *Trichinella*-positive walrus meat (Larrat et al., 2012).

Climate change, i.e., increase in global temperatures, has a potential impact on helminth infections in this region. Higher ambient temperatures may favour *O. felineus* transmission in Siberia by increasing cercariae survival and the amount of (non-permafrost) habitat available to *Bithynia* snails (Sripa et al., 2025). The latter consideration is also applicable to soil-dwelling embryonated eggs of *Toxocara*. Anisakid range may also be extended in polar areas (Rockicki, 2009), a zoonotic risk emphasised by the detection of these nematodes in Inuit fish and mammal food sources in the Canadian Far North (Pufall et al., 2012). We also note here the reports of cercarial dermatitis from lakes in northern Norway that experienced warm summers (Soleng and Mehl, 2011).

Herein we have brought together information from published seroprevalence studies, outbreaks, imported cases and compilations of official sources of national data to highlight this extant challenge to human health in the global Arctic and sub-Arctic. As demonstrated by these 21st century articles, helminth infections persist across this region, potentially posing a growing threat due to warming temperatures, so should not be overlooked in assessing the

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global impact on human disease burden. Future directions include the need for sustained research and public recognition of the ongoing risk, aided by the refinement of serological tests to improve specificity (sub-genus level) in epidemiological studies, and the broader implementation of control programmes with crucial community engagement, taking a One Health approach.

Data availability. No novel datasets were generated or analysed for this article. All cited references were available online via public-access resources.

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Table 1. Geographical distribution of seroprevalence studies surveyed herein.

Region	Site(s)	Year of sampling	Reported seroprevalence (%)			Reference
			Trichinella	*Echinoccoccus*	*Toxocara*	
Alaska	Various, southern Alaska	2007-8	5%	1.9%	-	(Miernyk et al., 2019)
Canada	Nunavik, northern Quebec	2004	≤1%	8.3%	3.9%	(Messier et al., 2012)
	Coastal Nunavut	2007 & 2008	18.6%	6.3%	1.7%	(Goyette et al., 2014)
Greenland	Mainly western Greenland	1979-81 & 1998-2004	a	-	-	(Møller, 2007)
	Western Greenland	2001	1.1%	-	--	(Møller et al., 2007)
	Ammassalik municipality, East Greenland	2004	3.1%	-	-	(Møller et al., 2010)
Norway	Bergen area	2010 - 15	-	-	11.7%	(Jõgi et al., 2018)
Russian Federation	Sakha/Yakutia, north-eastern Siberia	2007	4.4%	0	4.4%	(Magnaval et al., 2011)
	Sakha/Yakutia, north-eastern Siberia	2007-8	-	-	3%	(Akhmadishina et al., 2020)
	Bering Sea settlements, Chukotka	2010 & 2011	24.3%	-	-	(Uspensky et al., 2019)

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	Sakha/Yakutia, north-eastern Siberia	2012	0	1.3%	0	(Magnaval et al., 2016)
	Sakha/Yakutia, north-eastern Siberia	2018	2.2%	4.4%	1.1%	(Nakhodkin et al., 2019)

[a] see text

Table 2. Trichinellosis outbreak clusters surveyed herein.

Region	Site	Year	Cases	Authors' remarks	Reference
Alaska	Norton Sound area	2016 & 2017	10	Walrus meat consumption implicated in two outbreaks	(Springer et al., 2017)
Canada	Nunavik, northern Quebec	1997	3	A control programme prevented a larger outbreak caused by walrus meat consumption	(Proulx et al., 2002)
	Coastal Nunavut	1999	7	Walrus meat consumption	(Serhir et al., 2001)
	Kuujjuaq, Nunavik	2004	3	Black bear meat consumption	Cited in (Larrat et al., 2012)
	Kangiqsujuaq, Nunavik	2006	2	Walrus meat consumption outside Nunavik	Cited in (Larrat et al., 2012)
	Victoria Island, Nunavut	2009	5	Grizzly bear consumption by	(Houzé et al., 2009)

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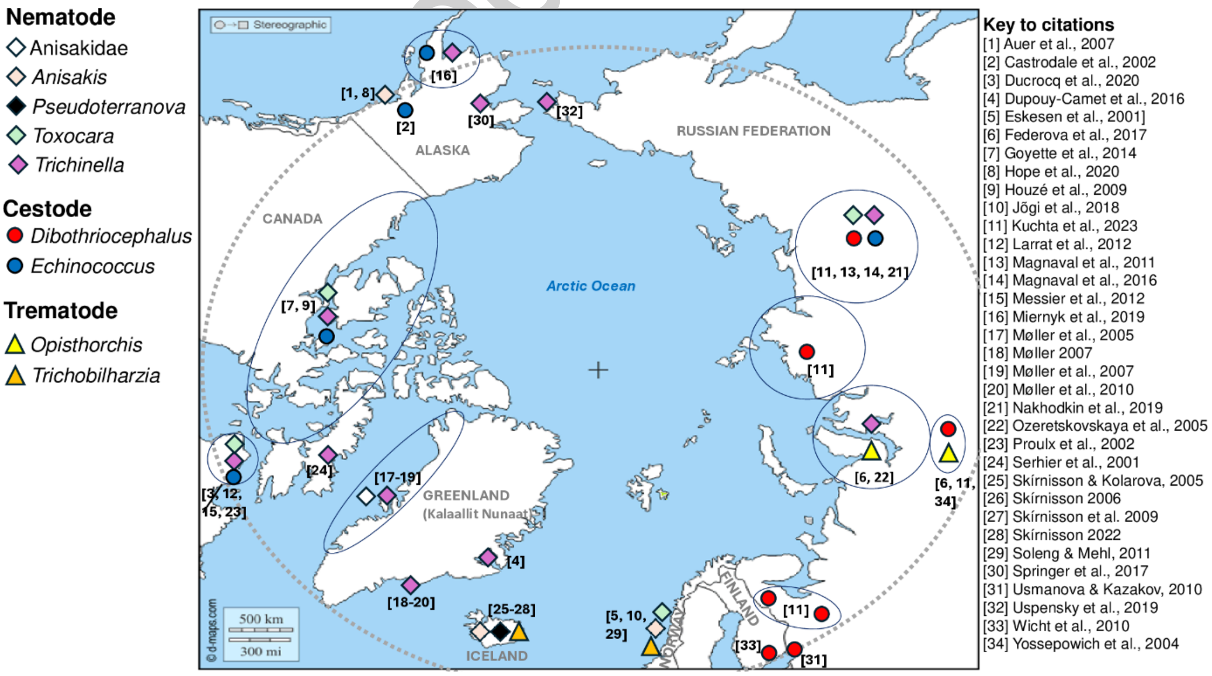
				travellers most likely source	
	Nunavik, northern Quebec	2013	18	Precise cause not identified, distributed polar bear meat considered most likely.	(Ducrocq et al., 2020)
Greenland	Western Greenland	2001	6	Walrus meat most likely source	(Møller et al., 2005)
	Eastern Greenland	2016	3	Polar bear meat consumption by travellers	(Dupouy-Camet et al., 2016)
Russian Federation	Yamal-Nenets, north-western Siberia	2002	10	Brown bear meat consumption	Cited in (Ozeretskovskaya et al., 2005)

Figure 1. Indicative locations of the studies surveyed herein. Encircled regions show the geographical scope of regional studies. Dashed line represents latitude 60°N.



Graphical Abstract:

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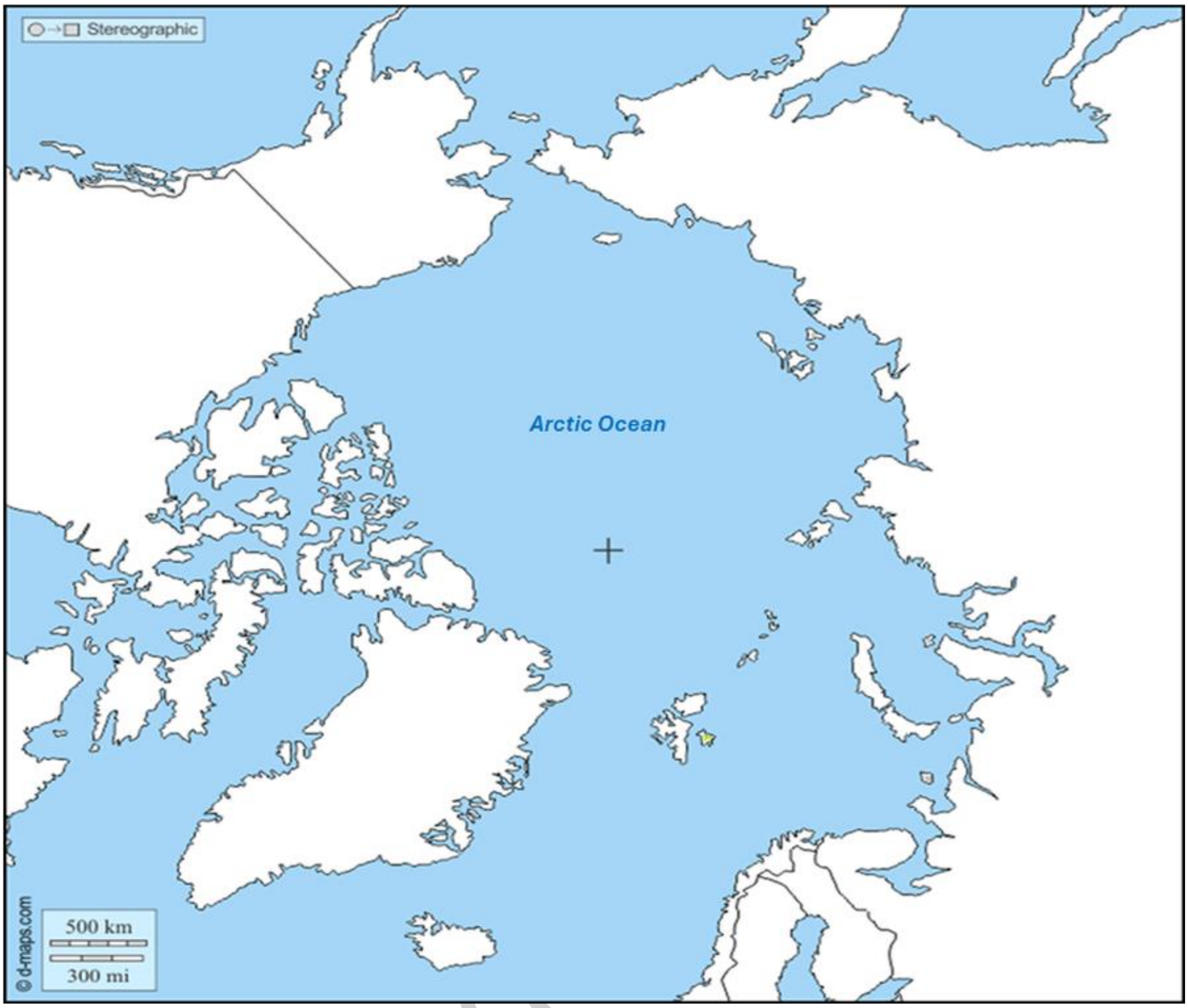

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