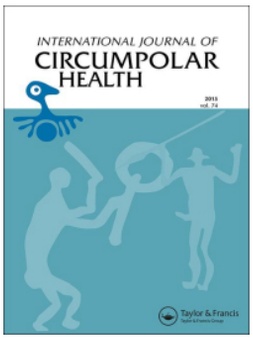

International Journal of Circumpolar Health

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/zich20

Beyond COVID: towards a transdisciplinary synthesis for understanding responses and developing pandemic preparedness in Alaska

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To cite this article: Taylor P. van Doren, Ryan A. Brown, Guangqing Chi, Patricia Cochran, Katie Cueva, Laura Eichelberger, Ruby Fried, Stacey Fritz, Micah B. Hahn, Ron Heintz, Davin Holen, Noor Johnson, Josée Lavoie, Emily Maxwell, Lisa McNair, Todd Nicewonger, Robert W. Orttung, Andrey N. Petrov & James E. Powell (2024) Beyond COVID: towards a transdisciplinary synthesis for understanding responses and developing pandemic preparedness in Alaska, International Journal of Circumpolar Health, 83:1, 2404273, DOI: 10.1080/22423982.2024.2404273

To link to this article: https://doi.org/10.1080/22423982.2024.2404273

INTERNATIONAL JOURNAL OF CIRCUMPOLAR HEALTH
2024, VOL. 83, 2404273
https://doi.org/10.1080/22423982.2024.2404273

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Beyond COVID: towards a transdisciplinary synthesis for understanding responses and developing pandemic preparedness in Alaska

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ABSTRACT

Pandemics are regularly occurring events, and there are foundational principles of pandemic preparation upon which communities, regions, states, and nations may draw upon for elevated preparedness against an inevitable future infectious disease threat. Many disciplines within the social sciences can provide crucial insight and transdisciplinary thinking for the development of preparedness measures. In 2023, the National Science Foundation funded a conference of circumpolar researchers and Indigenous partners to reflect on COVID-19-related research. In this article, we synthesise our diverse social science perspectives to: (1) identify potential areas of future pandemic-related research in Alaska, and (2) pose new research questions that elevate the needs of Alaska and its people, pursuant of a specific body of pandemic knowledge that takes into account the ecological and sociocultural contexts of the region. In doing so, we highlight important domains of research in the social sciences from transdisciplinary perspectives, including the centering of Indigenous knowledges and needs, the contexts of risk perception and resilience, food and housing security, and more. We highlight the contributions of social sciences to pandemic knowledge and provide a foundation for future pandemic-related research in Alaska.

ARTICLE HISTORY
Received 12 August 2024
Revised 2 September 2024
Accepted 10 September 2024

KEYWORDS
Pandemics; community-based research; social science; emerging pathogens; risk perception; housing security; food security; public health

Introduction

The beginning of the COVID-19 pandemic was a point of reckoning for public health, biomedical, political, and social institutions across the globe. Although pandemics have occurred throughout history with relative regularity, the appearance of the SARS-CoV-2 virus, its subsequent global dispersal, and near-immediate impact illuminated one universal fact: better pandemic preparation was needed. However, since March 2020, many public health efforts and research programmes have been dedicated to emergency responses and more proximate analyses of the current state of the pandemic rather than deep reflections on what could have been done to prepare for – much less prevent – a pandemic event. Systematic, research-based, community-based, and historically-based preparedness plans may better mitigate the risk of acute novel infectious disease outbreaks.

Pandemic preparation is not straightforward because people live in dramatically different contexts. For example, cities with millions of people and high population densities will experience a pandemic differently than the most rural communities accessible only by boat or plane; people in tropical climates will have different ecological pressures shaping their baseline health than those in temperate or Arctic climates; and population structures with a larger proportion of elderly individuals experience acute epidemic events differently than

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those with large young adult and infant populations. As such, there can be no single approach to identifying and developing preparedness plans for inevitable future epidemic outbreaks with pandemic potential. However, there may be foundational principles of pandemic preparation, such as considering community contexts and working with communities, which are translatable to multiple contexts. Therefore, reflection and preparation must be carried out within specific contexts and with an eye towards the synthesis of different approaches to pandemic studies for a holistic perspective of how to meet the needs of a given region and its people.

In this paper, we specifically focus on Alaska, one part of the broader region of the Circumpolar North, a region that is undergoing the most rapid environmental transitions on the planet [1]. The region is socioculturally and ecologically heterogeneous with many Indigenous Peoples who have stewarded the land for time immemorial. To this end, there are many transnational and international organisations and working groups dedicated to the pursuit of advancement and health in the region, establishing precedent for this region as a fundamentally and theoretically distinct space, including the Alaska Native Tribal Health Consortium (ANTHC), the Arctic Council, and the Interagency Arctic Research Policy Committee (IARPC).

Social scientists are well equipped to holistically assess the interconnected determinants of how people experience pandemics. For example, biocultural anthropologists work to understand how both the cultural and biological elements of human nature co-evolve and are specific to local ecologies [2–4], termed "local biologies" [5,6]. Cultural and ecological drivers of health can intersect in many ways, such as through social organisation (village/town interconnectedness, gender roles, and kinship roles), food sources (methods of acquiring food, nutritional content of animals and plants available, zoonotic pathogen exposure), cultural activities and traditions (use of traditional medicine, spirituality, connection to nature), and housing (single or multi-family homes, climate adaptations, material availability). Further, sociologists may focus more closely on how societies and their institutions identify, define, react to, and recover from pandemics [7,8]. Psychologists may approach pandemic studies through the investigation of risk perception, and how people identify, mitigate, reassess, and negotiate risks with themselves and their communities [9–11]. The field of political science may contribute to the understanding of the structural and systemic determinants of inequality – and therefore the heterogeneous pandemic severity – from the local to global levels [12], as well as the governance aspects of pandemic dynamics and responses [13,14]. With many places for potential overlap of perspectives in the pursuit of an understanding of the human experience with pandemics, it is additionally important to ask research questions and operationalise hypotheses within specific sociocultural and ecological contexts; that is, the knowledge produced about pandemics in Alaska through one or many of these social science fields will be specific to and benefit the region.

In April 2023, the National Science Foundation funded a conference of social scientists and Indigenous partners studying the COVID-19 pandemic in the Circumpolar North. Participants approached the pandemic from diverse perspectives, including disease ecology, policy research, environmental demography, water and housing security, public health, risk and resilience, community-based research, and infodemiology. The authors of this paper constitute the attendees of this conference. Though the scope of the gathering was broad and sought to include diverse perspectives from across the Circumpolar North, the resulting gathering and the research presented therein were primarily, though not entirely, focused on the Alaskan context, and all attendees were from North America. Thus, this paper discusses pandemic knowledge specific to research in Alaska, but with a broad conceptualisation of Alaska as one piece of the transnational Circumpolar North region. The primary conference goal was to share research undertaken throughout the duration of the COVID-19 pandemic thus far. In this article, we synthesise our findings from our diverse intellectual perspectives and lived experiences to identify areas for potential future pandemic-related research. Drawing upon this synthesis, we also put forth research questions that elevate the needs of the region and its diverse peoples. Through transdisciplinary engagement, we intend to apply our holistic understandings of COVID-19 to ask questions that could lead to new and continuing pandemic research endeavours.

Circumpolar North context

Although we will review research specific to the nature of the COVID-19 pandemic in Alaska in the following sections of this paper, we first seek to establish the broader context of the larger region of which Alaska is a part. The Circumpolar North is a vast and diverse area, home to around seven million people, including just over one million people Indigenous to the eight Arctic nations: the USA (Alaska), Canada, Kingdom of Denmark (Greenland [Kalaallit Nunaat] and Faroe Islands), Iceland, Norway, Sweden, Finland, and Russia [15]. With a large

land area and ecological and sociocultural diversities, studying the health of people who live in this region requires the expertise of many fields [16]. A significant stressor across the Circumpolar North is climate change, and the region is warming four times faster than the rest of the planet [1]. Housing security, food security, water security, and emerging infectious diseases are also all considerable stressors on circumpolar populations, all of which will be expanded upon throughout the following discussion.

There are significant disparities impacting population health in the Circumpolar North, as well as best practices that may be translatable to other contexts. Indigenous Peoples throughout the Circumpolar North draw from immense stories of wisdom, land-based knowledge, adaptability, and resilience. However, these populations have also been impacted by historical and ongoing trauma due to colonialism and racism that has resulted in health disparities. Specific attention to the Circumpolar North is critical because health disparities of populations here are often overlooked since most regions exist as parts of high-income nations [17–19]. For example, the US is considered an Arctic nation but only due to Arctic regions of the state of Alaska. US national-level health statistics include Alaskan data, yet the state has a population of ~733,000 people comprising only 0.2% of the 331.9 million people in the US [20]. Statistics on morbidity, mortality, disease incidence and prevalence, life expectancy, and more for the US provide little to no insight into the characteristics of the small proportion of its populace that make it Arctic. The Arctic regions of Northern Canada and Russia are at risk of similar homogenisation with the more southern regions, as are Greenland and Faroe Islands with Denmark. We do not detail the health inequalities here, but Snodgrass [19] provides a useful synthesis of research related to the health of populations Indigenous to the region and summarises overall health, key challenges, and lifestyle and environmental risks.

Pandemic research in the Circumpolar North

A pandemic is an acute stressor that disrupts daily life, culture, demography, and population health, and the COVID-19 pandemic has further challenged the health and wellbeing of northern populations. It is difficult to define a pandemic, but Dimka et al. [21] broadly definea *pandemic* as a large-scale epidemic — one that affects large regions or multiple continents at approximately the same time — that typically have more severe consequences than epidemics of any level of severity. Additionally, pandemics are often caused by novel pathogens that cause acute infectious diseases that can be transmitted rapidly and that affect populations with little or no prior immunity [21]. As such, there are many moving parts, so to speak, that characterise the pandemic experience with various epidemiological, pathological, ecological, geographic, and sociocultural determinants. High variability of determinants makes it difficult to generalise across highly heterogeneous nations and regions; therefore, more specific conceptualisations with clear boundaries for understanding experiences within particular contexts are necessary.

There are well-established organisations and publications dedicated to elevating research on circumpolar health, specifically, the International Congress of Circumpolar Health (ICCH), the International Arctic Social Sciences Association (IASSA), and the *International Journal of Circumpolar Health*. However, prior to the COVID-19 pandemic, there was little research dedicated to other pandemic events in this region. This is not to say that there is a dearth of infectious disease and epidemic research in the Circumpolar North. To the contrary, there is much research dedicated to the region's high burdens of infectious disease. Infectious diseases were historically a leading cause of death in Alaska, Russia, and the Canadian Arctic [22–25]. Fortuine [26] discusses the variety and characterises the burden of infectious diseases in Alaska from the 18th to 20th centuries, including discussions of zoonotic diseases (e.g. trichinosis, known in the Arctic since the 1940s [27,28], *Echinococcus* tapeworm [29]), influenza, pneumonia, and septicaemia [30] and smallpox [31]. A thorough review of the research dedicated to studying the breadth of infectious diseases and epidemics in the Circumpolar North is outside the scope of this paper; throughout the rest of this paper, we focus our discussions on pandemics in Alaska within the definition of *pandemic* provided above.

Within the specific definition of pandemic set forth in this section, there has been a modest amount of pre-COVID-19 pandemic research published in the Circumpolar North context. The 1889 "Russian flu" pandemic is an enigmatic event that is sometimes considered the first recorded pandemic of the industrial age [32]. Although relatively little is known about this pandemic, it was known to affect Russia first and it hit Tomsk in Siberia by mid-October 1889 [33]. This 19th century influenza pandemic could have potentially had a strong bearing on the age-based mortality pattern observed during the 1918 influenza pandemic via various immunological pathways [34,35]. Although there is little information on the 1889 influenza pandemic in

Alaska, there were well-reported severe outbreaks of influenza in 1897 and 1900 on the Northern Slope and in the Interior regions [36–39]. There are also a few notable exceptions related to the 1918 influenza pandemic, including a general comparison between pandemic experiences in Alaska and Labrador [31], a recently expanded exploration of the pandemic's impacts in Alaska [40], excess age-based mortality in remote Norwegian communities [41], the pandemic's consequences on natality in Scandinavia [42], and general experiences in Inuit and Innu communities in Labrador [43]. There is other research investigating the 1918 influenza pandemic in other Circumpolar North nations [44–48]. The knowledge produced therein is important to the fields of historical demography and epidemiology and can be further strengthened with more contextual information related to Circumpolar North ecology, social dynamics, population structures, and living conditions. Cliff et al.'s [49] exhaustive, century-long account of epidemics (including the 1918 influenza pandemic) in Iceland within the framework of geographic and ecological determinants of island epidemics is a good example of such applications. As such, there is ample opportunity for a place-specific approach to pandemic studies in the Circumpolar North broadly, and Alaska more specifically, that will contribute to future pandemic preparedness planning.

The COVID-19 pandemic in the Circumpolar North

There has been a substantial body of research disentangling the epidemiological and social impacts of COVID-19 in areas across the Circumpolar North since the onset of the pandemic. Petrov et al. [50] showed that the initial wave of the COVID-19 pandemic affected disparate subregions of the Circumpolar North in distinct ways. These authors have compiled a useful open access Arctic COVID-19 dashboard that updates the number of cases, deaths, and incidence rates in major locations throughout the region (https://arcticcovid.uni.edu/). Recorded data of early cases were dominated by Northern Russia, but case fatality rates were much higher in Sápmi (northern Scandinavia) than in any other country by summer 2020. Meanwhile, relative geographic isolation, strong quarantine policy and adherence, and effective public health messaging kept Greenland, Faroe Islands, and Northern Canada free of COVID-19 for much of 2020 [50]. Following this initial epidemiological description, updates were published in two more papers as the pandemic progressed using the data collected on the dashboard [51,52].

Other researchers have investigated the COVID-19 pandemic in the Circumpolar North from many perspectives, which include but are not limited to epidemiology, geography, ethnography, public health, food (in)security, anthropology, and more. Indigenous-led research programmes helped re-frame the Social Determinants of Health framework within the field of public health to better reflect the needs of Native Peoples [53] and described how the pandemic affected food access in rural Alaskan communities [54,55]. Other research has produced insights into vaccine administration in rural Alaska and among First Nations in Canada, highlighting the complexity of decision-making behind this process [56–58]. Further areas of investigation related to the COVID-19 pandemic in the Circumpolar North include food sovereignty in Russia [59], risk perception and resilience [60–64], and the nature of socio-political interactions between Greenland and Denmark that were instigated by pandemic-related public policy [65]. Specific interest in historical experiences and memories of the 1918 influenza pandemic have also informed cultural and public health approaches to COVID-19 [66–68]. Additionally, there has been research theorising circumpolar islands as unique compared to their mainland counterparts, specifically, Greenland and Iceland, and emphasising their isolated geography as a determinant of their relatively successful response to COVID-19 [68]. Finally, and most recently as the product of a project led by Fulbright Arctic Initiative Alumni, a new special issue in the *International Journal of Circumpolar Health* focuses on the impacts of COVID-19 on rural Arctic Indigenous communities [69].

In the light of the knowledge that has been produced in the 4 years since the beginning of the COVID-19 pandemic, the time has come to reflect upon this knowledge and consider how it can be used to not only better understand how diverse communities experienced COVID-19 but also how that knowledge can be applied to future pandemic preparedness endeavours and how social sciences can contribute highly valuable perspectives in the building of pandemic knowledge that centres Indigenous sovereignty. This knowledge can be used as a foundation for understanding the consequences of COVID-19 in the region, ranging from sociocultural to population health consequences.

In the following sections, we focus more specifically on research produced during the COVID-19 pandemic in Alaska to: (1) identify potential areas for further health- and pandemic-related research from social science perspectives; (2) outline areas for theoretical and conceptual synergy in future research with an eye towards generating new research questions; and (3) offer concluding remarks about the future of research and applications for preparedness for future infectious

disease outbreaks. We acknowledge that the synthesis of ideas presented here does not represent the breadth and depth of potential pandemic-related work to be done in Alaska specifically or the Circumpolar North broadly, but rather the ideas of the group that gathered for the meeting and authored this paper. That said, we seek no more than to offer ideas on how to fill identified research gaps and pursue new questions that can sustain current and future social science pandemic research programmes in the region.

Areas for further pandemic research in Alaska

Risk perception

Since the beginning of the COVID-19 pandemic in March 2020, risk perception has been a dense area of study for many social science fields [10,70–72]. Risk perception research has been well established in the field of psychology for decades and is a way to better understand how heterogeneous populations understand various risks, demographic factors related to risk perception, and how risk perceptions influence health-related behaviours [73,74]. However, risk perception studies during the COVID-19 pandemic have often focused on large (national) samples that may not accurately represent the perception, beliefs, and/or behaviours of everyone for which the sample claims to account. This is especially true for Circumpolar North communities, whose interests, culture, population health, and demography have been historically homogenised with the high-income nations to which they belong [19], and for Alaskan communities, which are primarily rural and, as a state, represent 229 federally recognised Tribes (over half of the total in the US) [75]. It is critical to understand how rural communities perceive risks related to emergent threats because specific structural, historical, and cultural forces shape risk perception and health-related behaviours [75–77], and there should be a heightened level of care when contextualising risk perception of historically marginalised communities [78,79].

Research has shown that the risk perception of the COVID-19 pandemic was the highest among Alaska Native individuals, minorities, and lower-income families. In a survey conducted during the commercial fishing season from May to June 2020 in the Bristol Bay area (southwest region) of Alaska, it was found that COVID-19 risk perceptions were the highest among Alaska Native residents and Hispanic migrant workers with lower incomes [61]. However, it is the same demographic group that was more likely to participate in the fishing season as they were concerned with whether they could find alternative employment. This study highlights the struggles of the vulnerable groups, who are more concerned with the COVID-19 risks but decide to participate in the fishing season anyway. Other risk perception research in Alaska showed that there were (mis)conceptions about risks related to the COVID-19 vaccines that specifically highlighted concerns for pregnant people [57]. Further, the complexities of how risk perception is related to the COVID-19 vaccines and the decision-making process to get them is not dichotomous, but rather a nuanced spectrum of priorities and concerns [80,81]. In short, social science investigations into risk perception in Alaska have shown that this is a highly complex process, and capturing the depth of human opinion is extremely difficult and cannot be comprehensively understood without exploring the context and historical socio- and biocultural origins of those risks.

There is ample space for transdisciplinary social sciences to holistically understand how the context of Alaska contributes to its residents' perceptions of risk. For example, the risk perception research that broadly describes hundreds, if not thousands, of survey responses to risk-related questions is primarily proximate and descriptive; they do not deeply engage with the ultimate determinants of risk perception in specific communities. When research identifies significantly higher perceived risk of getting sick or dying from COVID-19 and significantly modified health-related behaviours in historically marginalised communities [82–84], it is important to recognise that there are likely historical circumstances related to that marginalisation that inform contemporary perceptions of risk. As a more specific example, when higher perceived risk from COVID-19 was identified in Tlingit and Haida communities of Tlingít Aaní (Southeast Alaska), it is critical to contextualise that risk perception observed with Alaska Native communities' overlapping history of colonial violence and the 1918 influenza pandemic in the early 20th century [64]. In Bristol Bay, the memory of the 1918 influenza pandemic that wiped out 40% of the population and smaller minor epidemics that lasted until the 1950s, were events of historical trauma [61,85]. Anxiety of boat captains and tender operators (i.e. those in charge of moving materials), especially those Indigenous to the area, was high as their Elders had generational memories of these events that were passed on. There was a real perception of a high degree of risk associated with participating in the commercial fishery, where crew quarters are tight, and boats are often tied up in proximity [86]. The inquiry into risk perception cannot stop at identifying the nature of

that perception but must rather consider ultimate determinants of those perceptions.

This highlights four particular areas of pandemic risk research that can be considerably strengthened with the involvement of transdisciplinary social science perspectives: (1) more precisely defining *risk perception* within study contexts; (2) critically evaluating the context in which those risk perceptions exist with temporal depth on intersecting sociocultural, historical, and ecological levels; (3) identifying how baseline population health may be related to embodied responses to previous generations' trauma during colonisation [87] and how this may be linked to contemporary pandemic experiences; and (4) situating resulting knowledge within the capacities and priorities of small, rural communities, including those with large Native populations. The pursuit of these lines of inquiry will help buttress the understanding of ultimate determinants of pandemic outcomes in the region, which complement, but underly, the proximate determinants that are often the focus of epidemiological research.

Misinformation, malinformation, and disinformation

As the COVID-19 pandemic intensified, a parallel information pandemic, termed "infodemic" [88], complicated efforts to decelerate the spread of the illness. The threat of this infodemic, fuelled by gaps in data, politicisation, and social media, was recognised as a significant hindrance to increasing vaccination, mask usage, and other protective behaviours [89–92]. The Circumpolar North was not immune to this phenomenon, and the corpus of research focused on health misinformation in the region is limited, though there is emerging research on its effects in Alaska.

The CDC acknowledges that misinformation tends to thrive in situations where there is uncertainty and imperfect data, leading to a desire for concrete answers [93]. This makes it challenging to distinguish accurate information, particularly in technically complex fields like biomedicine and epidemiology. The role of media, both traditional and social, also played a crucial role in the infodemic. With an increase in digital media dominance, the pressure for sensationalism, bias, and polarising content has risen, further hampering the dissemination of accurate information [94]. Insufficient media literacy has contributed to higher levels of distrust in scientists (only 4 in 10 US adults learned to analyse science news for bias and credibility in high school) [95].

In Alaska, where diverse demographic and geographic challenges exist, the impact of misinformation is an issue requiring special consideration. The state's conservative political leaning, coupled with a significant rural population, diverse citizenry, and remote geography, yields unique challenges in ensuring accurate information reaches all communities. The COVID-19 vaccination rates in Alaska, while at 63% as of February 2024, show disparities based on geography and ethnicity, emphasising the need for targeted efforts to counter misinformation [96]. Studies conducted in Alaska reveal that misconceptions about COVID-19 are widespread, even in areas with high vaccination rates. Concerns about vaccine safety, side effects, and distrust in the political process were cited as reasons for hesitancy [57]. The impact of misinformation is evident in the varied perceptions and vaccination rates across different communities, emphasising the importance of targeted communication strategies.

The information and misinformation landscapes during the COVID-19 pandemic in Alaska are not yet fully understood. Recent studies have begun to address this data gap by exploring factors associated with vaccine hesitancy [97], perceptions of COVID-19 vaccines [57,61], hesitant adoption and the decision-making processes behind receiving COVID-19 vaccines [80,81], the relationship between news-media and vaccine uptake [98], and general trust in public health information from varying levels of government (federal, state, and local levels) [99]. In addition to these studies, Alaska was home to a small team of academics, public health professionals, communicators, and students who monitored Facebook pages for misinformation during the pandemic [100]. This group, the Alaska Public Health Information Response Team (APHIRT), collected posts containing misinformation and countered it with evidence-based information. Recent research has found that COVID-19 responders believed these tools provided useful insights and that these strategies should be built upon and employed during future infectious disease outbreaks [101].

The intertwining challenges of the COVID-19 pandemic and the associated infodemic underscore the critical need for targeted research and intervention strategies. The recognition of misinformation as a substantial impediment to public health efforts generates a set of priorities for future research. More research is needed to better understand the complex dynamics of the impacts of media literacy on public trust in healthcare institutions. The disparities in vaccination rates based on geography and ethnicity highlight the necessity for tailored communication strategies. Additionally, investigating the effectiveness of initiatives like APHIRT in countering misinformation provides a promising avenue for mitigating future

infodemics. As we navigate the evolving landscape of information in the context of public health crises, enhancing the body of knowledge in the young field of infodemiology will play a pivotal role in shaping evidence-based communication strategies and building resilient communities better equipped to confront future public health emergencies.

Housing and food security

In many areas of the Circumpolar North, the COVID-19 pandemic exacerbated the housing crisis, which is primarily characterised by extreme overcrowding and an unhealthy interior environment, and the housing crisis exacerbated the impacts of COVID-19 [102,103]. To prepare for the next pandemic, addressing housing security is a critical area for social scientists to collaborate with public health experts and cold climate builders.

Home construction was deemed essential in Alaska during COVID-19, and some hoped it would provide one of the pandemic's few economic bright spots [104]. Though interest rates were historically low, and funding was made available, many of the constraints that normally complicate home construction in Alaska worsened [104]. In addition to village travel restrictions and workforce shortages, supply chains were severely disrupted, and material costs soared. A rule of thumb among Alaskan builders is that approximately 50% of the material cost for construction in remote communities can be attributed to shipping [105], and Alaska's transportation infrastructure is limited: barges deliver cargo to some communities only once or twice during the open water season. Everything must be planned, procured, and delivered to the barge site months in advance, and construction can only begin after materials arrive, sometimes late in the short summer season.

In addition to investigating the impacts of the pandemic on housing security in Alaska, Nicewonger et al. [106] explored the history of and potential for prefabricated (i.e. modular or offsite) construction to address northern housing needs. As Alaska housing authorities explore prefab options and the US. Department of Housing and Urban Development [107] funds research into prefabricated building, specific investigations into how site-assembled modular homes can address housing security in the region are needed. For example, with projects supported by COVID CARES funding, modular "mini-homes" were constructed in Sitka and then shipped to Yakutat, where overcrowding is severe but the cost to construct can be a third higher [108]. Some prefab construction businesses predicted, incorrectly, that the pandemic would usher in an industry-wide shift to modular housing [109]. Research also tracked building system innovators at Fairbanks' Cold Climate Housing Research Center who were experimenting with prefabricated/modular designs [110] and others who had to collaborate on building projects via remote methods as the pandemic wore on.

Social scientists of northern infrastructure, public health experts, and innovative builders can collaborate on policy, building science, occupant comfort, and affordability to both build more and better homes and evaluate results that demonstrate how housing security is a vital part of comprehensive health care. Housing's relationship to community health and wellbeing (or "health security" [111]) is a multi-layered primary social determinant of population health and inequities [112]. A recent NIH analysis demonstrated "the value of viewing housing policies as public health policies that could significantly impact the health and wellbeing of populations, especially vulnerable groups" [113]. An interdisciplinary northern focus on housing should build on the growing nationwide research recognising housing as "a fundamental part of health care" and on the precedent that, in fall 2024, Medicaid dollars will be paying rent for some people in the United States [114].

The need for the same quarantine space in communities during COVID-19 highlight the problem of overcrowding, which in turn highlighted the issue of indoor air quality, one of the most complex cold climate building science problems and an environmental justice issue [115]. While energy efficient ("airtight") homes do help with the high costs of home heating and reduce houses' carbon footprint, the construction methods and materials used to achieve efficiency frequently exacerbate mould and poor indoor air quality. Issues with housing's physical facilities, condition, or overcrowding are almost five times more prevalent in Alaska Native communities, and the share of households with plumbing or kitchen problems or overcrowding is highest in Alaska Native communities [116].

While highlighting "the importance of health equity, the concept of the right to housing and the value of trauma-informed and co-designed housing structures, programmes, and services", there are five primary linkages between housing and health for research to pursue: (1) housing quality and condition; (2) residential stability and security, including the health implications for homelessness and migration; (3) housing affordability; (4) neighbourhood context; and (5) social connection and care [112]. A review linking housing to health outcomes in Alaska and the Canadian Arctic found ample evidence of the impacts of housing quality and condition on health, particularly for paediatric respiratory illness [117]. Access to piped water and sewer to the home was the most common community context

characteristic of housing that was linked to health. In addition, one-fifth of the articles intersected with food or food insecurity. There was a gap in the literature related to housing affordability, and more research is needed related to the wellbeing of Elders, people living in urban settings, and the links between housing, health, and climate change impacts [112].

To promote housing security to prepare for a future pandemic, research can benefit from the findings and guidance of the Arctic Council Sustainable Development Working Group's "Zero Arctic" project, which investigated "how various applications of traditional knowledge in Arctic construction have supported the environmental sustainability of buildings and how these principles can be applied in the development of modern construction" [118]. The Alaskan housing security researchers involved with this conference continue to engage in social infrastructure research guided by ideals described by leading Canadian housing security expert Julia Christensen, who asserts that alleviating Indigenous homelessness requires a two-pronged agenda: (1) addressing modern colonial geographies and their social and material expressions in Indigenous People's daily lives; and (2) supporting culturally rooted and self-determined frameworks in research and outcomes [119]. Research with a health equity approach can support the many Tribal organisations already working in that direction and help communities avoid importing more inappropriate housing solutions [112].

Food security is also of growing concern in the Circumpolar North in general and includes both market-based foods as well as wild or traditional foods from the land, water, and air [59,120]. For many communities in this region, wild foods are a significant portion of residents' diets, and are also a fulcrum of Arctic Indigenous cultures and a mainstay of local daily living and economies. Various factors are currently impacting wild/traditional food access including climate change, commercial fishing, resource management, maintaining traditional and local knowledge to procure foods, among others. While subsistence/traditional activities were cited as a common coping strategy among remote Alaska communities, and traditional food access was impacted less severely compared to store-bought food access, the future of this source of resilience during subsequent pandemics is uncertain [54,121]. Furthermore, traditional/subsistence activities are often done in groups and require advanced skills and knowledge often held by older members of the community. These two factors likely represent barriers to accessing wild/traditional foods during future pandemics due to concerns related to disease spread and higher vulnerability of Elders and older people. Planning on how to maintain wild/traditional sources of buffering despite pandemic-related challenges is an important component for strength-based pandemic preparation in the Arctic.

Despite rich local resources, communities in Alaska also rely on market-based foods and are continuing to experience the COVID-19-related disruptions of the global food system through lingering increases in food prices. The issue was compounded by reduced travel, postal services, and cargo/transportation services, which significantly impacted access to store-bought foods during the COVID-19 pandemic in rural/remote communities in which air cargo is the most common and reliable transportations for market foods [121]. Increased sharing of foods between community members, new phone ordering systems, and increased food assistance during the COVID-19 pandemic relieved some of the pressure on store-bought food access [121]. However, such infrastructure challenges should be addressed proactively on a regional, statewide, national, and/or international scale to reduce the risk of severe food insecurity during future pandemics, particularly in the light of increasingly problematic insults to infrastructure co-occurring due to climate change.

Climate change and infectious diseases

Climate fluctuations are normal occurrences throughout the life of our planet, but no prior changes have been influenced as much by human activity than the changes occurring now [122]. A recent estimate has shown that over half of known human pathogenic diseases can be aggravated by climate change [123]. Changes in environmental conditions related to temperature, flooding, drought, and extreme weather can influence several aspects of disease transmission. Shifts in the geographic range of pathogens, reservoir species (e.g. mammalian hosts of pathogens), or vectors (e.g. ticks or mosquitoes) can bring pathogens to new populations. For example, vector-borne diseases (pathogens transmitted by arthropods) are particularly sensitive to changes in temperature with evidence of expansion at higher latitudes due to warming temperatures [124–126]. Changes in human behaviour associated with extreme weather events can also affect exposure to pathogens, for example, a water-borne disease outbreak following a heatwave and an increase in recreational water use [127].

In the Northern and Arctic regions, the unique connections between climate, ecological change, and human culture both narrow the list of potential pathogenic concerns and expand the potential

pathways for disease emergence and health impacts [128,129]. Most known emerging diseases are of zoonotic origin, and pathogens that evolve and spread rapidly, like viruses, are of particular concern and important in changing environments [130–132]. Within the last decade, there are reports of rural Arctic communities with an increased risk of infection with pathogens transmitted by wildlife [133]. Many communities are dealing with substantial impacts to infrastructure due to permafrost thaw, coastal erosion, and loss of protective sea ice. This can have a major effect on infectious disease risk when there is damage to water sources, treatment plants, and community laundry and shower facilities and systems for collection and disposal of human waste [134]. There is currently no comprehensive data source that measures the status of water and sanitation services among Circumpolar North populations, but existing data suggest that access to running water and flushing toilets in this region is far below other areas, even within the same countries [134]. A recent review highlighted major gaps in climate, water, and human health research in the Circumpolar North, including a dearth of research on the future projections of climate change impacts on drinking water [135].

Many residents in the Circumpolar North rely on subsistence hunting, fishing, and gathering as a major portion of their diet. Additionally, many traditional food processing and storage practices rely on a stable environment (e.g. smoking fish or storing food in ice cellars). Changes in the climate may impact infectious disease risk through pathogen transmission from wild animals to people or through spoilage [136]. Closeness to animals, lands, and waters may put humans at risk for exposure to pathogens to which they previously would not be exposed. For example, permafrost thaw not only raises the risk of human exposure to emerging pathogens [137] but also exposures to "palaeobiological waste" (re-emerging animal carcasses and anthrax exposures in Siberia [138,139]) and increases in heavy metals such as mercury in waters, which can harm both humans and marine animals [140]. The risks of new and re-emerging infectious diseases because of climate change can be engaged by social science disciplines that understand deeply how the rapidly changing ecology of the Circumpolar North impacts the ways in which humans interact with non-human animals, lands, and waters, but also how these changes may pose risks to infrastructure, water security, and food security. Social science interventions may necessarily include conceptualisations of health in the Circumpolar North under the One Health framework [141], which we will expand further upon below.

Towards new research

The topics and research discussed in the previous section focused primarily on the Alaskan context through a variety of social science perspectives. Here, we outline and discuss three topics on a conceptual and theoretical level that may support and advance pandemic studies not only in Alaska but also more broadly throughout the Circumpolar North: centring Indigenous science, knowledge, and priorities; holistic health; and reflections on historical pandemics.

Centering Indigenous science, knowledge, and priorities

With over one million people Indigenous to the Circumpolar North, it is critical to ensure that Indigenous research priorities and capacities are at the forefront of future pandemic research endeavours in the region. Indigenous Peoples in the region have made these priorities transparent, and they actively encourage prospective partners to review documentation related to research priorities before proposing new research ideas. For example, the Fulbright Arctic Initiative fellowship identifies high priority topical areas for prospective fellows [142]; there is a newly established Alaska Arctic Observatory and Knowledge Hub network of Iñupiaq observers in the Seward Peninsula region of Alaska working in collaboration with academics to identify environmental change and elevates Indigenous-led observations and worldviews in the research process [143]; the Tribal consortium of Kawerak Inc. published a detailed guide for best research practices in the Bering Strait Region [144], as well as a long-term strategic plan and core values of their people [145]; in Qaujigiartiit Health Research Centre's Piliriqatigiinniq Partnership Model for community health research, an independent and community-based institute dedicated to the research of high priority topics in Nunavut (a territory of Canada) by Nunavummiut [146]; and a new Iñupiaq-owned and led course called Effective Community Engagement teaches Arctic researchers how to learn about community priorities and build sustainable collaborative relationships respectfully [147]. In short, Indigenous Circumpolar North communities have robust systems already in place with clearly stated and defined priorities for research that will best benefit their people, lands, and waters. Pandemic researchers who are keen on developing knowledge in the context of the

Circumpolar North broadly, and Alaska specifically must ensure that their research interests align with the established priorities and capacities of the communities with whom they seek to engage. In some cases, pandemic research may align with emergency response capacity building; however, that is something that must be communicated and established beforehand to protect against extractive research practices.

Yua et al. [148] and Degai et al. [149] published recent articles establishing expectations for the process of co-production of knowledge in the Circumpolar North. This framework emphasises that *all* aspects of the research process, from conception to dissemination, must be equitable, built on trust and respect, and respectful of the sovereignty of Indigenous science, knowledge, and people. We acknowledge that the concept of co-production has been problematised by both Indigenous and non-Indigenous scholars. Some have argued that the concept of co-production of knowledge is fundamentally rooted within Western intellectual traditions and approaches to knowledge production; therefore, without careful and critical examinations of privilege and power, true co-production is difficult to achieve [150]. Indeed, too often, the co-production of knowledge is used as a badge to access funding, when a better description of research that claims to be co-productive is collaborative at best [148]. Pandemic research in general is strongly biased towards the Western academic fields of demography, epidemiology, and biomedicine; transdisciplinary and holistic social sciences whose research is based on human experience and interaction can help effectively bridge the chasm between the pandemic research produced and the pandemic research that identifies how existing areas of strength in Circumpolar North communities can be used to further strengthen emergency response capacities.

In the process of true co-production of knowledge with circumpolar Indigenous Peoples, researchers must be prepared to work on communities' timelines to devote substantial time and resources to establishing trust between researchers and communities of all backgrounds; co-develop goals for research based on communities' priorities; dedication of funding to build and strengthen communities' capacities for research; honour an iterative, non-linear research process of development, execution, and communication; establish norms for communication and sharing of information; and upholding the sovereignty of Indigenous knowledge, lands, waters, and data [148]. Very often, the norm in pandemic studies is to do reactive research quickly in response to acute outbreaks. Without a doubt, this is important work that can assess the severity of the outbreak at any given time, make predictions, and advise policy. However, the speed required for reactive epidemiological and public health work may not align with Indigenous communities' timelines or capacities for research yet comprehensive understandings of infectious diseases, their determinants, and their impacts are necessary for small, rural communities.

Transdisciplinary social sciences in pandemic studies can strike a fine balance between human- and community-centred research, historical and ecological contexts, and community/researcher relationships to learn about ultimate determinants of pandemic outbreaks. Embracing research questions that address *ultimate* determinants rather than *proximate* determinants of infectious disease outbreaks and impacts may foster slower approaches to research but can effectively address community priorities for preparedness, which may include the development of emergency protocols long before they are needed.

Holistic health

Health is a notoriously difficult concept to define, not the least of which because there are many interconnected determinants of health that are too often parsed individually rather than in a holistic manner. The concept of "One Health" attempts to mitigate this issue by removing the notion that humans are apart from the environment in which we live – an environment that we change, and which changes us – to emphasise that the health of humans, animals, and environment is interconnected and dependent on one another [151]. In the context of pandemics, researchers must include the role of pathogens, as well as the sociocultural and demographic dynamics that contribute to their transmission and propagation, in this holistic framework.

Social scientists can ask and pursue research questions that can contribute to a comprehensive understanding of how humans, pathogens, animals, and environment interact in pandemic studies. From a transdisciplinary perspective, research can be pursued with purposeful engagement with communities and other researchers from disparate but complementary methodologies with non-overlapping weaknesses. Social sciences that include deep understandings of human behaviour, interspecies interactions, and human-environment interactions are well poised to contribute to One Health approaches and knowledge. Anthropology, sociology, and political science, among others, are skilled in community-centred approaches to developing health concepts, or those concepts risk becoming anthropocentric and/or ethnocentric [152].

Further, One Health approaches have been pursued in fields like communications, digital media studies, and psychology, which have become increasingly important as most information is now spread digitally (and quickly) [153].

Transdisciplinary One Health research in the Circumpolar North can approach pandemic-related questions specific to the region and its major ongoing challenges. First and foremost, while integrative thinking about the health of humans and animals is not new, as an academic concept, One Health is relatively young; the term "one medicine", the precursor to One Health, was coined in the 20th century [154–156]. However, "one medicine" and One Health are historically based squarely within Western scientific concepts, which minimises the overlaps between the integrative and holistic promises of One Health and Indigenous knowledges through Traditional Ecological Knowledge [157]. As such, effective One Health approaches in the Circumpolar North must recognise that Indigenous People's knowledge of the integrative health of humans, animals, and environment has been passed down for time immemorial and can fill important gaps in Western scientists' methodologies and interpretations.

As this pertains to pandemics, researchers may pursue projects that ask: *What is the relationship between anthropogenic climate change and shifts in baseline health in northern communities?* Further, *how might these shifts in baseline health impact future pandemic experiences?* The Arctic has warmed four times faster than the rest of the planet in the last 40 years, resulting in changes to terrestrial and marine environments that affect their respective animals' migrations, reproduction cycles, and population sizes [158]; permafrost thaw and coast erosion, resulting in potential biohazards of emerging and re-emerging pathogens from previously frozen ground and previously subterranean burials [137,159]; and threats to housing integrity [141]. These ecological consequences can have direct impacts on human food, water, and housing security, which have a strong bearing on physical, mental, and community health. Importantly, western concepts of health do not often include mental and community dimensions, which is the norm for Indigenous conceptions of wellness.

In the case of future emerging diseases with pandemic potential, it is difficult to trace what kinds of pathogens the diseases they cause are most likely. However, in addressing the second broad question posed above, researchers may choose to take a holistic approach to characterising these possibilities in the Circumpolar North. This is important because zoonotic diseases account for half of all known human pathogens [132] and nearly three-quarters of emerging and re-emerging diseases in modernity [160]. Many of the acute infectious crowd diseases through history, many of which have caused multiple pandemics (e.g. smallpox, measles, and influenza) have zoonotic origins [161]. Therefore, it is essential to understand how the relationship between humans and environment either elevates or reduces the risk of zoonotic transmission.

Additionally, the concern around emerging infectious diseases in any ecological setting is not limited to zoonotic transmission or the re-emergence of formerly epidemic infections. A complicating issue is the fact that there are layers of socioeconomic and sociopolitical contexts that can facilitate different pathways for emergent and re-emergent pathogens and the diseases they cause [162]. This foundational understanding of health inequalities helps contextualise, predict, and hopefully even mitigate unequal outcomes during acute epidemic and pandemic events. Transdisciplinary social science research, with the integration of Indigenous knowledges, are key to identifying what those heterogeneous risks are. Practices informed by holistic Indigenous knowledge are highly effective in Indigenous communities, and the communities themselves are best positioned to determine which practices are implemented [163–165].

Reflection on historical pandemics

It is inherently valuable to learn new information about historical events and to clearly define the lessons learned to either respond to or prepare for similar occurrences in the present day and future. When the COVID-19 pandemic began, there was no dearth of references back to other major historical pandemic events, most commonly the 1918 influenza pandemic. While we now know that the comparison of the 1918 influenza pandemic to COVID-19 is not so simple (e.g. the H1N1 influenza A virus and SARS-CoV-2 virus are different, and they motivate different disease processes, symptoms, and consequences), it is still useful to reflect on the contexts, determinants, and consequences of the century-old pandemic for lessons applicable to the current moment. Pandemics are a feature of modern humanity, and from our evolutionary histories to our politics, humans help create pandemics [166]. This fundamental truth helps link experiences across time, and the social sciences provide critical approaches to understanding those experiences with a clear eye for the role of human nature and behaviour.

One of the primary gaps in the recent literature regarding reflections on the 1918 influenza pandemic,

however, is that there have been little more than statements that reflection is necessary. There have been many useful comparisons between the 1918 influenza and COVID-19 pandemics, primarily in the alignment of the similarities and differences from pathological, epidemiological, and social perspectives [167–169]. Much public health actions in the early days of COVID-19 were very similar to those enacted in 1918, such as public lockdowns, social distancing, emphasis on hygiene, and self-isolation. All this information is highly valuable to elevate the importance of non-pharmaceutical interventions as a first-line public health action during a novel infectious disease outbreak. This information is general, but it provides a springboard of opportunity for researchers to investigate long-term pandemic impacts in specific contexts – such as on the community or regional level – that can contribute useful pandemic knowledge to the field *and* provide foundational information for the communities of study.

Therefore, we pose two large questions that social science pandemic research in the Circumpolar North may parse to more deeply engage with how past populations in the region experienced historical pandemics and what those lessons mean. Here, we used the 1918 influenza pandemic as the primary historical pandemic of interest for these examples. First, *what permanent changes did historical pandemics bring that will continue to impact lives?* In general, the literature surrounding the long-term consequences of the 1918 influenza pandemic is sparse and primarily considers experiences related to *mortality* rather than lived experiences [170–173]. However, many more people will survive a pandemic than they will not, and after a pandemic as devastating as the 1918 influenza pandemic, which could have resulted in up to 50–100 million deaths [174], the surviving population will live in a post-pandemic reality that is different from what it was a few years prior.

In the context of the Circumpolar North, there is currently no published research describing the long-term impacts of the 1918 influenza pandemic. Answering questions related to permanent consequences of the 1918 influenza pandemic requires deep engagement with the historical knowledges of people Indigenous to the region, which includes two spaces that suffered some of the highest mortality in the world: the Seward Peninsula region in Alaska and central Labrador [31,43]. However, epidemiological research with a broad temporal perspective identified that although there were distinct and substantial inequalities between severe 1918 influenza pandemic outcomes in Indigenous Peoples compared to settler populations in the same regions almost ubiquitously worldwide, this has not been universally true for COVID-19 [175]. Specific lessons learned should be rooted in historical memory and should be informed by sociocultural and ecological contexts. Additionally, lessons learned and *implementation* of those lessons should be led by the communities to which those lessons apply. Much more work is necessary to pursue specific lessons to inform tailored and actionable pandemic preparedness plans.

Another broad question we may ask is as follows: *are the people of the Circumpolar North prepared for pandemics in general, including those caused by pathogens that are not airborne and may spread in other ways?* It is important to develop effective preparedness plans rather than rely on disaster responses that require rapid catchup to the acute infectious threat, in the case of epidemics and pandemics [176]. Even though the public health response to COVID-19 was not totally pre-planned, the agency of Alaska Native Tribes' distribution of COVID-19 vaccines in late 2020 and early 2021 were key to Alaska becoming the most vaccinated state in the US early in the nation-wide vaccine roll-out [177]. Similarly, in 2021 the Manitoba Inuit Association was able to break through and develop Inuit-centred programmes and increase visibility of Inuit communities' needs [178]. Greenland's early and strict isolation measures, aided by being an island nation, were successful in greatly reducing the impact of the COVID-19 pandemic in its primarily Inuit communities [179]. Therefore, the last few years have shown that when Indigenous Circumpolar North communities have agency over protective actions, there has been measurable success. Indigenous-led, strength-based research and preparedness will be most effective moving forward to prepare pathogens with variable modes of transmission.

Conclusions

Throughout the discussions of this article, we have highlighted a few areas that have been explored through pandemic research from social science perspectives that were specific to Alaska, including risk perception, communications, housing and food security, climate change, and new and re-emerging pathogens. Additionally, we have addressed three topics relevant to engaging in transdisciplinary social science research in the region from a more theoretical perspective, including the importance of equity broadly in Circumpolar North research, elevating Indigenous communities' priorities and capacities, holistic approaches to understanding health, and reflecting on historical pandemics for lessons and

actionable applications of that knowledge. We acknowledge that these topics do not encompass the whole of research priorities or theoretical frameworks that are of high importance in the region, and we again emphasise and acknowledge that the bulk of the specific research discussed in this article is related to Alaska. However, these were topics of discussion that rose to the surface most often during the NSF-funded conference from which this paper is drawn, and we expand the theoretical discussion to include potential pursuit of questions in the Circumpolar North broadly. As such, our intention is for this article to be a summary of ideas that could be a springboard for sustainable future interdisciplinary social science pandemic research in the region.

Pandemics are acute stressors that require dedicated time, research, and resources for which to prepare. A deep understanding of the determinants and nature of pandemics in rural Circumpolar North communities and community networks can provide opportunities to move from a crisis-by-crisis model that tends to depend on emergency responses as new threats emerge. Instead, the reality could be an emphasis on the existing strengths, knowledge, and capacities of communities to put emergency preparations and responses in place long before they are needed. Much of the health-related research in the Circumpolar North has been more focused on perceived inherent vulnerabilities rather than on existing strengths. This has been previously criticised by mental health scholars as an indictment on non-Indigenous researchers who focus too often on what makes people sick rather than what makes them healthy [180]. Instead, transdisciplinary social science research that prioritises equitable, co-productive, community-based research at every level of the knowledge creation process can, with the leadership of sovereign Indigenous Peoples in the Circumpolar North, establish the standard for strength-based pandemic research. Indigenous cultural, knowledge, data, and health care sovereignty are essential features of pandemic resilience, and Indigenous-led research is an effective way to understand and address short- and long-term pandemic-related challenges in the Circumpolar North.

Acknowledgments

This research, and the conference that brought the authors together, was funded by the NSF OPP grant #2246268. We would also like to thank the Sitka Tribe for providing space in the Sheet'ka Kwaan Naa Kahidi Tribal Community House for this meeting.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The work was supported by the Office of Polar Programs [2246368].

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