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Arctic One Health

Challenges for Northern Animals and People

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A Holistic Approach to One Health in the Arctic

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1 What Is One Health?

The concept of One Health recognizes the interdependence of human, animal, and environmental health, and that a holistic approach to the wellbeing of all will lead to improved health outcomes and enhanced resilience. As the discipline is evolving, our understanding of the interdependence of animal, human and environmental health has broadened with the realization that none of these can be truly healthy unless they are all simultaneously healthy (Hueffer et al. 2019). At the time of this writing, the world is engulfed in a pandemic that has globally affected every aspect of life. The causes and impacts of this pandemic are a powerful example of a One Health issue. As we look to understand the causes of such problems it becomes immediately apparent that such understanding will require expertise from many disciplines and the ability to share that knowledge not just across academic disciplines, industries, and government sectors, but across cultures as well.

The term "One Health" was adopted by the veterinary and human medical professions to identify the relationship between human and animal health, and the influence the environment exerts on this relationship (Gibbs 2014; Zinsstag et al. 2010). Between 65 and 70% of emerging diseases in humans are of zoonotic origin (Wendt et al. 2015). The way we impact our environment and how that influences human–animal interactions play significant roles in how these diseases develop and spread. Human sourced drivers such as loss of biodiversity, repurposing of wildlife habitat, the expansion of large intensive livestock enterprises, and rapid

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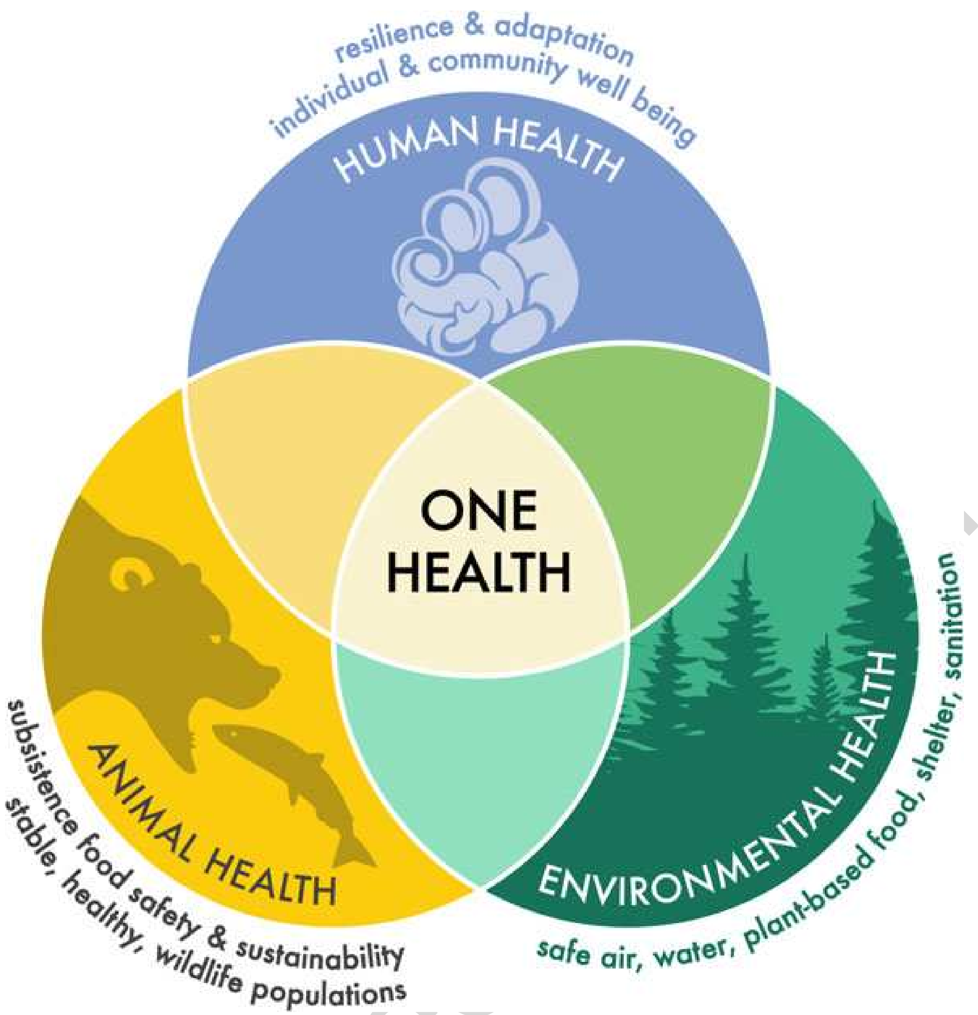

Fig. 1 A holistic approach to One Health in the circumpolar North

anthropogenic driven climate and environmental change, all impact the potential for endemic wildlife pathogens to become zoonotic disease threats (Zinsstag et al. 2010; Gibbs 2014; Wendt et al. 2015; Hueffer et al. 2013).

While human and animal health professions have only relatively recently developed and adopted the term One Health, concepts and ideas, recognizing the interconnectedness of all living beings and their environment, have been at the core of Indigenous worldviews for millennia (Kutz and Tomaselli 2019; Jack et al. 2020). Such an inclusive and holistic approach views health as more than the absence of disease, but rather as a state of individual and community well-being with a focus not only on physical health, but on behavioral, emotional, cultural, and spiritual health as well. Taking this holistic approach to health and applying it to the One Health paradigm, as presented in Fig. 1, allows us to bring in expertise across natural and social sciences and synergize western science with traditional Indigenous Ways of Knowing. Such a broad and, at the same time, deep integration of knowledge and experience provides opportunities to understand large issues like food safety, security, and sovereignty, zoonotic disease threats, and environmental contamination at their roots and engage diverse stakeholders to build effective solutions (Ruscio et al. 2015).

Two-eyed seeing, or Etuaptmunk, as stated by Mi'kmaq elder Elder Albert Marshall is an Indigenous concept that truly encompasses the spirit of One Health. It means "learning to see from one eye with the strengths of Indigenous knowledges. . .and from the other eye with the strengths of Western knowledges. . .and learning to use both these eyes together, for the benefit of all" (Denny and Fanning 2016). This concept explicitly acknowledges and values the views of different participants, recognizing the value of incorporating different worldviews. The two-eyed seeing approach has been increasingly applied to wildlife co-management where Indigenous rightsholders, government wildlife managers, and academics are coming together to better understand wildlife health in a more holistic and inclusive manner (Box 1). This approach leads to greater depths of understanding of complex issues and better informed decision-making. It responds to the call and requirements of many governments and conservation agencies to include Indigenous knowledge in decision-making, and importantly, it also responds to the calls of the UN Declaration on the Rights of Indigenous Peoples as well as the Truth and Reconciliation Commission, Canada.

2 The Role of the Veterinarian in One Health

For many reasons, veterinarians are uniquely suited to facilitate the transfer and application of this knowledge between disciplines, sectors, and across cultures at the interface of human, animal, and environmental health. Broadly, veterinarians are trained in comparative medicine, understanding health, and the vast array of determinants of health, across numerous species. Veterinarians have an intricate knowledge of physiology, anatomy, and pathology at an individual level, yet at the same time, are trained in animal welfare, herd health, public health and population medicine, understanding the epidemiology and control of disease at a population level, as well as the socio-economic and environmental factors that will influence the implementation and efficacy of health interventions. Veterinarians are adept at communicating with clients across a very broad socio-economic spectrum and adjusting their communication and treatment offerings to meet the needs and capacity of their clients.

Working within the public health domain, veterinarians are trained to identify zoonotic disease threats and frequently have a deeper understanding of the occurrence and prevention of the common domestic animal-derived zoonoses than their human health counterparts. Veterinarians also routinely work with (or as) wildlife and infectious disease researchers in the surveillance for zoonotic diseases and their vectors of transmission.

Veterinarians also play a critical role in ensuring food and water safety. In urban and non-remote areas veterinarians inspect animal sources of food for safety concerns. They play an important role in food safety in subsistence areas, where climate change, contaminant exposure, and emerging zoonotic diseases are threatening food safety and security in Northern communities in new rapidly changing ways. These challenges require adjustments in the application of both Traditional and Western ways of knowing to effectively monitor and manage. Due to their training and the natural connections they develop with people around animals, veterinarians can also serve as liaisons between community members and research and government agencies, including health and social welfare, as well as facilitators of knowledge transfer and best-practice implementation from these sources back to the communities involved. The breadth of people and organizations that veterinarians work with around individual and population health of wild and domestic animals results in working relationships that span a multitude of stakeholders in local, regional and national sectors.

3 One Health Concerns in the Circumpolar North

The Arctic has unique, sensitive ecosystems that are undergoing rapid change and this is profoundly influencing socio-ecological systems. The rate of Arctic climate warming is occurring at twice the rate of that experienced at lower latitudes (USGCRP 2018) (see also chapter "Climate Change in Northern Regions"). Simultaneously, the region is increasingly stressed by amplifying anthropogenic disturbance in the way of landscape change, shipping, and accelerating economic development. The flora and fauna of the Arctic are adapted to a highly seasonal environment with extremes in temperature and humidity and as this landscape changes the stressors on the endemic flora and fauna increase and invasive species become more common. At the same time, across many Arctic taxa, species diversity is low and there is little redundancy, thus challenging the capacity of the Arctic ecosystem as we know it to cope with these increasing pressures. For the people of the Arctic, these changes are superimposed over a population where poverty, marginalization, and food security are common. The complex interacting factors and rapidly changing socio-ecological system in the Arctic leads to many complex challenges that are ideally suited for a One Health approach.

Healthy domestic and wild animals are central to ecosystem health as well as to the physical, mental, and economic health of people (Fig. 1). In the following sections, we explore the One Health issues around these relationships (Fig. 2). AU2

3.1 Zoonotic Diseases

Many Northern communities are at least partially dependent upon subsistence activities for their dietary needs and cultural activities. This engages people and wildlife in an intimate relationship that may pose risks for emerging and endemic zoonoses. For example, tularemia from muskrats, anisakis and tapeworm from fish, echinococcosis and rabies from wild or domestic canids, and brucellosis and anthrax from caribou, reindeer or bison, are all recognized, and relatively common, zoonoses found around the Arctic (see also related chapters in this book). Less well understood

Fig. 2 Wildlife and One Health. Wildlife is central to One Health relationships in the circumpolar North. The history, culture, health and livelihoods of northern Indigenous peoples are intricately woven with that of the wildlife with which they co-exist. Around the Arctic, a diversity of wildlife species have served as a source of food, clothing, and tools, played a central role in cultural activities and transgenerational learning, and provided trade and economic opportunities. These fundamental contributions of wildlife to the health of Arctic peoples continues today. Figure designed by Renate Schlaht

potential zoonoses in the Arctic include pathogens such as *Erysipelothrix, Leptospira, Chlamydia*, Q-fever (*Coxiella burnetii*), Orf virus, a variety of arboviruses (arthropod-borne; viruses transmitted by blood-sucking insects), tick-borne pathogens and others. While we most often focus on zoonotic disease in people, pathogen transmission can occur in the opposite direction, as is thought to have occurred for *Giardia* in muskoxen where the human genotype is found circulating in muskoxen on Banks Island (Kutz et al. 2008). Other proposed/potentially emerging risks include COVID-19, where spill-over from people has caused widespread outbreaks in farmed mink (Munnink et al. 2020).

Many endemic zoonotic diseases have long been known and recognized by Indigenous peoples. In some cases, the knowledge of how to prepare food in a way to prevent transmission has been passed down through generations, and for others, public messaging efforts to reduce transmission have been implemented broadly for over a century. However, the decline of intergenerational knowledge sharing, in Canada largely an outcome of children being removed from their homes to attend residential school, together with overly zealous news reports and public health messaging around potential wildlife zoonoses, has led to a decline in confidence in subsistence or "country" foods. For example, elders are frequently heard saying that what is a 'normal' abnormality and 'what is safe to eat' have not been passed down to the youth, leading to excessive wastage of meat derived from wildlife. Similarly, reports from the press and in social media of 'mad cow disease', 'bird flu' and 'killer cat parasites' can lead to inappropriate fear about the safety of country foods. Thus, in this case, it is not the reality of country food safety that is of concern, rather it is a perception that may lead to people no longer trusting the food source that has sustained them for generations.

However, zoonotic pathogens can pose significant health risks to communities in the circumpolar North. Climate change is one of the main drivers behind the emergence of many zoonotic diseases and their vectors globally. At northern latitudes, warming temperatures support enhanced survival of invasive tick species and the northern spread of the diseases they carry (Waits et al. 2018). The release of pathogens frozen in permafrost, including from historical burial sites, is also of potential concern under climate change conditions (National Academies of Sciences, Engineering and Medicine 2020). For more information, see chapter "Anthrax in the North".

The remote location of many northern communities makes it challenging to monitor zoonotic risks via conventional means. The two-eyed approach described above provides a platform for integrating traditional knowledge with Western science to create a synergetic knowledge base that is more comprehensive than either would be separately. Recent development of a network for local citizens to report anomalies has improved data collection and potential early recognition of emerging zoonotic threats across the Circumpolar North. The Local Environmental Observer or LEO network, (www.leonetwork.org), sponsored by the Alaska Native Tribal Health Consortium connects local observers with scientists, government agencies and health care providers. This network has been used to alert experts at research, government agency, and health care hubs of marine mammal die-offs, unexpected post-mortem observations by hunters, emerging disease vectors, and unusual environmental events that occur hundreds of kilometers away in remote areas from which they would otherwise have very limited access to information. Recent advances in convenient, minimally invasive surveillance techniques such as filter paper whole blood sampling (see Box 1) can be used by hunters to monitor harvested wildlife for endemic and emerging diseases and give researchers and communities early warning for potential zoonotic threats. This has also been used in reindeer herding, with field necropsies conducted by herders. These new technologies help tie rural communities with urban research centers and greatly broaden information gathering to the benefit of all parties involved.

4 Food Safety, Security, and Sovereignty

Rapid environmental changes have made food safety increasingly difficult to achieve in Northern communities over the past 30 years. As the Arctic warms and weather patterns change, traditional means of food storage have been challenged severely. Ice cellars that have been used to preserve food for generations are failing across the circumpolar north (Brubaker et al. 2009). Unusually wet summers have at times made it difficult to make dried fish (see Fig. 3). In lower latitudes veterinarians inspect animals used for food. Many northern communities are under-served in veterinary services due to their small population and remote location, and so do not have access to veterinary inspectors to ensure that the animals they consume are safe to eat.

Climate change has also threatened the safety of marine-based foods. Warming ocean temperatures have increased the duration and severity of harmful algal blooms resulting in dangerously high levels of paralytic and amnesic toxins in filter-feeding shellfish. These changes have also supported the growth of the offending organisms further north than has been previously observed. In 2019, hazardous levels of these toxins were measured in shellfish on the northwestern coast of Alaska. Simultaneously, significant levels of these toxins were also measured in walrus and Bowhead whales on the northwestern and northern coastal areas of Alaska (Lefebvre et al. 2016).

Fig. 3 Fish drying in Emmonak Alaska. Photo courtesy of Dr. Walkie Charles

As described below, the Arctic has become a sink for many persistent toxins produced in the industrial centers of lower latitudes. Bioaccumulation of mercury and persistent organic pollutants have led to harmful contaminant levels in apex predators such as seals, polar bears, and northern pike (Atwell et al. 1998; Fisk et al. 2001; Braune et al. 2005) (see also chapters "Arctic Ecosystems, Wildlife and Man: Threats from Persistent Organic Pollutants and Mercury", "Oil Spills in the Arctic", "Nuclear Radiation", and "Rabies in the Arctic"). As these problems have evolved, concerns regarding the safety of traditional or country foods have led to confusion on the safety of these dietary choices. In the Yukon-Kuskokwim area of Alaska, an area where fish make up the majority of calories and protein of a primarily subsistence-based diet, reports of high mercury levels in northern pike and other key species has led to a syndrome referred to as "fish fear" and resulted in families moving away from traditional foods and towards a more "western" diet. A four-decade-long retrospective study of women in this area showed a progressive decline in plasma vitamin D levels which were concomitantly associated with a significant increase in pediatric rickets in the region (O'Brien et al. 2017; Singleton et al. 2015). Collaborative work between researchers, health care providers, and community members has concluded that although it is important to monitor contaminant levels in subsistence species, people were healthier eating these traditional foods (Mehruba et al. 2016). Rather than switching diets, food safety could be attained by regulating the way in which these foods were selected stored, and prepared. One example of such a recommendation aimed at reducing mercury exposure is to continue eating Northern Pike, but to avoid the larger fish, and focus on eating more small fish (Berner 2019).

Northern communities have a high rate of food insecurity (Huet et al. 2017). Socio-economic, infrastructural, regulatory, and environmental changes have negatively impacted food security in the North (Hueffer et al. 2019). These changes may also require hunters to cover greater distances to access game resources. Shifts to a cash economy and reliance upon using mechanized transportation may make harvesting more efficient but also puts time restraints on those that have to work to pay for these conveniences (Hueffer et al. 2019). The resulting challenges in access to subsistence food sources have negative impacts on food security, cultural practices, knowledge transfer, and mental and behavioral health. For communities off the road system, conventional foods often must be transported by air or barge at considerable cost. Household incomes in these areas are often below national averages impairing the ability to purchase high-priced food items (Huet et al. 2017). Many of these communities still rely heavily on subsistence foods for the majority of their caloric intake (Johnson et al. 2019). AU3

Unprecedentedly rapid environmental changes have challenged long-standing traditional knowledge on game movements, salmon returns, berry ripening times, and most hazardously, travel on ice. Severe and widespread population declines of caribou have left 'caribou people', those Indigenous groups that rely heavily on caribou for subsistence, without one of their main sources of food. In the fall of 2020, the Yukon river chum and silver salmon runs experienced an unprecedented collapse. Commercial harvests reported for this period were 97% lower than the 5-year average. Traditionally, millions of both species return at this time of year when it is easy to preserve them for use as winter food for humans and their dog teams. The catastrophic failure of this run has put both people and their dogs in a position of severe food insecurity.

No discussion of food security in the North would be complete without including the concept of food sovereignty. Access to habitat for reindeer grazing and plant and berry harvesting and to fish and game resources that are central to subsistence living is being challenged by rapid environmental change, socioeconomic shifts, and competition from both commercial and expanding urban personal use harvesting. The Inuit Circumpolar Council has addressed this issue very thoroughly in two documents relating to food security and food sovereignty, and the readers are directed to these resources for a more in-depth coverage of this issue (ICC 2015, 2020). Government regulation of these resources often does not consider traditional knowledge of the resource and traditional harvesting practices. This often results in a conflict when population assessments differ between traditional harvesters and western scientists. Traditional knowledge applied in this sense is often more adept at predicting and detecting population changes by evaluation of harvested animal body condition and overall health, than the technologically driven modelling methods often used by government agencies which set regulations (Kutz and Tomaselli 2019). The assessments used to make these regulations are frequently based on measurements made over a few places and a few days due to cost and time restrictions. In contrast, subsistence hunters are constantly on the land and observing the movement and state of the animals they rely upon and often have a more complete temporal and spatial understanding of these populations than the biologists formulating harvest regulations. Kutz and Tomaselli (2019) describe a "two-eyed approach" to wildlife management that integrates Traditional and Western knowledge in a way that combines the information bases and cooperatively generates solutions that may be superior to those reached by either alone. Under this approach, traditional knowledge holders can combine their knowledge with scientists and develop a more comprehensive model for understanding and predicting the state of fish and game populations (Box 1). For a more detailed description of the harvesting and storage of traditional foods please see chapter "Traditional Conservation Methods and Food Habits in the Arctic".

In northern Canada, community members, academics, and government wildlife agencies have come together to implement a collaborative wildlife health surveillance program. The communities of Ulukhaktok, Northwest Territories, Kugluktuk and Ekaluktutiak, Nunavut, rely heavily on local caribou and muskox populations (Tomaselli et al. 2018a, b; Hanke et al. 2021; Di Francesco et al. 2021). In response to community concerns about the health and population trajectories of these species, community-based caribou and muskox health surveillance programs were established with the hunters and trappers organizations in all three communities. These programs are multi-

(continued)

pronged, bringing traditional knowledge and scientific knowledge together to understand wildlife population health, disease, and zoonoses. They consist of: (1) baseline wildlife health interviews h (2) hunter-based sampling and (3) ongoing annual interviews. Baseline interviews on the past and current health and population status of caribou and/or muskoxen are done using a combination of individual and group interviews and participatory epidemiology methods (e.g., Tomaselli et al. 2017). This process documents important AU4 information on the ecology, health, and trajectory of the populations, identifies community concerns, and forms the basis for further monitoring and investigations. Harvesters are provided with standardized field-friendly sampling kits that they use to collect samples and data from caribou and muskoxen that they harvest for subsistence or through local guides/outfitting operations. Kits consist of data sheets, pre-labeled sampling bags, and Nobuto filter paper strips for blood collection (Fig. 4).

Samples are initially processed in the community by a hired monitor with the hunters and trappers organization and/or government wildlife employees and then sent for further laboratory analyses. Various health indicators, such as infectious disease, stress, nutritional status, genetics, and condition, are determined and the results are brought back to the community in the forms of presentations and reports with key community partners as co-authors on final publications. Ongoing annual interviews are used to document the Indigenous knowledge on population health and trends. These interviews serve to track populations from year to year in real time and identify changes and concerns on a much more rapid time scale than may be detected by the infrequent population surveys. Together, these three steps bring local, traditional and scientific knowledge together to establish historical baselines and trends, document the current status of the populations, and detect any new/emerging conditions, diseases, or concerns. Extensive co-learning is manifested through training of hunters on sampling, monitors on sample processing, scientists/graduate students on traditional harvest methods, animal uses, and knowledge of the land, and the general public on wildlife health and disease. Through this enhanced interaction among community, government and academic partners there is ongoing knowledge sharing, trust building, and vastly improved communication networks which leads to more effective co-management.

Conventional western approaches to the management of these resources may also impose time and individual harvest limits which may not fit the new migration patterns of the animals or the traditional cultural practices of the local Indigenous people. Indigenous culture has developed practices over millennia that harvest fish and game in a manner that takes only what is needed, shares with those in need, and leaves behind sufficient animals to maintain a healthy population (Fig. 5). Traditional harvests take place at the time the animals are available and when the conditions are most favorable to preserve them. Conflict often arises when harvest

Fig. 4 Muskox samples collected through community-based wildlife health surveillance program. Blood on filter paper allows the easy collection of blood that can then be frozen immediately (e.g., at ambient winter temperatures). Blood collected on filter paper can be used to do a variety of serological assays, as well as DNA isolation. The ease of sampling in the field, which does not require test tubes or any technical or time sensitivity makes it a simple, yet elegant tool for hunter-based wildlife health surveillance

windows are set that do not incorporate traditional practices. An example of this conflict can be seen when a salmon harvest opening occurs during a rainy period when the fish cannot be dried (Fig. 3). Traditional practices would not support harvesting and potentially wasting the fish but would allow people to fish when the conditions are correct for preserving the catch. Governmental regulations often place limits on game harvest to protect over-harvesting, particularly under circumstances when species may be susceptible to this problem. These regulations are often based on singe person allotments for hunters who are in the field only a few days each year and are appropriate for urban households. Indigenous harvesting is often focused on providing food for the whole community. Indigenous hunters usually share their harvest with others outside their household and particularly with elders who may be physically limited. These conflicts are another place where co-production of knowledge may be engaged to support regulations that work optimally for all involved. The prioritization of subsistence resource use brings us back to the concept of food sovereignty as an integral part of food security in areas where Indigenous people have lived for millennia but now may not have say over their access to traditional foods. As described below, the operationalization of One Health as a bridge between Indigenous worldview and Western Science may provide a platform for this type of policy development.

Fig. 5 The Yup'ik Men's Dance Fan. This fan is used in ceremonial dance. The fan represents the human hand with each feather representing a finger. The space underneath the feathers represents the Yup'ik cultural practice of taking only what you need and leaving the rest behind for others that come after and also to maintain sustainable wildlife and plant populations for generations to come. Photo courtesy of Dr. Walkie Charles

5 Contaminant Monitoring

The Arctic Council Arctic Monitoring and Assessment Programme working group (AMAP) has demonstrated that the Arctic is a sink for Anthropogenic pollution and climate change (Gibson et al. 2016). Ocean and atmospheric currents bring organic and heavy metal contaminants from lower latitudes, where they are generated by industrial societies, to the Arctic, where they accumulate in the physical environment and bioaccumulate in the food web (Fisk et al. 2001; Braune et al. 2005; Atwell et al. 1998). Climate change has exacerbated the movement and impact of these contaminants (Braune et al. 2005). The recent and rapid accumulation of these toxins has resulted in many new stressors upon Arctic ecosystems threatening the survival of several species and endangering the safety of subsistence food sources.

For over 20 years the AMAP working group has monitored contaminant levels in humans and sentinel species across the Arctic (Gibson et al. 2016). These studies have found significant and potentially health-threatening concentrations of industrially produced mercury and persistent organic pollutants (POPs) in humans and apex predators such as polar bears, seals, narwhals, and northern pike. Mercury accumulation can impair central nervous system functions and therefore affect cognition and locomotion which may decrease hunting efficiency and result in aberrant behavior (Black et al. 2016). POPs have multi-systemic effects. They can alter hormone transportation and receptor activity resulting in decreased fertility, enhanced rates of miscarriage, low birthweight, and enhanced neonatal mortality (Black et al. 2016). They also impair immune function and enhance the risk of developing certain forms of neoplasia. Climate change has enhanced not only the transport of these contaminants to the Arctic but also their impact. Shrinking sea ice has forced marine mammals to swim further than normally required to obtain food and shelter, causing an enhanced utilization of lipid depots and resulting in mobilization of lipophilic compounds during periods of high stress.

Species such as seals, narwhals, and even polar bears have traditionally been staples in the subsistence diets of coastal inhabitants across the Circumpolar North. This puts these people at the highest position in the food chain and therefore at the greatest risk of the bioaccumulatory impacts of these toxins. POP concentrations in Inuit living in Eastern Greenland are among the highest measured anywhere and have been associated with an increased incidence of cancer and immune-related issues in this population (Gibson et al. 2016).

Contaminant accumulation in the Arctic is a clear example of an issue that can be addressed well through a One Health lens. AMAP, CAFF, and ACAP have incorporated a One Health approach by combining environmental monitoring with the monitoring of humans and sentinel animal species. Programs that monitor sentinel species in the food web such as seals, narwhals, and polar bears, provide an understanding of the trends and severity of contaminant bioaccumulation in the food web. Monitoring companion sentinel species, such as sled dogs, may also provide useful information in developing dietary recommendations for people living a subsistence lifestyle in these areas. Studies of sled dogs have been useful in determining mercury and POP bioaccumulation (Sonne et al. 2017; Dunlap et al. 2011) as these dogs often eat similar diets to the humans they live and work with. The relatively higher metabolic rate of these dogs in comparison to their human counterparts may also permit scientists to see health issues in the dogs before they become problems in people.

6 Mental and Behavioral Health and Well-Being

In Indigenous populations, rapid social and economic change associated with colonization and assimilation practices has been associated with pervasive social issues including suicide, substance abuse, and domestic violence (Hueffer et al. 2019). Loss of language (Krauss 1980; Gone 2013), cultural practices, and cultural knowledge have been associated with a severe increase in the incidence of these problems. Added to these stressors are rapid environmental changes which have impacted, traditional activities such as travel on ice, hunting, fishing, and gathering of plant resources. When traditional knowledge struggles to accommodate rapid rates and previously unexperienced types of environmental change, it can adversely affect the self-esteem of resource providers and the self-efficacy of a society. Indigenous people have lived in and stewarded their traditional lands for millennia. Indigenous worldview has historically seen the terrestrial and marine environments and the flora and fauna they encompass as benefactors which people are not only dependent upon but also inseparable and indivisible from. When such cultural foundations change from being benefactors to becoming threats in the form of contaminated foods, unreliable fish and game populations, and unsafe or unreliable ice conditions, this challenges belief systems and can result in severe and negative impacts on mental and behavioral health and well-being.

Suicide is now the leading cause of death for Alaska Native people between the ages of 15 and 25 (Berman 2014; Hicks 2007) and in Canada, the suicide rate of Inuit is approximately 9 times that of non-Indigenous Canadians (Kumar and Tjepkema 2019). Prior to 1950, suicide was rare and most common among aged men that no AU5
longer felt capable of contributing to the needs of their community. Conventional approaches, which isolate and treat individuals perceived to be at high risk, have done little to prevent the continuation of these issues (Hicks 2007). Recent approaches focusing on building strengths rather than managing outcomes have begun to show promise (Rasmus et al. 2019; Rivkin et al. 2019). Reintroduction or retention of cultural practices, transfer of traditional ways of knowing, and fluency in the original language are all traits common to Indigenous communities that have shown resilience to suicide in the Circumpolar North (Rivkin et al. 2019). Recently, programs, using a One Health approach, have shown real promise in preventing negative mental and behavioral health outcomes in Northern Indigenous communities. These community-based programs incorporate the relationship and inseparable nature of the human, animal, and environmental health as foundations of strengths that can be used to build resilience to these problems. One prominent example of this is the Alaska Native Cultural Hub for Resilience Research (ANCHRR). This NIH-funded community-based program partners University (UAF) researchers with community members and elders to study and define best practices in resilient communities and share them with communities that are struggling. Instead of identifying and isolating at-risk individuals, which may exacerbate the issues by focusing on these individuals as being "different," this program emphasizes building strengths through cultural activities, sharing of personal stories, and transfer of traditional knowledge. This work is often done out on the land during hunting, fishing, or berry picking activities. In this way, potentially susceptible youth are "wrapped in a blanket of community support and strength" that builds self-efficacy and self-esteem through gaining proficiency in skills and acknowledgement of accomplishments from respected community members.

Other examples of such programs are the Frank Attla Youth and Sled Dog Care Program (FAYSDCP) and the Alaska Care and Husbandry Instruction for Lifelong Living (ACHILL) described in the chapter "Dogs and People: Providing Veterinary Services to Remote Arctic Communities" (Veterinary medicine in remote arctic communities). These community-based programs holistically address mental and behavioral issues by simultaneously addressing environmental and animal health.

The interdependence of the One health triad is central to the culture and knowledge base of these communities and so this approach addresses the human health issues at their root causes rather than treating their outcomes. Veterinarians, who by the nature of their education are trained in preventive health care and understand the value of the human–animal bond, are essential stakeholders in the development and implementation of these One Health processes.

7 Operationalizing One Health

The One Health approach to describing, understanding, and managing large issues that span the interface between human, animal, and environmental health is gaining support from community members, health care professionals, academics, governmental agencies, and NGOs across the globe (Ruscio et al. 2015; Arctic Council SDWG 2017). This approach is particularly relevant in the Circumpolar North where environmental changes are happening at a rate that has been unprecedented and making it difficult for social and ecological systems to adapt in a healthy manner. Although these changes pose a tremendous challenge to northern communities, they simultaneously present an opportunity to understand and address related changes that are happening to a lesser degree at lower latitudes.

While One Health is being embraced as the way to work on these "Wicked Problems," it is often easier to conceptualize this approach than to operationalize it (Vesterinen et al. 2019). Putting One Health into action requires stakeholders to work across disciplines and cultures and work in a constructionist approach that addresses issues starting at the community perspective and working outwards. Each part of this strategy requires a paradigm shift from conventional academic and scientific approaches to problem-solving. This paradigm shift is simultaneously the greatest potential strength and the greatest potential challenge encountered in operationalizing One Health.

For centuries, western scientists have used a reductionist approach to study and solve problems. This method entails breaking down or reducing problems to a single underlying cause and has been used to identify individual pathogens as the cause of a disease, or a single gene mutation as the source of an error in metabolism. Many of the hallmark successes of modern science have resulted from this approach which has become the default method of scientific problem-solving. While reductionist reasoning has worked well for single-issue problems, this approach falls short when addressing issues which may have multiple causes and interactions.

"Wicked problems" require knowledge that not only penetrates deeply into a single discipline but also spans across all of the disciplines involved. At this writing (May 2021), vaccines against the COVID-19 have arrived and are being used to control the pandemic which has spanned the globe and affected nearly every aspect of life. These vaccines may well stem the spread and effects of the virus but their development and implementation will not help us understand why this catastrophe occurred in the first place and what we might be able to do to prevent or mitigate the next pandemic from gaining a foothold. For this, we must understand how anthropogenic environmental changes have impacted wildlife populations that serve as potential reservoirs for emerging zoonotic threats and how these are influenced by current livestock husbandry, cultural, social, and economic practices. This understanding requires a constructionist approach that integrates information across disciplines and cultures and approaches the issue from the perspective of the communities involved in a bottom-up, rather than top-down, prescriptive approach. One Health applied in this manner supports the gathering of knowledge both broadly and deeply, and the solutions acquired are likely to be effective because they have arisen with the input of the communities where they will be implemented.

Working across disciplines challenges the current paradigm under which research and problem management are conducted. Instead of working within a single discipline and communicating findings to others with similar education and training, those working in a One Health approach must be capable of both giving and receiving information to and from those with different backgrounds than their own. This can be challenging even across conventional western disciplines. Natural scientists use different methodology and terminology in their work than that used by social scientists, and these differences require significant adjustments when studies are designed to incorporate both approaches. Bridging the gap across cultural knowledge systems in a "Two eyed approach" is another example of the advantages and challenges associated with working outside of conventional western scientific methods (Kutz and Tomaselli 2019). Scientists are often uncomfortable transferring the implications of their work outside of their own narrow fields of study, however, science communication to non-scientists, such as community members and policy makers, is central to the success of a One Health approach. The shortfall in science literacy and the resulting negative impacts from non-adherence to CDC recommendations led to the world's greatest per capita case and fatality rates in the United States during the first 9 months of the COVID-19 pandemic. This example serves as a warning to all involved for the need to improve science communication between researchers, medical professionals, and the general public (Eysenbach 2020).

While there is no handbook for operationalizing One Health, several systems have been developed for use as a platform to begin the process. The US CDC has developed a One Health Zoonotic Disease Prioritization process (CDC-OHZDP) for emerging zoonotic disease threats (Salyer et al. 2017). This process uses a workshop format and engages stakeholders including community members, academic researchers, health care providers, and those working for government agencies. The process and its application in regional, national, and international situations have been published in peer-reviewed journals (Salyer et al. 2017). The CDC co-sponsored such a workshop with the UAF Center for One Health Research (COHR) in March of 2019 to prioritize emerging zoonotic disease threats in Alaska. The top seven threats identified in this workshop are listed in Table 1. This was the first time this process had been implemented in the Circumpolar North and serves as an example of what could be developed in other Arctic countries. The resulting report can be used to support surveillance and research efforts focused on these

Table 1 Priority zoonotic diseases selected in Alaska by participants in the One Health Zoonotic Disease Prioritization workshop conducted May 20–21, 2019. Reproduced from Goroyka et al. (2020) t.1

Zoonotic disease	Human disease burden	Animal disease burden	Diagnostics, treatment and prevention
			t.2
Amnesic shellfish poisoning/ paralytic shellfish poisoning	Between 1973 and 1996 over 200 cases of paralytic shellfish poisoning were reported in Alaska and were attributed to more than 70 outbreaks across the state[1]	Nearly all molluscan shellfish in Alaska are affected by paralytic shellfish poisoning and the Alaska Department of Environmental Conservation regularly tests commercially harvested shellfish[2] In a recent study by the University of Alaska SE, PSP measurements in mussels at sites around Juneau reached 4500 micrograms per 100 grams of shellfish. This level is fatal to a person after only consuming a few mussels[3]	Clinical diagnosis is based on recent shellfish ingestion and the presence of clinical manifestations of toxicity such as nausea, vomiting, paresthesia, dysarthria, dysphagia, and weakness. The toxin can also be confirmed in a clinical specimen such as blood or urine[1] To stay safe, clean shellfish thoroughly, removing all butter and discarding the gut. Also only consume shellfish sold commercially and routinely tested as cooking and freezing will not destroy the toxin[4] Treatment for severe cases is the use of a mechanical respirator and oxygen[4] t.3
Zoonotic influenza	There have been no human infections with Asian HPAI H5N1 virus reported in the United States. However, sporadic human infections with avian influenza A (H7) viruses have been identified in the United States[5] Since 2010, 466 cases of swine flu have been reported in the United States[6]	H1N1 and H3N2 swine flu viruses are endemic among pig populations in the US with outbreaks normally occurring in colder weather months[7] As part of a large-scale Avian influenza surveillance study from 2007–2011, researchers reported a mean apparent prevalence of avian influenza virus of 11.4% within wild birds. Prevalence was	As a general precaution, people should avoid wild birds, contact with domestic birds that appear ill or have died, and avoid contact with surfaces that appear to be contaminated with feces from wild birds[10] One mode of prevention is via the seasonal flu vaccine which can be given to humans and animals The best way to prevent infection is to

(continued)

Table 1 (continued)

	Zoonotic disease	Human disease burden	Animal disease burden	Diagnostics, treatment and prevention
t.5				
t.4			highest in dabbling ducks whose mean prevalence was 15.8%[8] As part of the USDA ongoing surveillance for swine, over 120,000 samples have been tested between 2010 and 2016 resulting in over 10,000 positive cases for influenza[9]	avoid sources of exposure specifically contact with infected poultry[5] Treatment includes antiviral drugs and continued monitoring[10] Diagnosis for influenza and novel types of zoonotic influenza includes respiratory specimens for laboratory testing using PCR[11]
t.5	Rabies	Three human cases have been reported in Alaska since 1914 but none have been reported since 1942[12]	Between 15 and 50 cases of wildlife cases are reported each year in Alaska. Rabies is enzootic among the fox populations in the North and West regions in Alaska. There have been periodic epizootics documented every 3 to 5 years[12]	Rabies is diagnosed in animals using direct fluorescent antibody tests. Several rapid laboratory tests are required for diagnosis in humans There is a vaccine available to both animals and humans. Following any contact or bite from a rabid animal, medical attention is immediately necessary Prophylaxis is the immediate treatment; however, following the onset of clinical symptoms, there is no treatment, and the disease is fatal[13]
	Cryptosporidiosis/ Giardiasis	A recent study reported a 28.8% seroprevalence of cryptosporidium in people with or without wild bird contact in Alaska. The same study reported an 18.9% seroprevalence of Giardia intestinalis in the same	One study looking at the prevalence of cryptosporidium and giardia subspecies found that prevalence was highest among ring seals (22.6% cryptosporidium, 64.5% giardia) and right whales (24.5%	Both cryptosporidiosis and giardiasis are diagnosed through microscopic analysis of stool samples. In both cases, PCR can be used to determine species. Those with competent immune systems will recover

(continued)

Table 1 (continued)

Zoonotic disease	Human disease burden	Animal disease burden	Diagnostics, treatment and prevention	t.7
	population[14] From 2001–2010, there were 1042 human cases of giardiasis reported. Annual rates of giardiasis in Alaska have repeatedly been higher than in the rest of the United States[12] Another study looking at the prevalence among Alaska residents found the prevalence of giardia antibody was highest among subsistence hunters and their families at 30%[15]	cryptosporidium, 71.4% giardia)[15]	from cryptosporidiosis without treatment, fluid replacement and nitazoxanide may be recommended. For giardiasis metronidazole, tinidazole, and nitazoxanide are recommended. Prevention for both are primarily good hygiene practices and avoiding contaminated food and water[16,17]	t.6
Toxoplasmosis	A 2019 study reported a 2.9% seroprevalence for Toxoplasma gondii in people with or without wild bird contact in Alaska[14]	A recent study looking at seroprevalence among sea otters reported 32% of sea otters tested positive for *T. gondii*[18] Another study looking at serum antibody prevalence for T. gondii within Alaska wildlife reported 23% positive among moose, 43% for black bears, 9% for wolves, and 7% for Dall sheep[19]	Toxoplasmosis is primarily diagnosed through serologic testing. Healthy individuals typically do not require treatment to recover. However, pyrimethamine and sulfadiazine, plus folinic acid can be administered. Prevention includes cooking foods to proper temperatures and avoiding contact with cat feces[20]	t.7
Brucellosis	A 2019 study reported a 0.1% seroprevalence for Brucella spp. in people with or without wild bird contact in Alaska[14]	There are 10 species of *Brucella* recognized in animals[12] One recent study looking at seroprevalence of Brucella in Alaskan harbor seals found that overall, 52% of adult seals tested positive for antibody seroprevalence[21]	Diagnosing brucellosis is done through bacterial isolation in blood cultures and serologic testing There is no standardized diagnostic tests for different species of animals[12] Antibiotics, generally doxycycline and	

(continued)

Table 1 (continued)

Zoonotic disease	Human disease burden	Animal disease burden	Diagnostics, treatment and prevention
		A study looking at serum antibody prevalences for Brucella among caribou, wolves, and bears reported the highest prevalence in the northwest region of Alaska[22]	rifampin, are given to treat the infection. Brucellosis can be prevented by avoiding the consumption of undercooked meat and unpasteurized dairy products. Additionally, those handling animal tissues should wear protective clothing[23] Prevention includes vaccination of domestic livestock[12]
Q Fever	A recent study reported an 8.3% seroprevalence of *Coxiella burnetii* in people with or without wild bird contact in Alaska[14]	A 2015 study reported a 17% seroprevalenve of *Coxiella burnetii* in live seemingly healthy northern sea otters Enhydra lutris kenyoni of Alaska[24]. Another study in 2013 found an 80% seroprevalence in northern fur seals of Alaska[25]	Q fever is diagnosed through a blood test. The majority of those infected are able to recover without treatment. But, a 2-week course of doxycycline may be recommended. Prevention methods for Q fever include avoiding contact with animals and refrain from consuming raw milk products[26]

diseases and the policy and funding necessary for this work to proceed (https://www.cdc.gov/onehealth/pdfs/Alaska-508.pdf).

The CD-OHZDPP is the first step in operationalizing One Health as it can play a key role in prioritizing One Health issues. Once an issue, such as a zoonotic disease threat has been identified, the next step is to use a One Health approach to analyze and manage it. The One Health Systems Mapping and Analysis Toolkit Process (OH-SMART) uses systems mapping and analysis to achieve these goals (Vesterinen et al. 2019). OH-SMART was developed in a joint effort between the University of Minnesota and the USDA to analyze and facilitate communication and collaboration across government agencies and other stakeholders as presented in Fig. 6.

Beginning with an identified One Health challenge, the first step is to identify the network of stakeholders that will be involved in the process. These stakeholders are then interviewed to determine their approach to the issue and which other

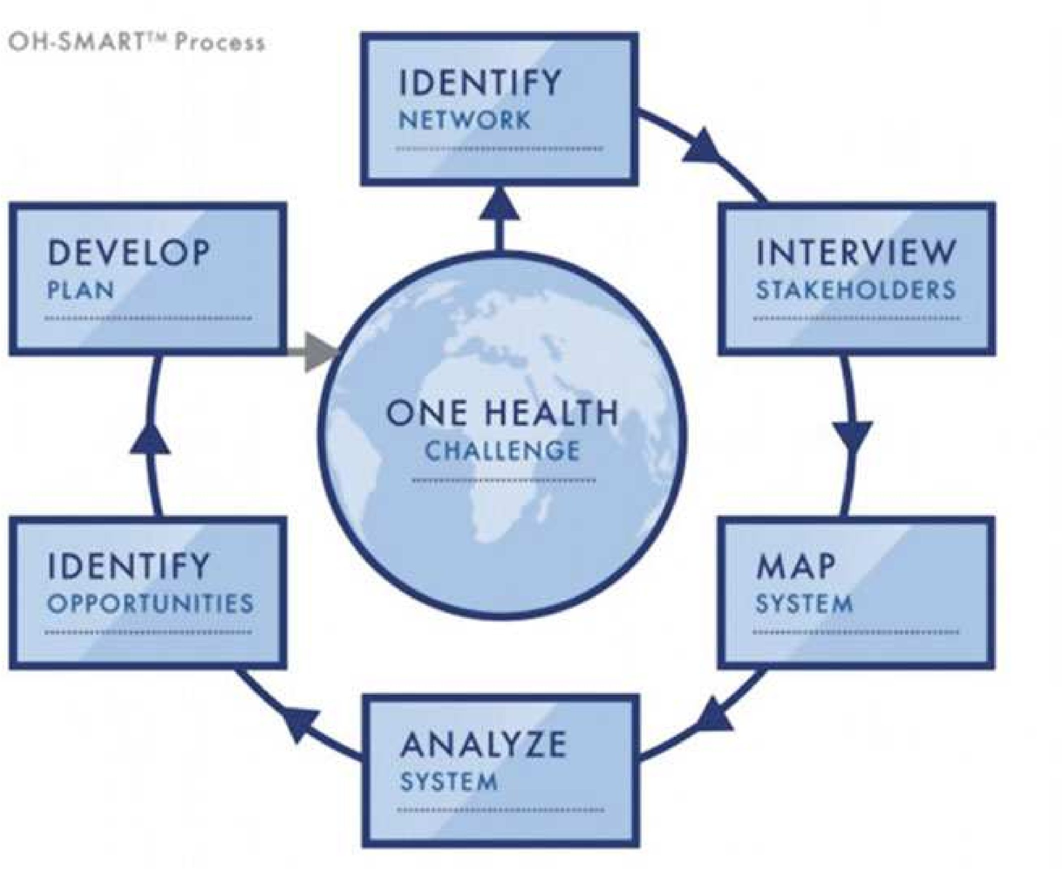

Fig. 6 The OH-SMART model. Used with permission of the authors (Vesterinen et al. 2019)

stakeholders they collaborate with and the depth of these collaborations. These interviews are then placed on a swim lane map so that the flow of resources, data, and lines of communication can be followed. The map is analyzed for best practices and discrepancies. Opportunities are identified for improving and strengthening the system. These are best practices which can be institutionalization or otherwise made stronger and discrepancies which can be resolved. These opportunities are prioritized based upon the impact, resource requirement, feasibility, and sustainability of doing so. In the final step, action plans are developed to implement the highest priority opportunities as identified by the group. This is an iterative process at all levels, and each progressive step will often uncover new components of previous steps which need to be considered to improve the effectiveness of the outcomes.

This technique can be applied in a several-day, in-place workshop, or over a longer period of time by distance. It can address problems retrospectively, prospectively, or while they are occurring. Retrospective analysis seeks to understand what went well and what can be improved for future situations. Prospective analysis helps prepare One Health workers for potential future problems by analyzing the current system for efficiencies and improvements. OH-SMART analysis during a situation helps workers analyze how well the system in place is working and to make needed adjustments in real time. For a detailed description of the OH-SMART process and its implementation, the readers are referred to Vesterinen et al. (2019).

While the OH-SMART technique was developed to assist in the sectoral analysis of a system focused on government agencies, it can be applied to community-based problems as well. In this case, the first step is to develop an understanding of the problem from the perspective of the community that is experiencing it. This entails time and relationship building and often results in a different focus than would have been the case if the problem and questions to be analyzed were determined by those working outside of the community. How well the first step engages community collaboration and support will determine the community's engagement in further steps and the potential overall success of the process. Engaging communities at the onset and in this manner also provides an opportunity to bring Traditional Ways of Knowing into the discussion and support its incorporation in future steps of the process. This approach is now being utilized in academic programs in Alaska (https://www.uaf.edu/onehealth/education/master.php).

Veterinarians are uniquely suited as facilitators of operationalizing One Health. They are trained to communicate scientific concepts to lay clients and do so as an integral aspect of their daily practice. They have public health training, are used to working with government and regulatory agencies, and across disciplines and specialties within and outside of their profession. They are frontline workers in animal welfare, zoonotic disease surveillance, reporting, and treatment and in the maintenance of food safety and security. Their daily job encompasses the interface of human, animal, and environmental health, and so, they have a working knowledge in all areas of One Health and familiarity of communicating that knowledge across disciplines and cultures. This emerging role for veterinarians is demonstrated in the inclusion of One Health in the mission statement of veterinary colleges across the globe. As One Health becomes a more conventional approach to understanding and managing large, complicated issues at the interface of human, animal, and environmental health, veterinarians will be increasingly called upon to facilitate and implement the operationalization of One Health. This will be especially true in the North where people still have close ties to the land and the animals they live with and depend upon, and, during a time when these relationships continue to change rapidly.

The Arctic is experiencing environmental, social, and economic change at a historically unprecedentedly rapid rate. This poses great challenges and, simultaneously, great opportunities to operationalize paradigm shifts supporting adaptation and resilience to these changes and which can then serve as a management model for similar changes that are occurring more gradually on a global scale. Addressing these issues effectively requires a One Health approach that integrates knowledge across disciplines and cultures, recognizes the interdependence of human, animal, and environmental health, and begins the process from a community-based perspective.

References AU7

Arctic Council Sustainable Development Working Group (2017) One Health: Operationalizing One Health in the Arctic. DWG, Tromsø

Atwell L, Hobson KA, Welch HE (1998) Biomagnification and bioaccumulation of mercury in arctic marine food web: insights from stable nitrogen isotope analysis. Can J Fish Aquat Sci 55:1114–1121

Berman M (2014) Suicide among young Alaska native men: community risk factors and alcohol control. Am J Public Health 104(Suppl 3):S329–335. https://doi.org/10.2105/AJPH.2013.301503

Berner J (2019) One Health One Future conference presentation. Fairbanks, Alaska November 5, 2019

Black S, Duigan P, Akeegok J et al (2016) Marine animal health in a changing environment. In: Cook S, Hall, D, Liljebelke K (eds) One Health case studies. 5M Publishing, Sheffield, pp 164–165

Braune BM, Outridge PM, Fisk AT et al (2005) Persistent organic pollutants and mercury in marine biota of the Canadian Arctic: an overview of spatial and temporal trends. Sci Total Environ 351–352:4–56. https://doi.org/10.1016/j.scitotenv.2004.10.034

Brubaker M, Bell J, Rollin A (2009) Climate change effects on traditional Inupiak food cellars. Center for Climate Change and Health, Bulletin No.1, October 19. Alaska Native Medical Center, Anchorage Alaska

Center for Disease Control (2021) Workshop summary: one health zoonotic disease prioritization for multisectorial engagement in Alaska. CDC. Available via https://www.cdc.gov/onehealth/pdfs/Alaska-508.pdf. Accessed 1 June 2021

Denny SK, Fanning LM (2016) A Mi'kmaw perspective on advancing Salmon governance in Nova Scotia, Canada: setting the stage for collaborative co-existence. Int Indig Policy J 7(3). https://doi.org/10.18584/iipj.2016.7.3.4

Di Francesco J, Hanke A, Milton T et al (2021) Documenting indigenous knowledge to identify and understand the stressors of muskoxen (*Ovibos moschatus*) in Nunavut, Canada. Arctic (in press)

Dunlap KL, Reynolds AJ, Gerlach SC et al (2011) Mercury interferes with endogenous antioxidant levels in Yukon River subsistence-fed sled dogs. Environ Res Lett 6(4):044015. https://doi.org/10.1088/1748-9326/6/4/044015

Eysenbach G (2020) How to fight an infodemic: the four pillars of infodemic management. J Med Internet Res 22(6). https://doi.org/10.2196/21820

Fisk AT, Hobson KA, Norstrom RJ (2001) Influence of chemical and biological factors on trophic transfer of persistent organic pollutants in the northwater polynya marine food web. Environ Sci Technol 35(4):732–738. https://doi.org/10.1021/es001459w (Erratum in: Environ Sci Technol 35(8):1700)

Gibbs EPJ (2014) The evolution of One Health: a decade of progress and challenges for the future. Vet Rec 174(4):85–91

Gibson J, Adlard B, Olafsdottir K et al (2016) Levels and trends of contaminants in humans of the Arctic. Int J Circumpolar Health 75:33804. https://doi.org/10.3402/ijch.v75.33804

Gone JP (2013) Redressing first nations historical trauma: theorizing mechanisms for indigenous culture as mental health treatment. Transcult Psychiatry 50(5):683–706. https://doi.org/10.1177/1363461513487669

Hanke AH, Angohiatok M, Leclerc L-M et al (2021) A caribou decline foreshadowed by Inuit in the Central Canadian Arctic: a retrospective analysis. Arctic (in press)

Hicks J (2007) The social determinants of elevated rates of suicide among Inuit youth. Indig Affairs 4:30–37

Hueffer K, Parkinson AJ, Gerlac R et al (2013) Zoonotic infections in Alaska: disease prevalence, potential impact of climate change, and recommended actions for earlier disease detection, research, prevention, and control. Int J Circumpolar Health 72:1–11

Hueffer K, Ehrlander M, Eyz K et al (2019) One Health in the circumpolar North. Int J Circumpolar Health 78:1. https://doi.org/10.1080/22423982.2019.1607502

Huet C, Ford JD, Edge VL et al (2017) Food insecurity and food consumption by season in households with children in an Arctic city: a cross-sectional study. BMC Public Health 17 (1):578. https://doi.org/10.1186/s12889-017-4393-6

Inuit Circumpolar Council (2015) Alaskan Inuit food security conceptual framework: how to assess the Arctic from and Inuit perspective; summary and recommendations report. Inuit Circumpolar Council – Alaska. Available via https://iccalaska.org/wp-icc/wp-content/uploads/2016/03/Food-Security-Summary-and-Recommendations-Report.pdf. Accessed 01 April 2020

Inuit Circumpolar Council (2020) Food sovereignty and self governance: Inuit role in managing Arctic marine resources. Inuit Circumpolar Council – Alaska. Available via https://iccalaska.org/wp-icc/wp-content/uploads/2020/09/FSSG-Report_-LR.pdf. Accessed 01 Nov 2020

Jack JC, Gonet J, Mease A et al (2020) Traditional knowledge underlies One Health. Science 369 (6511):1576. https://doi.org/10.1126/science

Johnson JS, Nobmann ED, Asay E et al (2019) Dietary intake of Alaska native people in two regions and implications for health: the Alaska native dietary and subsistence food assessment project. Int J Circumpolar Health 68(2):109–122. https://doi.org/10.3402/ijch.v68i2.18320

Krauss ME (1980) Alaska native languages, past, present, and future. Alaska Native Lang Center 4:1–121

Kumar MB, Tjepkema M (2019) Suicide among First Nations people, Métis and Inuit (2011-2016): Findings from the 2011 Canadian Census Health and Environment Cohort (CanCHEC). Statistics Canada. 99-011-X2019001. ISBN 978-0-660-31402-0. https://www150.statcan.gc.ca/n1/en/catalogue/99-011-X2019001

Kutz S, Tomaselli M (2019) “Two-eyed seeing” supports wildlife health – bridging indigenous and scientific knowledge improves wildlife surveillance and fosters reconciliation. Science 364 (6446):1135–1137

Kutz SJ, Thompson RA, Polley L et al (2008) *Giardia* assemblage A: human genotype in muskoxen in the Canadian Arctic. Parasites Vect 1(32). https://doi.org/10.1186/1756-3305-1-32

Lefebvre KA, Quakenbush L, Frame E et al (2016) Prevalence of algal toxins in Alaskan marine mammals foraging in a changing arctic and subartic environment. Harmful Algae 55:13–24. https://doi.org/10.1016/j.hal.2016.01.007

Mehruba A, Ridpath A, Berner J et al (2016) Medical toxicology and public health – update on research and activities at the Centers for Disease Control and Prevention and the Agency for Toxic Substances and Disease Registry. J Med Toxicol 12(3):315–317

Munnink BBO, Sikkema RS, Nieuwenhuijse DF et al (2020) Jumping back and forth: anthropozoonotic and zoonotic transmission of SARS-CoV-2 on mink farms. bioRxiv. https://doi.org/10.1101/2020.09.01.277152

National Academies of Sciences, Engineering, and Medicine (2020) Understanding and responding to global health security risks from microbial threats in the Arctic: proceedings of a workshop. The National Academies Press, Washington, DC. https://doi.org/10.17226/25887

O’Brien DM, Thummel KE, Bulkow LR et al (2017) Declines in traditional marine food intake and vitamin D levels from the 1960s to present in young Alaska native women. Public Health Nutr 20(10):1738–1745. https://doi.org/10.1017/S1368980016001853

Rasmus SM, Trickett E, Charles B et al (2019) The qasgiq model as an indigenous intervention: using the cultural logic of contexts to build protective factors for Alaska native suicide and alcohol misuse prevention 25(1)

Rivkin I, Lopez EDS, Trimble JE et al (2019) Cultural values, coping, and hope in Yup’ik communities facing rapid cultural change 47(3)

Ruscio BA, Brubaker M, Glasser J et al (2015) One health – a strategy for resilience in a changing Arctic. Int J Circumpolar Health 74:27913

Salyer SJ, Silver R, Simone K et al (2017) Prioritizing zoonoses for global health capacity building-themes from one health zoonotic disease workshops in 7 countries, 2014-2016. Emerg Infect Dis (13):S55–64. https://doi.org/10.3201/eid2313.170418

Singleton R, Lescher R, Gessner BD et al (2015) Rickets and vitamin D deficiency in Alaska native children. J Pediatr Endocrinol Metab 28(7–8):815–823. https://doi.org/10.1515/jpem-2014-0446

Sonne C, Letcher RJ, Jenssen BM et al (2017) A veterinary perspective on One Health in the Arctic. Acta Vet Scand 59(1):84. https://doi.org/10.1186/s13028-017-0353-5

Tomaselli M, Kutz SJ, Gerlach C et al (2017) Local knowledge to enhance wildlife population health surveillance: conserving muskoxen and caribou in the Canadian Arctic. Biol Conserv 217 (1):337–348. https://doi.org/10.1016/j.biocon.2017.11.010

Tomaselli M, Gerlach SC, Kutz SJ et al. (2018a) Community of Iqaluktutiaq. Iqaluktutiaq voices: local perspectives about the importance of muskoxen, contemporary and traditional use and practices. Arctic 71(1):1–4

Tomaselli M, Kutz S, Gerlach C et al (2018b) Local knowledge to enhance wildlife population health surveillance: conserving muskoxen and caribou in the Canadian Arctic. Biol Conserv 217:337–348

USGCRP (U.S. Global Change Research Program) (2018) Fourth National Climate Assess II:1–470

Vesterinen HM, Dutcher TV, Errecaborde KM et al (2019) Strengthening multi-sectoral collaboration on critical health issues: one health systems mapping and analysis resource toolkit (OH-SMART) for operationalizing one health. PLoS One 14(7). https://doi.org/10.1371/journal.pone.0219197

Waits A, Emelyanova A, Oksanen A et al (2018) Human infectious diseases and the changing climate in the Arctic. Environ Int 121:703–713

Wendt A, Kreienbrock L, Campe A (2015) Zoonotic disease surveillance – inventory of systems integrating human and animal disease. Zoonoses Public Health 62(1):61–74

Zinsstag J, Schekking E, Waltner-Toews D et al (2010) From “one medicine” to “one health” and systemic approaches to health and well-being. Prev Vet Med 101(3–4):148–156

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