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Vulnerability to unintentional injuries associated with land-use activities and search and rescue in Nunavut, Canada

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Abstract

Injury is the leading cause of death for Canadians aged 1 to 44, occurring disproportionately across regions and communities. In the Inuit territory of Nunavut, for instance, unintentional injury rates are over three times the Canadian average. In this paper we develop a framework for assessing vulnerability to injury and use it to identify and characterize the determinants of injuries on the land in Nunavut. We specifically examine unintentional injuries on the land (outside of hamlets) because of the importance of land based activates to Inuit culture, health, and well-being. Semi-structured interviews (n=45) were conducted in three communities that have varying rates of search and rescue (SAR), complimented with an analysis of SAR case data for the territory. We found that risk of land-based injuries is affected by socioeconomic status, Inuit traditional knowledge, community organizations, and territorial and national policies. Notably, by moving beyond common conceptualizations of unintentional injury, we are able to better assess root causes of unintentional injury and outline paths for prevention.

1. Introduction

Injuries are the leading cause of death for Americans and Canadians age 1 to 44 (Centers for Disease Control and Prevention, 2011; Parachute, 2015). Injuries occur disproportionately among populations, with certain demographics and regions experiencing higher rates of life loss and associated disability (Viner et al., 2012). Socioeconomic status, educational attainment, age, location, and gender have been demonstrated to influence an individual's exposure to hazards and sensitivity to injuries from a variety of risks including motor vehicle crashes (MVC) (Cubbin, LeClere, & Smith, 2000), pedestrian injuries (Hippisley-Cox et al., 2002), fires and burns (Duncanson, Woodward, & Reid, 2002), and drowning (Towner, 2005). Disparities have been demonstrated at an individual (Hippisley-Cox et al., 2002), neighborhood (Cubbin et al., 2000; Duncanson et al., 2002), and regional scale (Viner et al., 2012). Such disparities of unintentional injury are widely documented within public health and injury literature; however, common frameworks used in unintentional injury research do not capture the extent to which both social and environmental context may influence risk of unintentional injury (Towner, 2005).

In this paper we develop a framework for assessing vulnerability to unintentional injury, drawing from both injury and natural hazard vulnerability literature bodies. We apply the framework to identify and characterize how social and physical environments are influencing risk of unintentional injury among harvesters and travelers in the territory of Nunavut, Canada. We focus on search and rescues (SAR) and the safety of Inuit harvesters and travelers because of the health and cultural importance to Inuit of harvesting animals, berries, and eggs, traveling to visit cabins or other hamlets, and accessing culturally significant sites. We collectively refer to this out of hamlet travel as 'land-use' activities or being on the land. In addition to the

importance of being on the land, there is a high prevalence and cost associated with land-use injuries. Proxied through (SAR), unintentional injury and near-injury on the land cost approximately $850,000 annually and in 2015 represented over 450 individuals requiring assistance (Nunavut Emergency Management, 2015). We use SAR as a proxy for land injuries and near-injuries (when injury would occur without rescue) in this study because they are often synonymous to land-users.

2. Methodology

2.1 Vulnerability to Injury Framework

We draw from both the natural hazard vulnerability and injury scholarships to conceptualize determinants of risk to unintentional injury on the land in the Arctic. The concept of vulnerability has a long history in the natural hazards field, rooted in political and human ecology, which in the 1970s began to ask who, how, and why a population may be influenced by external perturbations, placing emphasis on the social construction of 'natural' hazards (Adger, 2006; Hewitt, 1983; Turner et al., 2003). Beginning in the 1990s, vulnerability concepts were increasingly applied in climate change research to understand how socio-ecological conditions affect the way climate change is experienced and responded to (Smit & Wandel, 2006; Turner et al., 2003). Two distinct approaches of assessing vulnerability are evident in the literature: risk hazard or outcome-based approaches, and pressure and release or contextual vulnerability (O'Brien, Eriksen, Nygaard, & Schjolden, 2007; Smit & Wandel, 2006). Although each approach fundamentally denotes the susceptibility of a population to being 'wounded',

associated research questions and perspectives differ (Adger, 2006; O'Brien et al., 2007; Turner et al., 2003). Outcome-based vulnerability assessments focus primarily on biophysical exposure and assess vulnerabilities directly related to these exposures, while contextual vulnerability begins with human systems and examines what makes populations vulnerable to external conditions in the context of multiple stresses and adaptive capacity (O'Brien et al., 2007). We also note that in recent years some have critiqued to use of vulnerability concepts in Arctic research, where it has been argued that labeling a population as 'vulnerable' has been said to have degenerative intonations and perpetuate colonial legacies and downplay the role of historical non-climatic factors (Cameron, 2012; Haalboom & Natcher, 2012). Others have responded to such critiques, noting the centrality of non-climatic factors in vulnerability analyses, with much Arctic focused work rooted in political ecology tradition, and emphasis on adaptive capacity (Ford et al., 2013; Ribot, 2014). Further, in a medical context 'vulnerable' is widely used to denoting a population's sucesptability to a disease (Frohlich & Potvin, 2008).

Unintentional injury science approaches have also evolved over the past century. Throughout the 19th and much of the 20th century, injury was largely examined through a behavioral lens, whereby 'accident proneness' was viewed to cause injury (Haddon Jr, 1968). During this period, less interest was placed on the physical process of injury (corporeal impact and physiological harm), particularly the social environment was de-emphasized (Froggatt & Smiley, 1964; Newbold, 1926). In the 1970s, work by Haddon shifted the focus of injury research to exposure and transfer of energy, which continues to be the dominant paradigm in the injury field (Haddon Jr, 1972; Langley & Brenner, 2004). . This approach is consistent with outcome based

vulnerability, whereby injury research tends to begin by assessing energy potential and asking how it could be transferred to an individual and inflict harm, as opposed to how context promotes sensitivity to risks (Haddon Jr, 1968).

Unintentional injury frameworks often use a static time-scale because the physiological process of injury is bound in time by medical definition (Langley & Brenner, 2004). However, while injuries may be physiologically acute, extended social and physical contexts influence one's risk. That is, an injury that occurs over seconds, such as a MVC, may be influenced by social processes throughout someone's life (Towner, 2005). By overlooking the dynamics of socio-ecological systems, the capacity of people to adapt to environmental perturbations and systemic oppressions are unobserved. In addition to temporal barriers, the Haddon Matrix and dominant injury conceptualizations do not promote an examination of multiscale dynamics that influence vulnerability to injury (Gibson, Ostrom, & Ahn, 2000).

Our proposed vulnerability to injury framework expands the temporal and spatial horizon beyond that of the Haddon Matrix to evaluate risk of injury (Figure 1). The framework begins by assessing a single event, or current risk state, (e.g. what variables directly lead to a MVC). Informed by Haddon, this single state is influenced by both physical and social context (Haddon Jr, 1972). As in the Haddon Matrix, we conceptualize the environmental inputs as impacting exposure (sufficient energy for injury) and sensitivity (available paths for energy transfer to create harm). Grounded by natural hazards vulnerability literature, we also conceptualize the environment as influencing capacity to adapt (change behavior after an injury) or near-injury (a

point where physiological harm almost happened, a 'close call'). We define adaptation as a "process, action or outcome in a system in order for the system to better cope with, manage or adjust to changing condition, stress, hazard, [or] risk" (Smit & Wandel, 2006). Adaptation is seen as being dependent on: 1) ability to cope with an injury and recover; 2) recognition of the injury process that occurred; 3) ability to alter the exposure or sensitivity of an agent to a host. Adaptation provides a bridge between a single period and the dynamics of an individual or population over time. That is, throughout an individual's life, she/he has multiple injuries and near-injuries with each incident being a point that may prompt adaptation or maladaptation. Consistent with natural hazards literature, we focus on risk states of individuals, communities, and regions. By assessing vulnerability to injury at various scales, focus is not only placed on individual behaviors, but the institutional policies, entitlements that influence vulnerability to injury.

2.2 Study Region and Community Case Studies

2.2.1 The territory of Nunavut

The territory of Nunavut has a population of approximately 32,000 (84% Inuit), who live in 25 remote communities (Statistics Canada, 2013). At approximately 2 million km^2, Nunavut is the northernmost and largest territory in Canada. Inuit across Nunavut engage in harvesting activities including hunting, fishing, trapping, and berry picking as a source of food and income, with strong links to food security and cultural identify (Wenzel, 2013). These activities involve

extensive travel on terrestrial and ice-based environments by snowmobile, boat, and all-terrain vehicle (ATV), with no permanent roads connecting communities.

While Inuit continue to hunt and fish as a source of food, economy, and cultural identity, traditions have changed over the past half century (Wenzel, 2013). The settlement process, residential schooling, and healthcare contributed to a shift from a semi-nomadic to sedentary life in fixed communities (Aporta, 2011). Use of dogsleds has diminished, replaced by snowmobiles and All-Terrain-Vehicles (ATVs), allowing land-users to travel farther faster but also increasing the cost of hunting. International and national policies and environmental activism have affected the cash economy from harvesting, and government-based and administrative jobs, and mining have brought in new livelihood options for some (Wenzel, 2013). Social changes have been compounded by climate change impacts, with temperatures over land rising by 1.9^{o}C in the past 30 years, making Nunavut a global hotspot of climate change (Ford, McDowell, & Pearce, 2015). Weather has become less predictable, and in the coming century, the duration of ice cover is expected to further decrease by a month or more (Stroeve et al., 2012). Changes in climate already documented have altered hazards that land-users are exposed to across northern Canada (Durkalec, Furgal, Skinner, & Sheldon, 2015; Ford et al., 2013).

Although literature on unintentional injury on the land is limited, broader social and environmental determinants of Inuit health have been widely researched (Ford, Berrang-Ford, King, & Furgal, 2010; Furgal et al., 2008; Young, 2003). Social determinants of health are

particularly important in an indigenous context given vast health inequity (Adelson, 2005; Carson, Dunbar, Chenhall, & Bailie, 2007; Giles, Cleator, McGuire-Adams, & Darroch, 2014; Marmot, 2011; Möller, Falster, Ivers, & Jorm, 2015). Key social determinants that pertain to unintentional injury on the land include, systems of education, policies restricting generation of income through harvesting, transition of Inuit Qaujimajatuqangit (IQ) or Inuit traditional knowledge, and the changing economy of land-use (Aporta, 2011; Condon, Collings, & Wenzel, 1995; Kendall, 2001; Wenzel, 2009). While it is beyond the scope of this paper to broadly review social mechanisms of health among Inuit, the impacts of colonial and post-colonial structures and policies are well documented elsewhere, and have informed our research approach (Adelson, 2005; Ramsden, 2007; Richmond & Ross, 2009).

2.2.2 Community case studies

We applied the vulnerability to injury framework to land injuries in case studies from three Nunavut communities: Arviat, Pangnirtung, and Whale Cove (Figure 2). Communities were selected based on the incidence rates of SAR during 2013 and 2014, capturing communities with a low number of searches per capita (Arviat: 8.8/1000), medium number (Pangnirtung: 14.9/1000), and high number (Whale Cove: 73.4/1000). In contrasting data among select communities we are able to understand distal causes of land-use injury.

2.3. Methods

2.3.1 Semi-structured interviews

We conducted 45 semi-structured interviews with officials (n=21), active harvesters (n=17), and elders (n=7) across the communities to identify and characterize exposure and sensitivities to land risks as well as adaptive responses. Officials interviewed included: Hamlet Senior Administrative Officers, Royal Canadian Mounted Police (RCMP) Officers, Community Health Representatives, nurses, SAR committee members, Canadian Rangers, Hamlet Wildlife Officers, and Parks Canada employees. We selected active harvesters and land-users by asking Hunters and Trappers Organizations for names and cross-validating the names with SAR committee members. Elders were identified by hamlet officials and prominent land-users. Participants included 9 females and 36 men. 16 interviews were conducted in Arviat, 14 in Pangnirtung, and 15 in Whale Cove. Interviews took place in both homes and offices after written consent was obtained. Sample size was determined by saturation. Interviews were conducted in English and Inuktitut with interpretation provided by a locally hired research assistant. All interviews were audio recorded. The work was conducted under Nunavut Research Institute License.

Interview themes were outlined using the vulnerability to injury framework. While interviews were conversational and semi-structured, an interview guide was used to ensure a level of consistency and replicability across interviews and communities. However, specific questions were not always asked, allowing the participant to guide the conversation. Interviews often began by asking respondents about their history in the community or region, their social background, and how they interact with the land. Exposure to hazards was assessed through discussions about temporal patterns of harvesting, identification of hazard changes over time, and through stories about hazard locations, and weather and ice conditions. Sensitivity themed

questions aimed to gauge how safe respondents felt while on the land, what land-user do to be safer, how equipment has changed, and how the respondent decides when to go out on the land. Questions about adaptive capacity centered around the dynamics and behaviors of respondents and their community to manage risks.

2.3.2. SAR data

SAR case data were used to examine regional trends and community-level variation, helping to select the case study communities, describe the nature of SAR incidents affecting the communities, and examine trends over time. SAR data were obtained for 2014 and 2013 from the National Search and Rescue Secretariat (NSS) (Clark et al., 2016). Data were not available for years prior to 2013. Incident severity and mechanism of injury were reported in around half of the incidents.

2.2.3. Participant observation

'Observer as participant' type participant observation was conducted by the lead author to gain a deeper understanding of land-use behavior, risks, and build trust in the study communities (Collings, 2009; Laidler et al., 2009). Observations generally began by interacting with harvesters near community docks or public spaces with occasional dialogue. After initial trust was developed, interactions transitioned to participation (e.g. helping repair machines). The lead author also participated in land trips and harvesting activities (Collings, 2009). Subjects were aware of the research objectives throughout the observation process, clarifying questions related to the research were asked after trust was developed (Collings, 2009). During activities,

we observed trip preparation practices, levels of risk aversion, equipment conditions, IQ, harvesting patterns, and the geography of local hazards. A cumulative three months was spent in the study communities during the period from May to November 2015. Observation was conducted in numerous seasons to capture various types of land-use. The study included six day trips. Data were recorded as field notes, specifying what was observed, conversations, and land-use behavior. Notes were categorized into the themes of exposure, sensitivity, and adaptation informed interview analysis (Collings, 2009).

2.2.4 Analysis

All interviews were first transcribed. Using thematic content analysis, we used selective coding for themes of exposure, sensitivity, and adaptive capacity, based on the vulnerability to injury framework (Esterberg, 2002). Topics within and between conversations were compared to inductively assess data and establish sub-themes (Corbin & Strauss, 2014). In our constant comparative analysis, we applied the following iterative steps, building on Cunsolo Willox, (2013): 1) Data within each category were reviewed to draw out primary themes and geographic distinctions. 2) Interviews were re-listened to, noting conversational tone and nuances. 3) Data themes were mapped out within each category and links drawn. 4) Primary results were discussed with regional SAR experts and community members for feedback. Individual level transcripts and recordings were not released to protect subject confidentiality, although initial findings at a community scale were shared with participants and hamlets. Initial data analysis was done by the lead author and themes reviewed by co-authors. Results are presented based on these themes.

Descriptive statistics were conducted with SAR data provided by the NSS. Events during 2013 and 2014 were aggregated by community to examine rates of SAR. We used population data from the 2011 census estimates (Statistics Canada, 2013). Reported cause and severity were summarized at a territorial level for 2013 and 2014, age is not recorded by the NSS. Further, available community level unintentional injury data there is very limited and provided minimal information (Supplementary Materials).

3. Results

Results are presented based on the vulnerability to injury framework. As there were more similarities among communities than differences, distinctions are highlighted in each category.

3.1 Exposure

Across Nunavut, SAR case data indicate that SAR incidents in 2013 and 2014 were largely attributed to mechanical breakdown and running out of fuel (53% of reported cases), with most SAR having a positive outcome (locating and rescuing parties before serious injury or death). 11% of recorded incidents in 2013 and 2014 were deemed “life in imminent danger.” Quantitative analysis of SAR data could not be conducted at a community level due to a small sample size.

Based on interviews, community variation in exposure was largely due to differences of land-use activities (Table 1). While there is year around risk, seasonality affects both type of activity (boating, floe edge travel, ATV travel inland) and the hazards present. Participants discussed the

floe edge as being a very dangerous place to be, particularly in the spring when ice conditions are very dynamic, although, floe edge risk often correlates with good hunting conditions (e.g. seal use cracks for breathing). Participants also described any travel in mid-winter as being especially dangerous. However, travel during this period of the year is generally less common. Hazards in the fall and spring related to exposed rocks that snowmobiles can hit and temperatures that lead to machines overheating were also described, although these hazards were not described to be as life threatening.

Exposure to hazards at an individual level varies widely. While land-use is common in all of the study communities, there are sub-populations that do not go out on the land frequently. Participants in Whale Cove and Arviat reflected that youth go out on the land less frequently than previous generations. Additionally, the gendered roles of harvesting are still strong in the study communities and while women do travel and harvest, it was reported to be less common among women.

> "The most dangerous time of the year to go [out], where the margin of error is very low, is the dead of winter. It is cold... There is very little margin for error and that is when your life is on the line if you are not prepared and you are not thinking straight." (Arviat – Harvester)

3.2. Sensitivity

In the past decade, SAR rates have more than doubled across Nunavut. In 2015, there were 251 incidents, compare to 111 in 2006. Key themes from the interviews identify a number of factors underpinning sensitivity to hazards.

3.2.1. Knowledge transition

Participants expressed great concern that younger generations do not have the knowledge necessary to be safe on the land. Critical skills and IQ mentioned include land navigation, understanding weather patterns, ability to build a snow shelter, capacity to fix machines, and self-awareness to make good decisions and not panic. Without experience building snow shelters, surviving nights on the land, or fixing machines, individuals described a non-critical incident like a snowmobile breakdown as potentially leading to severe injury from cold exposure or death. Individuals having less experience on the land also were described as not being able to think as clearly and make good decisions in an emergency.

> “When I was young and trapping… the longest I was away from home was 21 days. I was very young, but I [knew] how to survive, I guess, so I didn’t freeze to death... But today, between here [Whale Cove] and Rankin people go missing. White out. Lose the trail... I learned to travel with no compass, no nothing. If you grow up that way, like the snowdrifts, the wind, the grass, the rocks… there’s a mark there, telling you which is south and east and whatever. But the young people, they don’t know the stars." (Whale Cove – Elder)

Many individuals interviewed between the ages of 40 and 60 have been active on the land throughout their lives, but grew up in hamlets. These individuals described learning about the land as a lifelong process, continuing to learn each time they go out. Participants also emphasized that to learn land skills one had to be out on the land, *Pilimmaksarniq*. Loss of IQ was described most in Arviat and in Whale Cove, while individuals in Pangnirtung described youth as more actively participating in activities on the land with their parents and elders.

3.2.2. Economic stress

Costs associated with hunting increase susceptibility of some land-users to injury. New snowmobiles may cost upwards of $20,000 and often do not last more than four years. Similarly, new boats and ATVs cost from $10,000 to $30,000, while the mean household employment income of the three communities is $16,837 (Supplementary Materials). This cost of new equipment and spare parts can be beyond the price range of many individuals. Subsequently, it is common to 'jerry-rig' machines, which may involve welding a broken swing arm or plugging flat tires as a long-term fix. This increases the susceptibility of land-users to becoming stuck on the land and having prolonged exposure to cold temperatures.

Individuals described the mixed wage and subsistence economy in the North as having introduced an additional dichotomy, whereby money earners who can most afford to hunt have the least amount of flexibility due to work schedules. The mixed economy is seen as displacing land-use to the weekend, particularly among those with full- or part-time jobs. Some participants described that even if the weather was better (e.g. less chance of a storm) during

the work week, inflexible schedules would push them to go out on the weekend instead. Based on time restrictions, land-users can be more likely to go out right before a predicted storm, trying to beat it, or be in a rush to return before work or school commitments.

> "It is hard today. If you have machines only you need the gas and equipment to go on the land, but you need the money to take it. It is hard to get all the gas and equipment without working. So you have to work and hunt at the same time. Weekends are very short… so you have to rush. I used to have a permanent job and it was a stress for me. My mind wanted to go out when it was good weather, calm weather, and I was having to work." (Arviat – Harvester)

Individuals in Whale Cove described economic constraints most, while they were discussed less in Pangnirtung and Arviat. The size of Whale Cove and subsequently low numbers of government employment, and lower rates of tourism and economic inflow were described as contributing factors.

3.2.3. Equipment

Elders describes faster speeds of travel, due to equipment changes, as increasing the risk of serious injury from blunt trauma by machine crashes and risk of becoming stranded farther away from hamlets and emergency medical care. Participants in Arviat and Whale Cove described the transition over the past decade from two-stroke snowmobile engines to computerized four-stroke machines has further increased sensitivity of land travelers; while

many land-users can fix two-strokes machines, newer snowmobiles are more difficult to fix while out on the land and often do not have pull starts. Newer boats seen as more resilient to capsizing or damage from hitting rocks, however the aluminum surface was reported to be riskier for slipping on.

3.2.4. Culture of Preparation

Elders and frequent land-users perceive being prepared as having warm clothing, caribou skins, a Coleman stove with extra fuel, extra gasoline, tools to fix machines or sleds, extra bullets, food, and SPOT devices (satellite locators), CB and VHF radios, or a satellite phone. Individuals also discussed the importance of informing family members where they are going and when they will return, and if possible traveling with other people. Although definitions of being prepared were similar among most individuals, actions do not always reflect knowledge. The cost of supplies is one reason that some individuals do not adequately prepare. This was noted most in Whale Cove, a community where there mean income is lower (Supplementary Materials). Additionally, younger land-users across the region may not have access to all the necessary gear but will have access to a snow machine or ATV through sharing networks.

We observed elements of risk compensation, particularly among youth. Younger land-users that have access to GPS or SPOT devices may become over-confident of their land skills, going farther from their hamlet in poor weather without adequately preparing or having enough land knowledge.

"You have to keep up with the system the way I see it... Things are different now and you know that if a storm comes and you have to build an igloo you will have to look for snow, don't just sit there. Some people don't know how to build an iglu anymore so they just sit by their [snowmobile or sled] and that is where you'll find them frozen sitting up." (Whale Cove – Harvester)

3.2.5. SAR Operations

SAR operations are initiated most often when land-users experiences a mechanical breakdown, run out of fuel, becomes stuck due to mud or ice, or experience a change in environmental conditions that preclude return. The SAR system across Nunavut is largely dependent on volunteers. Most communities have volunteer committees that organize a search, rescuing the party, and coordinating with RCMP, Nunavut Protection Services (NPS), and worried families. The level of support that SAR committees receive from community members and the hamlet varies widely across the territory. For example, the community of Whale Cove is smaller and has high rates of SAR (73.4/1000). Many active land-users in the community have at some point been involved as SAR volunteers, with attrition from burnout and time demands. Arviat on the other hand has a larger population and lower rate of SAR, community resources have not been depleted and the community more actively focuses on prevention. Most searches across the territory are successful by ground; however, air support is occasionally used, generally using a Canadian Forces C-130 and Civil Air Search and Rescue Association support.

It is challenging for communities to lead SAR operations with current levels of support from the government bodies. Although NPS reimburses volunteers for gasoline and oil, some individuals do not want to put wear on their machines, or simply do not have a functioning machine. In Whale Cove, the SAR committee at times has to wait twelve or more hours before finding a machine to use for a search. Additional stress can be placed on the volunteers in small communities as the lost person is often a friend or family member.

> "It is really tough right now. All the members here, there are not so many of us and most of us we do not have equipment of our own. We tend to borrow it from other people and they sometimes don't like to lend it out." (Whale Cove – SAR Member)

The combination of high stress, emotional weight, and feeling ill-supported contributes to high turnover rates in some communities and subsequently low levels of institutional memory among volunteers. In Whale Cove, first aid and search training had not taken place in one and a half years prior to interviews. Since past training sessions, SAR volunteer membership had turned over with no opportunities for new members to receive training. Very few volunteers in the study communities had any first aid knowledge; however, their knowledge of travel on the land and local geography was very detailed.

3.2.6. Climate Change

Almost all interviewees noted changing climatic conditions. Participants observed increased unpredictability of weather. Ice and snow conditions were described as changing quicker in the

fall and spring. Additionally, in Whale Cove elders described higher velocity winds blowing more snow off inland lakes and causing ice to be thicker.

> "The elders …. say… they can't predict [the weather] anymore, it is changing fast like culture itself. It is not safe anymore like it used to be, in fall and spring it is like later freeze up and earlier thaw sort of thing. During the fall the weather seems like it is a lot more unpredictable." (Arviat – Harvester)

Many participants linked changing weather and ice conditions to climate change. Unpredictable weather and highly dynamic environmental conditions place further importance of preparation on land-users. Participants reported that although the weather is changing, prepared land-users are not affected because they are ready to make a shelter and spend the night, or if necessary call for help.

3.3. Adaptive Capacity

Individuals and communities are actively changing their behavior to address perceived risks and hazards. We observed adaptive capacities in the form of community initiatives (e.g. prevention programs, young hunter programs) and land-user patterns. Not all adaptations are intended to directly improve safety, although many have implications for vulnerability to injury. It was commonly noted that an individual's income level and a community's level of funding influences their capacity to adapt, with most financial constraints to adaptation reported in Whale Cove.

The use of satellite phones, GPS and SPOT devices has increased across the North. For example, in Arviat from May of 2013 to May of 2014, SPOT devices were checked out 131 times. All Hamlets have a limited number of SPOT devices provided by NPS for the public to check out. These devices can allow individuals to call for help, although elders brought up concerns about risk compensation. Without communication devices, searches are only called after a family becomes worried when someone is overdue. CB radios are also commonly used on boats. Where sea travel is common, like in Pangnirtung, land-users relay messages from one to another to overcome transmission restrictions of the CB frequency. These devices are expensive with a SPOT device costing ~$200 with monthly fees, a satellite phone ~$500 plus monthly fees, CB radios ~$100, and VHF ~$150. While communities lend out SPOT devices for free to anyone, all three study communities reported that during busy times of year, all of their devices get checked out. Participants reported in Pangnirtung and Whale Cove that SPOTs have also inaccurately placed lost parties. SAR officials stated that this is due to limited GNSS coverage in far north latitudes.

> "We have the SPOTs available here…. but we don't always have it here due to other people having them. Talking about the satellite phones [they] are very expensive, you can only afford it you're making good income. Your husband or wife is working, they'll have that, but not everyone is the same." (Pangnirtung – SAR Member)

Aluminum boats have become more common in many communities. Aluminum boats were described as much safer than wooden or fabric canoes with the ability to float even if they capsize and are not as susceptible to damage from running into ice or rocks. However, aluminum boats too are significantly more expensive and not everyone can afford to make the investment.

> “They are stronger, aluminum. Bigger motors. They can take you out farther. In an hour or two. But not everybody has them. Not everybody can afford the big aluminum with the big motor on it." (Pangnirtung – Elder)

Adaptation can also be achieved through education, capacity building, and behavioral changes. Arviat has numerous programs to increase safety on the land. The Young Hunters Program, for example, exposes youth to harvesting activities. Youth are taught about land navigation, firearm safety, land safety practices, and local hazards by elders and active hunter in the community. The program addresses key vulnerabilities, reducing the susceptibility of participants, and encouraging them to recognize hazards. Study participants were supportive of the programs as they were seen as an avenue to maintain IQ, cultural identity, and protect youth. Arviat has also taken an active role with the SAR committee to ensure the necessary resources are provided for them to operate effectively. Similarly, Pangnirtung has taken steps to train SAR members and has a Coast Guard Auxiliary Unit.

4. Discussion and Conclusion

Just as social and environmental factors influence chronic and infectious diseases, injuries are influenced by the environment we are born into, live in, and work in. In Nunavut mechanical breakdowns, injuries, and/or becoming stranded on the land happen over seconds and minutes, but the factors that make a person more vulnerable to these risks accumulate over a lifetime and are compounded across generations.

We demonstrate strong interconnected relationships between hunting, socio-economic status, IQ, equipment changes, types of land-use, and safety on the land. We were able to use the vulnerability to injury framework to analyze the impacts of these factors on safety. Socioeconomic status emerged as a root or distal factor to land safety at an individual and community scale, affecting the sensitivity of individuals, influencing the condition of machinery, the amount of gear an individual has, and the level of land-use they can afford.

There was variation among communities based on IQ transitions, and socioeconomic impacts on land safety. Individuals in Whale Cove described economic constraints most, while they were felt less in Pangnirtung and Arviat. Although socioeconomic data at a community in Nunavut is limited and skewed from non-Inuit earnings, mean employment earnings in Whale Cove are approximately $8000 less (40%) than in Pangnirtung and Arviat (Supplementary Materials). Economic resources and government support was also discussed more in Whale Cove in relation to SAR operation resources. Whale Cove is a smaller community with one of the highest rates of SAR in Nunavut. Many active land-users in the community have at some

point been involved as SAR volunteers, with high attrition from burnout and time demands. Arviat on the other hand has much lower rate of SAR and community resources have not been depleted. Arviat and Pangnirtung also had higher institutional capacity and resources for prevention programs and SAR response training. Finally, IQ loss was described most in Arviat and in Whale Cove, while individuals in Pangnirtung described youth as regularly participating in activities on the land with their parents and elders. IQ loss was attributed most in Arviat to the rapid rate of population growth, and in Whale Cove was attributed to a lack of interest among youth in being on the land or financial constraints to land-use. Substance abuse and 'loss of a traditional life' was discussed by various participants in Whale Cove and Arviat as affecting IQ loss. Less variation was observed in relation the impacts of changing equipment, concepts of what it means to be prepared, and the effects of climate change.

Inuit youth live and grow-up in a different environment than they would have in previous generations (Aporta, 2011; Wenzel, 2013). Youth were documented to be particularly vulnerable to injury on the land due to a weakening of environmental knowledge and land skills, decreased participation in hunting and land-use, and increasingly fast equipment, much of which is designed for southern terrains and recreation use. This has been observed in other Nunavut communities (Aporta et al., 2005). Limited agency and economic means also constrains the ability of many young adults to adapt without family or community assistance.

While there is a large focus in the unintentional injury literature on age as a key determinant of risk to injury, although youth tended to use the land less, interviews suggested that experience

and IQ has a stronger relationship to unintentional injury than age related risk taking behavior and safety. Although youth usually do not have as much experience as their parents, some youth go out very frequently and are highly competent. Injury studies also frequently focus on unintentional injury rate disparities by gender (Giles et al., 2014). We were not able to fully examine the role of gender on vulnerability to injury in the study communities. This was largely because we could not account for the wide differences in exposure among male and female land-users. While it is common for women to travel to cabins, go berry picking, and harvest caribou depending on location, travel outside of town is still far more common among men (Dowsley, Gearheard, Johnson, & Inksetter, 2010).

Climate change is seen as a proximal source of sensitivity, although we acknowledge that climate change may influence distal determinants through economic impacts or wildlife impacts. It is uncertain, however, what implications increasing temperatures and thinning sea ice will have for injury. While there may be increased risk of engines overheating, hitting rocks in the spring and fall, getting stuck near inland streams, or increased danger due to changing ice dynamics, it is also possible that the shoulder seasons which are most dangerous now will become shorter and therefore decrease annual hazard exposure.

We were not able to assess all communities in Nunavut, or compare unintentional injury determinants between territories and countries. In other locations or at different scales there may be additional determinants or adaptive capacities. Further, based on available data and the research approach, we were not able to quantify the relationship between various potential

determinants of vulnerability and injury. Although the relationship between SAR and weather has been quantified (Clark et al., 2016), it would be beneficial to quantify how determinants interact and quantify their significance. Other unintentional injuries across the North are also common in the communities, such as drownings, burns, and MVCs, these injuries require similar studies (Do et al., 2013; Giles et al., 2014).

As social determinants of unintentional injury are further researched, targeted prevention efforts must focus on the upstream physical and social determinants of health. Insights gained through this study suggest that prevention should focus on eliminating social barriers to adaptation and factors that enhance sensitivity to hazards. This may include hunter support programs; improving access to SPOT devices, satellite phones, or GPS devices; increased support for SAR operations; and, encouraging IQ and skill transfer from active harvesters and elders to youth as well as opportunities for youth to learn on the land. Given the impact of socioeconomic status, IQ transitions, and adaptive capacity constraints on risk to injury, unintentional injuries on the land are seen to be another example of colonial and post-colonial impacts on Inuit health (Carson et al., 2007; Möller et al., 2015).

Death and disability from injury may be physiologically acute, but occurs within a context altered by social and physical dynamics. Injury has been neglected, with no common means to research or conceptualize how environment influences risk throughout life. Our proposed vulnerability to injury framework provides an approach for injury research that captures both distal and proximal causal mechanism at various scales.

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Tables and Figures

Figure 1. The vulnerability to injury framework.

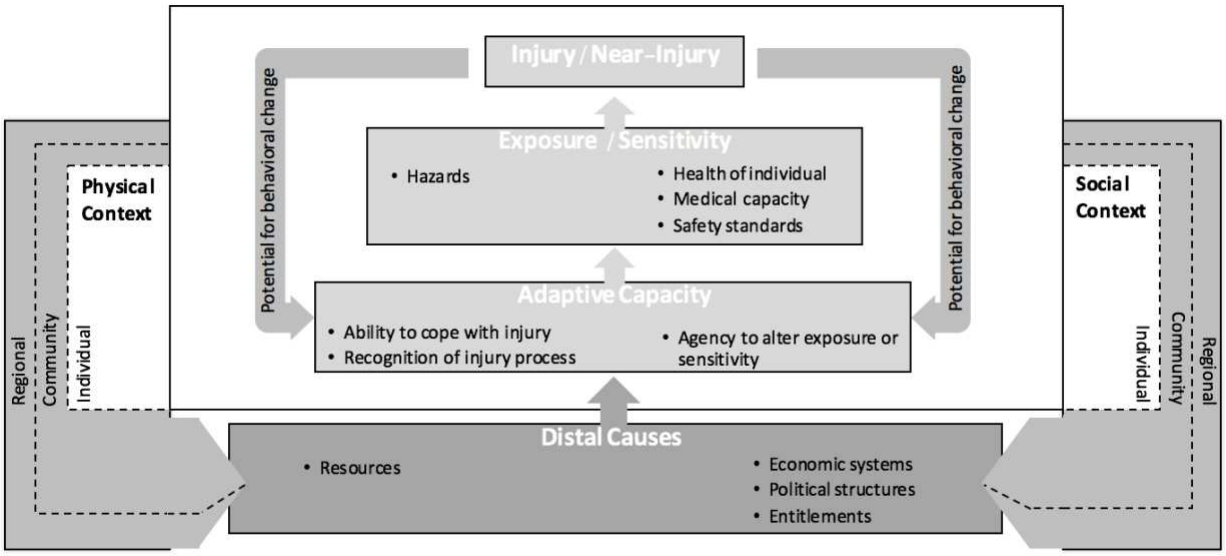
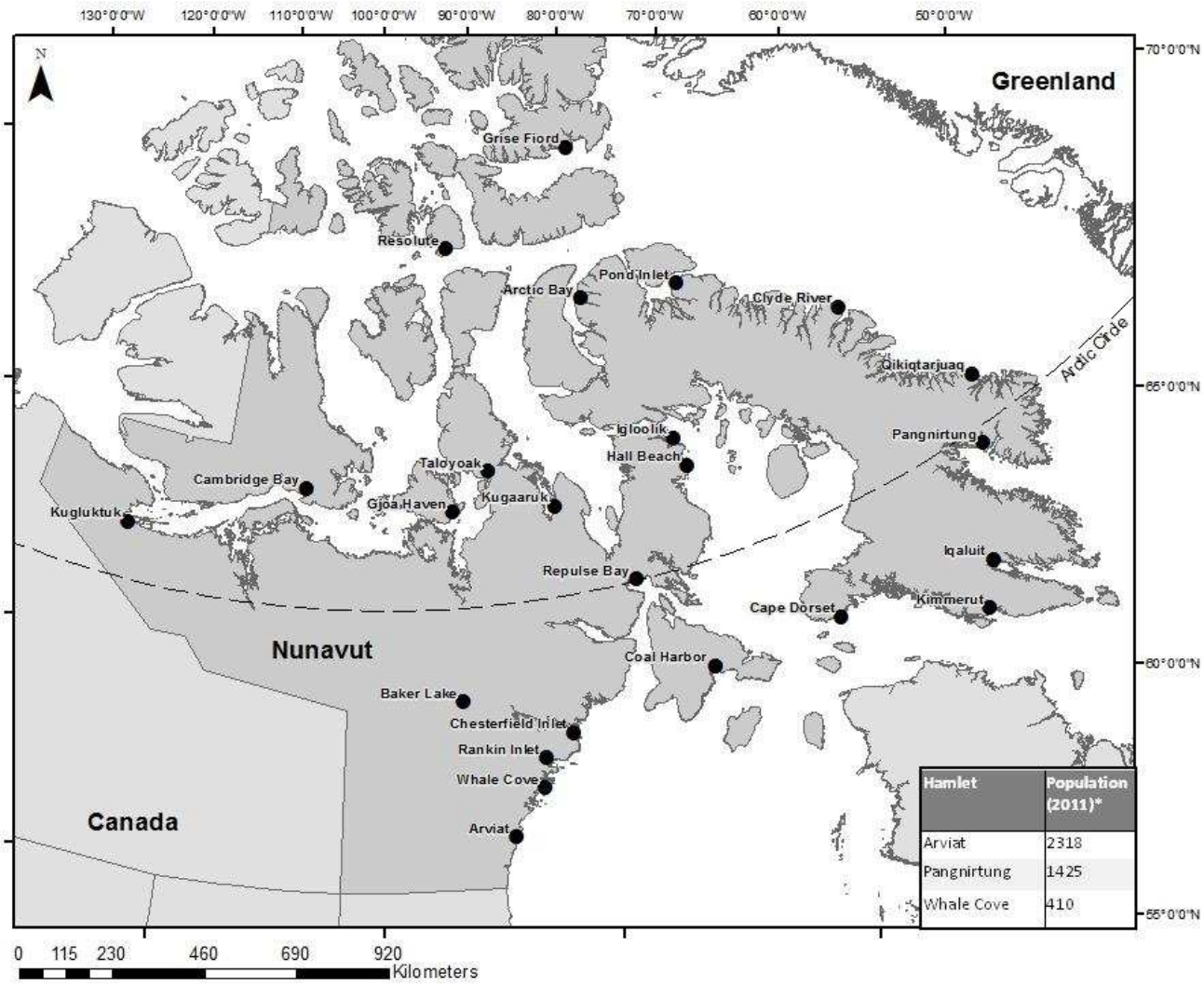


Figure 2 Nunavut, Canada. *Population data from Statistics Canada, 2013



Hamlet	Population (2011)*
Arviat	2318
Pangnirtung	1425
Whale Cove	410

Table 1. Exposure to hazards in study communities depends largely on the time of year and type of land-use. Exposure at an individual scale is largely determined by frequency of land-use. Table based on interviews and participant observation.

	Commonly harvested species	**Common activities by time of year**	**Associated hazards**
Arviat	Ringed seal, Bearded seal, Beluga, Arctic Char, Lake trout, Cod, Caribou, Arctic Fox, Snow goose, Canada goose, Goose eggs	• Spring – caribou, seal, fishing, goose and egg hunting • Summer – fishing, beluga, narwhal • Fall – caribou, seal • Winter – fishing, seal, arctic fox	• Spring – machine overheat, hitting a rock, run out of fuel, stuck from ice, fall through ice • Summer – drowning, stuck inland from mud or high water • Fall – machine overheat, fall through thin ice (inland), boat stuck from ice movement • Winter – machine breakdown, become lost with few supplies
Pangnirtung	Ringed seal, Bearded seal, Beluga, Arctic char, Turbot, Eider duck, Ptarmigan, Duck eggs		
Whale Cove	Ringed seal, Beluga, Arctic char, Lake trout, Caribou, Arctic fox, Canada goose		