Integrating indigenous knowledge in wildlife health surveillance: lessons learned from participatory work on muskoxen in the Canadian Arctic

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Abstract
The implementation of veterinary surveillance activities on free ranging animal populations still faces significant limitations, especially in remote and resource-constrained settings. However, indigenous or local knowledge can be extremely valuable to enhance wildlife health and disease surveillance. In addition, community based participatory methods can assist in the collection of epidemiological data and observations about wildlife populations critical for effective surveillance activities. Here we present the approach we used to study the health of a declining population of muskoxen on Victoria Island in the Canadian Arctic. We present an overview of the participatory methods that we have successfully implemented in the context of a muskox health surveillance program. This work is applicable to other species and settings, greatly increasing the capacity for wildlife veterinary surveillance.

Keywords: *Ethnoveterinary knowledge, participatory epidemiology and surveillance, public health, wildlife conservation and management, zoonosis*

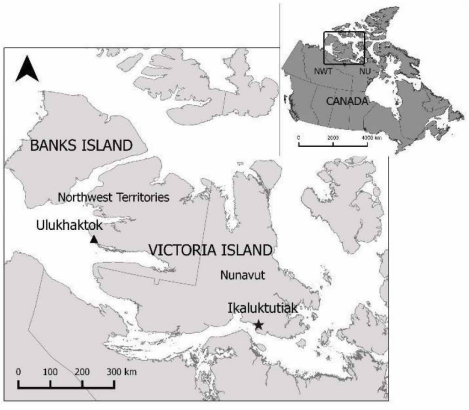
Introduction
Understanding wildlife population health is now recognised as essential for biodiversity conservation (Scott 1988, Lafferty and Gerber 2002), wildlife management (Wobeser 2007), as well as for protection of animal and human health (Daszak *et al.* 2000, Jones *et al.* 2008, OIE 2014). However, the implementation of wildlife health surveillance, a key tool that provides critical epidemiological health data on free ranging species, still faces major constraints (Wobeser 2007, Ryeser-Degiorgis 2013). Consequently, the health status of wildlife is often not considered for management and conservation decisions and/or for the evaluation of the critical interface of human and domestic animal health. This is particularly true in remote settings, where logistic and economic limitations significantly reduce veterinary surveillance capacity. However, such areas are often characterised by subsistence economies that rely heavily on the harvesting of natural resources, including wild game, with this serving as a critical component of local food security. In these contexts, monitoring wildlife health is of extreme importance, to both ensure sustainable harvesting practices and protect human health.

The integration of indigenous knowledge and participation of local resource users in surveillance programs can help to overcome some of the limitations that exist when working with free ranging animal populations. The application of participatory methods, adapted to the local context and wildlife species of interest, can be of extreme value in filling knowledge gaps on wildlife health and population status. It can also facilitate the ongoing implementation of wildlife health surveillance programs by government agencies, non-governmental organisations, wildlife co- management stakeholders, and researchers.

Our objective are to: (i) illustrate a useful approach for implementation participatory methods to gather information on health status of free ranging wildlife in remote and resource-scarce settings; (ii) consider the socioeconomic and sociocultural dimensions of wildlife at a community level; (iii) understand the intersection between wildlife and human health useful for public health considerations and mitigation strategies. We are doing so by presenting a study on a declining muskox (*Ovibos moschatus*) population in the Canadian Arctic. This work will provide insights on the applicability of participatory wildlife health surveillance to other settings and species.

Materials and methods
The project started in 2014 and is still ongoing in the community of Ikaluktutiak (Cambridge Bay) on Victoria Island, Nunavut, Canada (Figure 1).

Figure 1. Map of the area of study (generated in QGIS 2.8.9).



We structured the program in five different phases, using both quantitative and qualitative research methods (Figure 2).

Figure 2. Schematic representation of the phases of the project.

Phase I	Importance of muskoxen
Phase II	Muskox population health assessment
Phase III	Identification of priorities and logistics
Phase IV	Evaluation of the surveillance components
Phase V	Recommendations

We conducted semi-structured individual and group interviews with local harvesters and community residents to: (i) understand the significance of muskoxen for the community members with particular emphasis on the traditional food system, and the impact of declining muskox populations; (ii) collect historic and contemporary epidemiological data on muskoxen, including demography, morbidity and mortality data, relative prevalence of diseases and their trends over time, and spatial and temporal patterns of disease outbreaks; (iii) identify priorities of local stakeholder and logistics for implementation of hunter based sample collection from hunted muskoxen.

Interviewees were purposefully selected and triangulation was applied as a mean to increase data quality and reliability. During individual and especially group interviews, participatory analytical activities were implemented, adapting participatory epidemiology techniques described by Mariner and Paskin (2000) to our context and needs (e.g. participatory mapping, proportional piling, participatory drawing, seasonal calendar, timeline of events). Finally, the analysed interview data were validated with study participants.

In addition, we designed and implemented hunter based sampling in collaboration with local and territorial stakeholders, and, where applicable, we performed field disease investigations including necropsies of dead animals.

Our plans for the future include evaluation of the identified surveillance components and the formulation of recommendations for the implementation of future surveillance activities customised to the local context.

Results

The project is ongoing, thus herein, we present the preliminary results from phase I and II.

The interviews were essential for understanding the deep socio-cultural and economic implications of declining muskox populations, at a community level. This highlights the relevance of the project and further justifies the importance of developing and implementing a muskox health surveillance program. The analysis of the traditional food system, with specific emphasis on people's interaction with and use of muskoxen, highlighted important points of intersection between human and wild animal health, with further consideration on the importance of wildlife surveillance at a public heath level.

Indigenous knowledge was essential for understanding the historic and current status of muskox health. Qualitative and quantitative data generated during the interview process were critical to identify and compare epidemiological characteristics of local muskox populations during periods of higher abundance and periods of decline. Proportional piling techniques were useful to generate quantitative data on demographic characteristics of local muskox populations, as well as overall morbidity and mortality, and relative prevalence of diseases. Participatory mapping was essential to define spatiotemporal patterns of mortality outbreaks. In addition, information on endemicity and emergence of specific diseases were identified. In combination, these data provide insights on the fitness of local muskoxen and their resilience over time.

Observations of local resource users regarding specific lesions or syndromes (syndromic surveillance approach) were also collected and were corroborated by field disease investigations, leading to the first confirmation of Orf virus (*Parapoxvirus*) and identification of *Brucella suis* biovar 4 in a harvested muskox (Tomaselli *et al.* 2016). This provides further insights on the sensitivity and timeliness of participatory methods, as already underlined by Jost *et al.* (2007) and Catley (2012), and the value of prompt field disease investigation activities.

Future analysis will focus on understanding community perspectives on the drivers of muskox health and answering specific questions generated from the interview process using archived biological muskox samples, as well as the newly implemented hunter based sampling. We will then evaluate the surveillance components and ultimately give recommendations on surveillance frameworks of practical use in Arctic community settings.

Discussion

The work conducted in the present study highlights the value of indigenous knowledge and participatory methods for the assessment of wildlife population health.

We anticipate this system to be portable and adaptable to other wild animal species and settings, ultimately highly increasing the capacity to undertake regular wildlife veterinary surveillance activities by government agencies, non-governmental organisations, wildlife co-management stakeholders, and researchers.

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