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Review article

Human infectious diseases and the changing climate in the Arctic

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ABSTRACT

Climatic factors, especially temperature, precipitation, and humidity play an important role in disease transmission. As the Arctic changes at an unprecedented rate due to climate change, understanding how climatic factors and climate change affect infectious disease rates is important for minimizing human and economic costs. The purpose of this systematic review was to compile recent studies in the field and compare the results to a previously published review. English language searches were conducted in PubMed, ScienceDirect, Scopus, and PLOS One. Russian language searches were conducted in the Scientific Electronic Library "eLibrary.ru". This systematic review yielded 22 articles (51%) published in English and 21 articles (49%) published in Russian since 2012. Articles about zoonotic and vector-borne diseases accounted for 67% (n = 29) of the review. Tick-borne diseases, tularemia, anthrax, and vibriosis were the most researched diseases likely to be impacted by climatic factors in the Arctic. Increased temperature and precipitation are predicted to have the greatest impact on infectious diseases in the Arctic.

1. Introduction

Evidence shows that the Arctic land surface temperatures have warmed considerably since the mid-twentieth century (Larsen et al., 2014). In some regions, the rate is nearly double the global average (Hassol et al., 2004). By 2040, there is a predicted increase of 2 °C, and by 2100, between 4 and 7 °C (Hassol et al., 2004). Warmer temperatures in the Arctic cause changes in sea ice, snow coverage, permafrost, ocean warming, and precipitation. Additionally, climate change is occurring concurrently with unprecedented globalization in the Arctic. Greater accessibility to remote locations, increases in tourism and industry, and social change bring new health challenges to the Arctic as well, in addition to already complex issues such as health disparities between indigenous and non-indigenous people, high concentrations of environmental contaminants, and rising chronic disease rates (Arctic Council Ministerial, 2009).

As the Arctic warms at an unprecedented pace, understanding how climatic factors affect infectious diseases in the Arctic is essential. Climate change has been predicted to be the most influential factor in the emergence of infectious diseases (Sonne et al., 2017). The changes in the Arctic climate will have both direct and indirect impacts on the health of Arctic residents, especially in relation to infectious diseases (Larsen et al., 2014). Directly, warmer temperatures can accelerate growth rates of pathogens and animals, including insect vectors (Baylis, 2017; Noskov et al., 2017; Yasjukevich et al., 2013). Increased connection and human migration can introduce infectious diseases to previously isolated areas, exposing highly susceptible populations to new pathogens (Dudley et al., 2015). Extreme precipitation may result in flooding and disruption of water/sanitation infrastructure, elevating the risk for waterborne outbreaks. Indirectly, climatic factors affect infectious disease transmission by altering human behavior. For example, warmer temperatures lead to more people using public bathing waters, providing more opportunities for a waterborne outbreak to start (Eze et al., 2014). Similarly, people spend more time outside (i.e. in forests and public places for picnics and other free time activities), increasing the likelihood of contracting a tick-borne disease (Chashchin et al., 2017). Additionally, changes in climatic factors can expand a disease-vector's geographic range, or enlarge its population, for example more vector species and individuals survive though the winter (Bruce et al., 2016; Burmagina et al., 2014; Chashchin et al., 2017; Mesheryakova et al., 2014; Parham et al., 2015; Yastrebov et al., 2016). Increases in public and health personnel education, vaccination programs, and hygiene, however, help combat the spread of disease, potentially reducing infections even though opportunities for infection may increase as a result of climate change.

Infectious disease rates across the Arctic are highly variable depending on country, disease, age, and sex (AMAP, 2009). For example, disease rates for tularemia in the Arkhangelsk region and Khanty-Mansi

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autonomous area (a.a.), are several times higher than averages registered for the Russian Federation in total (Dudarev et al., 2013). From 2005 to 2015, the Russian male population suffered more deaths from infectious and parasitic diseases than females in virtually every region (Federal State Statistics Services of the Russian Federation, 2017). Even though there has been a significant improvement and less respective deaths for males in the European North of Russia, those in the Khanty-Mansi a.a., Yamalo-Nenets, and Chukotka a.a. still experience a general increase in the related mortality (Federal State Statistics Services of the Russian Federation, 2017). There has been a decline in infectious disease rates in Arctic countries due to improved sanitation, medical treatment/vaccination, and education, but the impacts of the changing Arctic climate are predicted to increasingly affect the health and well-being of Arctic residents (AMAP, 2009).

A previous study suggested that there is a strong association between climatic factors and food- and waterborne diseases in the Arctic, while more research needs to be done to confirm the relationship between vector- and rodent-borne diseases with weather and climatic factors (Hedlund et al., 2014). Temperature and precipitation appear to be the most influential climatic factors on infectious disease incidence in the Arctic. The purpose of this review was to find recent publications in the field and compare the results to a previously published review (Hedlund et al., 2014) to find if any trends or gaps in knowledge emerged.

2. Materials and methods

English searches of this systematic review were conducted in PubMed, ScienceDirect, Scopus, and PLOS One. For the PubMed search, a custom date range, 2013/05/01–2018/03/31 to capture articles published after a previous review (Hedlund et al., 2014). Because ScienceDirect, Scopus, and PLOS One had not been used in the previous review, no date restrictions were used.

The following Medical Subject Heading (MeSH) terms were searched in PubMed: bacterial infections and mycoses; parasitic diseases; virus diseases; climatic processes; climate; climatic; weather; temperature; humidity; rain; snow; Scandinavia; Arctic regions; Canada; Alaska; Greenland; Iceland; Sweden; Norway; Finland; Russia; and Siberia. The MeSH terms used were the same as those from a previous review (Hedlund et al., 2014), but additional terms “humidity,” “snow,” “rain,” “Sweden,” and “Norway” were added. MeSH terms were used rather than single keywords, following search term criteria used in previous reviews (Hedlund et al., 2014; Verner et al., 2016). Because MeSH terms we used for the PubMed search, searches contained subsequent phrases in the MeSH hierarchy. For example, the MeSH phrase “virus diseases” included the following terms via the MeSH hierarchy: “dengue, encephalitis, tick-borne diseases, yellow fever, zika virus infection, encephalitis, and zoonoses.” The “disease” phrases used; bacterial infections and mycoses; virus diseases; and parasitic diseases, all include “zoonoses” within their MeSH hierarchy, in addition to specific zoonotic diseases. Because of this, “zoonoses” was not searched as a stand-alone term. Additionally, “arctic region” is a MeSH term and includes the individual search term “arctic.”

For searches in ScienceDirect and PLOS One, the following terms were used: arctic; bacterial infections; mycoses; parasitic diseases; virus diseases; climatic processes; climate; climatic; weather; temperature; and precipitation. These search terms were selected to try and keep the searches across databases as comparable and inclusive to the selection criteria as possible.

Using all of the search terms from the PubMed, ScienceDirect and PLOS One searches in Scopus yielded very few results. Consequently, the only search terms used were “infectious disease,” “climate,” and “arctic.”

The largest Russian domestic database, the Scientific Electronic Library “eLibrary.ru,” was searched to identify publications relevant to this review among the Russian research literature. The database contains over 28.5 million articles, books, dissertations, conference proceeding, scientific patents, and other research materials across all disciplines. It is integrated with the Russian Science Citation Index. The Advance Search engine was used for conducting the search of all the databases compiled in the eLibrary.ru database. The types of the publication to conduct the search were: research journal articles, books, and academic dissertations. The period of the search was limited between 2013/01/01 and 2017/12/31.

One limitation of the eLibrary.ru database is that there is not possible to work with multiple key words at a time. Therefore, only one key word or phrase was used to fill in the query window. The search terms used were: bacterial human infections; viral human infections; zoonotic infections; vector-borne infections; parasitic infections in humans; tularemia; anthrax; leptospirosis; legionnaire's disease; Sindbis fever; tick-borne borreliosis; tick-borne encephalitis; Lyme disease; hantavirus; West Nile virus; brucellosis; toxoplasmosis; Q fever; climate change related diseases; new infections in the Arctic; and exotic infections in Russia. Additional searches were also done using the reference lists from suitable articles, to see if any authors referenced had published relevant articles for our review.

Selected articles needed to meet the following criteria: involved the Arctic or subarctic regions, consider a correlation between human infectious diseases and climatic factors, and are original research. Because of varying definitions of the Arctic and subarctic, articles were selected if the research focused on cases occurring in Alaska (US), Canadian provinces with Arctic or subarctic territory, Greenland (Denmark), Iceland, Norway, Sweden, Finland, and regions in Russia's Arctic zone. Review articles and vaccine studies were excluded. All searches were conducted in March 2018.

The search terms used for each search were recorded as well as the number of results retrieved for each search. Article titles and abstracts were evaluated for their relevance to the inclusion criteria. All articles that appeared to meet the criteria were selected for a full text review. The articles that met the inclusion criteria after the full text review were included in this review. If an article was found in more than one database, it was only counted for the first database it was found in, eliminating duplicates from the selection process. Fig. 1 includes the selection process and number of articles selected at each phase from the databases.

We also searched the phrase “Arctic AND human AND climate AND one health AND zoonosis” in Scopus ($n = 2$), PLOS One ($n = 17$), ScienceDirect ($n = 28$) and PubMed ($n = 3$, search was restricted to 2013/05/01–2018/09/20) to look for articles relevant to our inclusion criteria specifically relating to “one health” and “zoonosis.” Additional searches of Russian literature in eLibrary (covering years 2013–September 2018) used terms “Arctic” (number (n) of articles found, $n = 8655$), “Climate change” ($n = 6227$), “One health” ($n = 80$), “Zoonosis” ($n = 56$) and “Climate change health” ($n = 69$). Limited Russian literature conceptualized their work based on the “One health” concept used in English literature. The phrase “one health” can often be seen but as just as a part of random sentences meaning “a person has only one health to take care of” or “integral health of all body systems,” rather than the integrated approach to evaluating human, animal, and environmental health. Many of the results overlapped between databases and included articles and reviews that have already been included and referenced in our manuscript, therefore no new articles were found. Excluded results were review articles, pertained to wildlife, or did not meet our specific inclusion criteria.

An additional PubMed search was conducted for each United Nations (UN) designated geographic region, using MeSH terms for climatic factors and infectious diseases to see how the number of publications in the Arctic compared with other regions of the world. Because the Arctic is not a UN designated geographic region, the eight countries with Arctic territories were searched together and not included in the search for their initial UN designation. Alaska and Greenland, however, were searched as Arctic territories, while