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## Natural hazard experiences and adaptations: A study of winter climate-induced road closures in Norway

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### ABSTRACT

The effects of global climate change include more extreme weather events that harm lifeline infrastructure such as road access. The questionnaire-based study takes a novel natural experiment approach to subjective personal experiences and perceptions of lifeline vulnerability in two seaside communities in Norway that have been sporadically isolated due to avalanches, heavy snowfall, and/or snowdrifts. The enquiry aims at filling a research gap on sudden winter climate-induced disconnections and road travel hazards in advanced societies. The results show that weather-induced road closures lead to worries about road travel and practical problems, but also that many people are able to adjust to reduce their vulnerability. The authors concluded that community characteristics such as available services and social and human capital are important for understanding people's vulnerabilities, worries, and hazard preparedness.



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### Introduction

Transportation systems are designed to provide access to and from communities and to ensure two-way flows of people, goods, and services. In the '24/7 society', there is an expectation of unimpeded road access to and from most areas. Roads have been seen as lifelines, networks upon which health, safety, comfort, and social and economic activities depend (Platt 1991; Holand 2014). As climate change will create more winter season hazards in many areas (Jaedicke et al. 2008; Dyrddal et al. 2012; IPCC 2012), increasing road-user risks and more frequent and erratic highway closures are expected. Demonstrating the scale of such hazardscapes, at least 27% of the public roads in Norway have been estimated to be vulnerable to avalanches and rockslides

(Frauenfelder et al. 2013, 36, 57). At the end of the 20th century, avalanches caused 70–80% of road blockages in Norway (Public Roads Administration Hordaland 1995). Not only do avalanches interrupt access and cause infrastructure damage, but they have caused at least one fatality on Norway's public highways each year (Kristensen et al. 2003). It is thus increasingly important to study road-users' perceptions of uncertainties, risks, and problems and the affected people's experiences of highway closures as hazards and lifeline interruptions (Platt 1991), particularly in areas with little or no redundancy in road networks (Holand & Rød 2013). Even though many Norwegians are accustomed to extreme weather conditions, some communities and people are left vulnerable (O'Brien et al. 2004).

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Several studies of residents' perceptions of extreme weather effects and other natural hazards have concentrated on less developed countries (Wisner et al. 2004; Patt & Schröter 2008; Becken et al. 2014). In more developed countries, research has been conducted mainly on traffic accident risks (Andrey et al. 2003; Chinowsky et al. 2013), flooding (Grothmann & Patt 2005), and wildfires (McGee & Russell 2003). This has resulted in a dearth of research addressing several natural hazard consequences in advanced societies (Kuhlicke et al. 2011), including studies of inhabitant winter vulnerabilities and problems in areas with dispersed settlements and sparse lifeline networks (Holand 2014). Examinations of people's reactions and adjustments in response to the effects of extreme weather events and other climate-related hazards have increased extensively during the first decades of the 21st century. Still, there is a pressing need for more enquiries into the social aspects of vulnerability (Cutter et al. 2003), particularly subjective hazard aspects (Brace & Geoghegan 2010). Thus, a pivotal subject matter is the scrutinisation of people's personal experiences, namely localised lay knowledge, and understandings of winter climate-induced access and safety problems as well as their local implications (Brace & Geoghegan 2010, 14; Larsen et al. 2011), as locals' viewpoints may contextualise the understanding of personal adjustments (Pelling 2011).

Our study was guided by the following research questions: How are erratic winter climate-related lifeline cut-offs experienced by inhabitants in affected areas? How do sudden interruptions to road access affect people in terms of personal vulnerabilities, problems, frustrations, worries, and risks?

In order to answer these queries, we decided to explore the experiences and viewpoints of persons who had recently been subjected to winter climate-induced road closures. The chosen study areas were two seaside locales that are dissimilar in terms of industries, local services, and demography, thus making it possible to throw light also on community differences. Based on data from a self-completion questionnaire survey, this contribution is intended to fill a research gap about how people in Western European communities experience and endure temporary winter interruptions in their ability to travel and receive services and supplies.

## Lifeline vulnerabilities

### *Natural hazard-imposed vulnerability*

The effects of global climate change include more extreme weather events leading to infrastructure disruptions, making it important to investigate personal experiences and

perceptions of vulnerability. In the context of climate change and natural hazards, vulnerability has been defined as the susceptibility to be harmed (Adger 2006) and the potential for loss (Cutter et al. 2003). The notion of vulnerability is derived from engineering and environmental sciences (Manyena 2006). However, Holand et al. (2011) have provided a definition that makes the concept also applicable to social sciences by distinguishing biophysical vulnerability from social vulnerability. Biophysical vulnerability is the likelihood of hazards and impacts on social systems. By contrast, social vulnerability is the 'inherent property of a human system before a potential event, and independently of exposure to hazard' (Holand et al. 2011, 2). In line with this understanding, vulnerability is regarded as being socially created and dependent on available resources and the residents in an area. Additionally, vulnerability should be understood within the contexts of hazard experiences and risk interpretations (Eiser et al. 2012).

Vulnerability is related to the knock-on effects of erratic infrastructure interruptions as well as the availability of local services in areas that experience road closures. Accessibility to medical services including community care nursing within areas that have been cut off may reduce vulnerability (Skinner et al. 2009; Ullsfjord i utvikling 2011). The same applies to the local availability of shops for groceries and other daily necessities (Ringholm & Aanesen 2004). Correspondingly, it is plausible that worries about sudden highway closures are less prevalent in communities with vital neighbourhood service functions than in areas without such services.

Lifeline vulnerability is one aspect of vulnerability (Cutter et al. 2003). Lifelines refer to physical networks that are vital to health, safety, comfort, and livelihoods (National Research Council 1984; Platt 1991). Such networks include roads, electricity grids, telecommunications, and water supply. Lifeline vulnerabilities can emerge in a community when its road access to the outside world is erratically closed (Holand 2014), forcing inhabitants to adjust to the inconveniences of access interruptions and road travel risks (Nelson et al. 2007; Simmie & Martin 2010). One key research deficiency is thus in understanding how residents act when lifelines have been abruptly cut off and what capacities people think they have at their disposal to deal with subsequent uncertainties, worries, and problems (Zinn 2008; Brace & Geoghegan 2010).

### *Factors that reduce vulnerability*

The literature has highlighted a variety of factors that contribute to reducing vulnerability such as human capital, social capital, and dependency networks. Human capital is resources in humans rather than in, for example, physical infrastructure (Becker 1975) or, in

this case, people's skills and knowledge to grapple with winter hazards. Human capital is created by spending time and effort on transformation and transaction activities in order to be prepared for the future (Ostrom et al. 1993; Ostrom 1999). Moreover, Tapsell et al. (2010) have employed the notion of personal capital (i.e. efforts, motivations, commitments, competence, and time), which may influence a person's ability to anticipate, respond, recover, and adapt from a natural hazard event.

Social capital refers to resources, trust, and networks that may help people to act effectively (Coleman 1966; Putnam 1995; Adger 2000). Coleman (1988) has identified three key forms of social capital: obligations and expectations, information channels, and social norms. Furthermore, regarding people's handling of natural hazard effects, Nakagawa & Shaw (2004) have maintained that social capital encompasses a willingness to engage in mutually beneficial collective action, including trust in public administration and government departments. People's dependence on a set of relationships in a society has also been termed 'social embeddedness', and there are various levels of such embeddedness (Edmonds 1999). What has been labelled as generalised trust has been regarded as beneficial to a society and socio-economic networks (Putnam 1995). Not only can social networks in one's place of residence buffer stressful situations (Cohen & Wills 1985), but also the length of time people have resided in an area may contribute to hazard preparedness (McGee & Russell 2003). Social capital may thus become more evident when lifelines have been cut. Furthermore, place attachment and a sense of belonging have been assumed to increase people's capabilities to deal with the effects of erratic hazards (King & MacGregor 2000; Fresque-Baxter & Armitage 2012).

Especially since the later part of the 20th century in Western countries, self-reliance and personal preparations for impetuous natural hazard effects have often been replaced by networks of dependencies, such as a tendency to demand services (Horlick-Jones 1995; Alexander 2008). This may vary between locations and disruption types, and people cannot always rely on authorities and other service providers. Although Norwegian public authorities (i.e. the Public Roads Administration or the police) close a road when they consider it unsafe, they are not always able to respond instantaneously to unexpected natural hazard situations.

### Responses to vulnerability

Natural hazards are associated with both risk and worry (Pelling 2011). Researchers have addressed different responses to lifeline vulnerability, including perspectives on risk and what actions people take. Four main response

patterns to natural hazard exposures (hazardous places) have been recognised: risk denial, passive risk acceptance, action to reduce future losses, and change in livelihood (Horlick-Jones & Jones 1993). Risk can be understood both as threats posed to individuals and strategies used to cope with such threats (Alaszewski & Coxon 2009). Worry has been defined as a penchant to regard ambiguous or uncertain situations as threatening (Butler & Mathews 1987). Worry has also been described as a cognitive element of anxiety that is associated with emotional reactions to hazards (Sjöberg 1998; Moen & Rundmo 2006; Backer-Grøndahl et al. 2009).

To endure changes that may threaten the routines of everyday life (Kelly & Adger 2000), mitigate expected adverse effects of natural hazards, and enhance the viability of everyday life, people's adjustments may be passive, reactive, or anticipatory (Smit et al. 2000).<sup>1</sup> In many cases, adjustments to hazard outcomes depend on the abilities of actors and their networks to learn and to accumulate knowledge and experience as well as to creative flexibility in risk evaluations and decision-making (Smit & Wandel 2006). Local social networks can be just as vital as advisory services to learning, according to Pelling (2011). Numerous studies of personal natural hazard experiences have shown that preparedness increases with the severity of previous damage (Weinstein 1989). Moreover, a study of Norwegians' risk perceptions of climate and/or weather has indicated that personal experiences of damage from natural hazards affect people's concerns about climate change, to the extent that they largely influenced the respondents' presumptions that the mentioned natural hazards would increase in the future (Lujala et al. 2015). In several coastal and fjord societies in Northern Norway, a considerable number of residents are accustomed to braving the elements and enduring a temporary lack of connectivity; they consider themselves adept at preparing and adjusting to winter weather-induced events. A common saying in this area is 'We stand tall, regardless of the stormy weather' (Eidheim 1993), but the extent to which this is actually true still merits examination.

When addressing responses to vulnerability, it should be highlighted that, although related, there is a difference between the responses to and impacts of events. Vulnerability is the susceptibility that exists before an event occurs, making people predisposed to be negatively impacted by the potential event (Adger 2006). Consequently, lifeline vulnerability does not emerge when a road or another lifeline is closed; rather, it is the susceptibility resulting from dependency on functioning lifelines. For example, persons with disabilities who are dependent on everyday assistance also rely on infrastructure through which help is provided (e.g. roads, vehicles, and provider organisations). Thus, lifeline and other

vulnerabilities are incapacities, disadvantages, and dependencies that exist before an event, and that may shape hazard event preconditions differently for various persons in dissimilar communities.

Impacts arise when a road is closed and people experience problems such as not being able to travel to work or to a hospital, or to receive assistance. Problems tend to worsen the longer it takes to open the road. Hence, in areas where people repeatedly experience extreme weather, natural hazards, and knock-on effects such as highway closures, explicit risk denial might assumingly be rare. However, people in good health and without particular short-term travel and supply needs can tolerate access interruptions. Preparedness may be more common, such as having necessary resources available when personal mobility and supplies of goods and services are temporarily blocked. People who find their lives or health at risk may take action to reduce their losses and/or change their livelihood, such as by relocating or ceasing to commute along roads that are exposed to natural hazards (Horlick-Jones 1995). Particularly people who are retired or disabled may choose to relocate (Ullsfjord i utvikling 2011).

### Study areas

People in many Norwegian communities experience worrying and dangerous winter weather conditions that may affect local infrastructure, including unexpected highway closures. However, most communities have alternative routes or the weather conditions do not result in temporary inaccessibility. Still, as many as 10% of Norwegian municipalities have only one connection to the national road system (Holand & Rød 2013). Based on a review of a number of places, the seaside areas Jøvik/Olderbakken and Senjahopen/Mefjordvær were selected for study (Fig. 1). Almost every winter in these areas, sudden interruptions to access have occurred due to snow and slush avalanches, heavy snowfall, and/or strong winds and drifting snow. In some winters, there have also been electricity outages and telecommunications breakdowns. In addition, we found interesting differences between these areas in terms of industries, services, and demography, making it possible to gain insights into how different conditions may affect personal perceptions of and adjustments to erratic climate-related natural hazards.

The community of Jøvik/Olderbakken is located along a dead-end road by Ullsfjord (Sørfjorden), on the south-western shores of the alpine Lyngen peninsula. There are few local employment opportunities besides agriculture and gravel extraction, and therefore it is common for the inhabitants to commute to work outside

the area. There is a chapel, but the school has been closed since 2010. In 2015, there were c.60 households and c.100 inhabitants.<sup>2</sup> The population has been aging, and some elderly residents have moved to nursing homes in the city of Tromsø (Ullsfjord i utvikling 2011). Historically, this community has been closely connected to the Lakselvbukt area farther south along the fjord, where there is a school, a church, a grocery shop, and some other institutions and services. Due to municipal mergers, the area (Lakselvbukt and Jøvik/Olderbakken) has been included in the geographically large municipality of Tromsø, with its centre about 1 hour's drive away. In 2015, there was one daily bus to and from Tromsø, except on Saturdays. The seashore highway to Jøvik/Olderbakken has been closed erratically almost every winter due to avalanches or predicted avalanches, sometimes for several days. Because of the length of the avalanche area (Holmbuktura) on the access road and the velocity of most avalanches, there is a fatal risk of travellers being on this stretch of road when an avalanche occurs, typically from mountain snowdrifts more than 1000 m above the road. Following an avalanche, the snow depth on the seaside road has been recorded in the range of 2–20 m (Fig. 2).

Senjahopen and Mefjordvær are only a few kilometres apart and are thriving fishing villages in the mountainous ocean-facing shores of the large island of Senja, and they are connected to the mainland by a bridge near Finnsnes (Fig. 1). Mefjordvær is on a dead-end road. Fishing dominates the local economic life, and there are two large fish processing plants. In Senjahopen, there is an ambulance station, a grocery shop, a convenience store, a kindergarten, and a primary school. In 2015, Senjahopen and Mefjordvær had a combined population of c.500, a number that had been quite stable for some years.<sup>3</sup> Senjahopen and Mefjordvær are parts of the sparsely populated municipality of Berg, with its administrative centre, Skaland, located c.20 km south-west of the villages, on the other side of two mountain ranges. The two fishing villages are connected by two highways and are therefore not as easily cut off as Jøvik/Olderbakken. Still, fish farming and the large fish processing plants depend on continuous road access for production input and output. The main access highway to this area has usually been exposed to minor avalanches and has reopened relatively soon after an avalanche or the risk of one (e.g. when there is a risk for an avalanche at night, the road has commonly been reopened early the next morning). However, at times, both highways have been closed due to avalanches, heavy snowfalls, and/or strong winds leading to drifting snow. Moreover, in situations with icy roads, heavy goods vehicles have often blocked the highways on

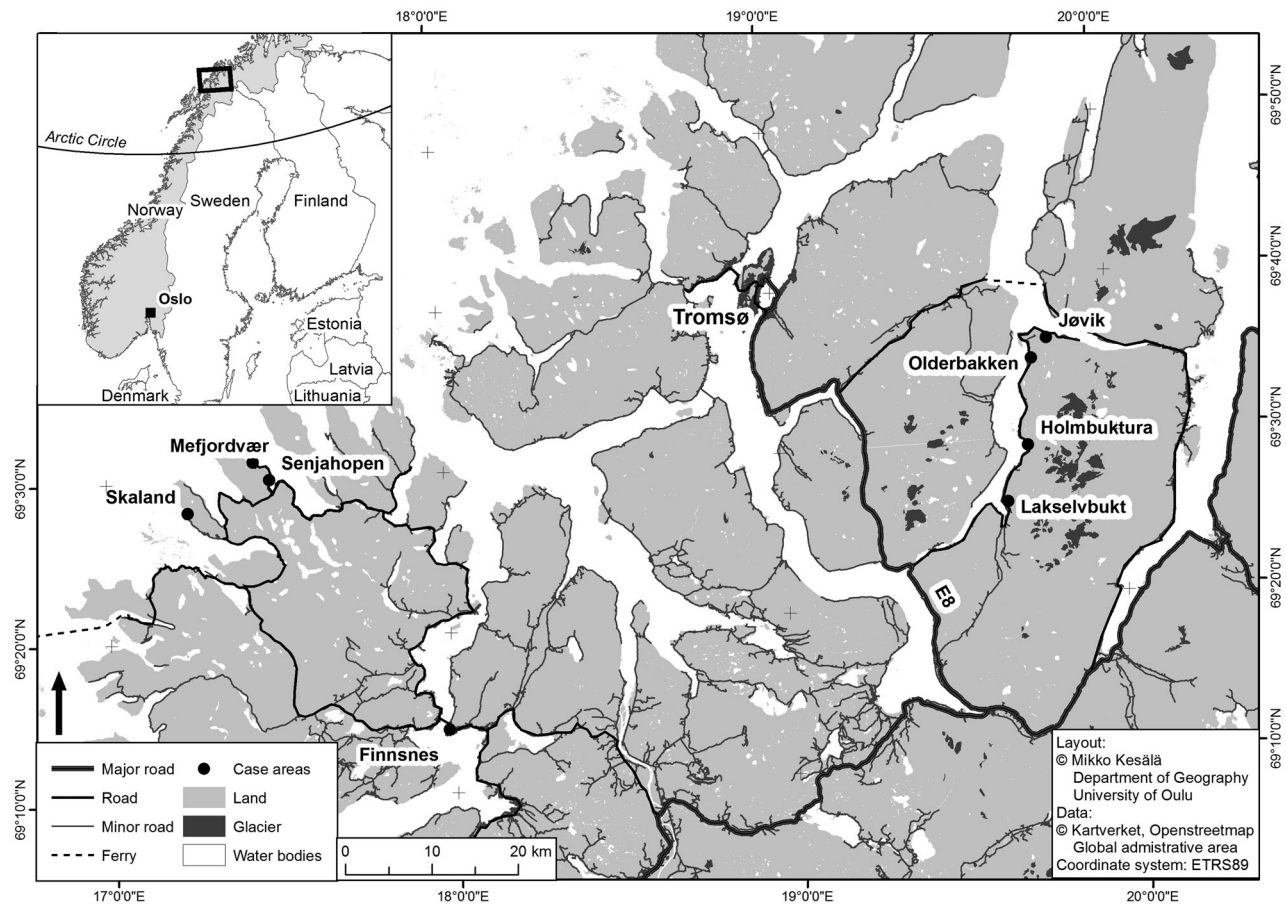


Fig. 1. Location of the study areas in Northern Norway

steep hills and in narrow and curved stretches. Additionally, blizzards, drifting snow, and avalanches have sometimes blocked the internal road between these villages. During highway closures, a search-and-rescue boat in the area may serve the villages.

## Method

A natural experiment was regarded as a suitable way to study residents in areas that had recently been exposed to the knock-on effects of winter climate-related hazards. Simply speaking, a natural experiment is an empirical study of people subjected to circumstances shaped by dynamics outside the researcher's control (Dunning 2012). Quite a few natural experiments that have been related to nature processes have had the features of an intervention (Woodward 2003) and they have thus been termed nature's experiments (Morgan 2013). Natural experiments are typically employed when controlled experimentation is unethical, difficult, or impossible (Dunning 2012). As our natural experiment took place in the context of the participants' everyday life environments, with no researcher influence on the independent variables, it had high ecological validity (i.e. a good

capacity for research findings to be generalised to real-life settings) but it may be difficult to replicate it (Bronfenbrenner 1977).

Project staff distributed unnamed envelopes containing an introductory letter and two questionnaires to almost all letterboxes in the two study areas on 7 and 8 March 2015, ensuring complete anonymity as no names or address lists were used. This was only one day (in Jøvik/Oldbakken) and three weeks (in Senjahopen/Mefjordvær) after these communities had experienced closed roads, thus minimising memory bias (Dex 1995). Persons over 18 years of age were asked to fill in a self-completion questionnaire and return it in an enclosed postage-paid envelope. A reminder was placed in the same letterboxes some weeks after the initial survey delivery. The percentage replying among those who were asked to fill in the questionnaire was not known, partly because the exact number of adult inhabitants and their distribution in terms of families and couples was not known. The response rate was also influenced by the fact that several couples, families, and households completed and returned a single questionnaire. The response rate was estimated to be c.40%. The effective sample size was 195.



**Fig. 2.** Snow clearance after an avalanche at Holmbuktura on the seaside road, facing towards Lakselvbukt (Photo: Bjørn Stakkenes, March 2014)

The questionnaire was based on a literature review and contact with persons with detailed knowledge of the study areas. Prior to the final survey design, the research team communicated with a number of inhabitants to ensure that the questions were relevant and understandable. The questionnaire design process and the phrasing of survey items included ethical considerations, as some topics could be a source of anxiety or unwanted self-knowledge (Pidgeon et al. 2008). The respondents were requested to indicate on a five-point Likert-type scale whether they agreed or disagreed with some statements about their experiences related to road closures resulting from avalanche or risk of avalanche during the current winter. They were also asked which consequences listed in the questionnaire the life-line cut-offs possibly had for them, such as whether they adjusted in a special way in relation to lack or possible lack of connectivity due to avalanches and/or adverse weather events. Responses that expressed subjectively important aspects for living in the area were utilised to indicate place attachment. Equally, questions about local relations and trust in local and/or regional authorities and road maintenance staff were used to measure social capital. Moreover, the study elicited common demographic variables such as gender, age,

occupation, and household type and size. The respondents were also asked how long they had resided in the area or village, whether they had lived in other areas for two years or more, and whether they commuted to their workplace or school or travelled to attend a course outside their village or area.

Independent sample *t*-tests were employed to discover possible associations between continuous outcome variables (mean scores) and categorical determining variables. The chi-square statistic ( $\chi^2$ ) was used to test the statistical significance of the observed association in cross-tabulations. Only differences that were statistically significant at the 0.05% level ( $p < 0.05$ ) have been reported. Factor analysis (Principal Component Analysis, PCA) was used to explore patterns of subjective personal experiences of winter challenges. Varimax rotation was employed in order to minimise the number of variables with high loadings on a factor and thus enhance interpretability (Hair et al. 2006). An initial rotated solution with eigenvalues cut off at 1.0 yielded five factors but was difficult to construe. It was thus decided to attempt using a fixed number of factors (four), a solution that was meaningful to interpret and that met the eigenvalue criterion of 1.0. Three items were excluded because of double loadings or low interpretability.

After computing scales based on the items with the highest loadings, the Cronbach's alpha values were 0.81 for factor 1 (four items), 0.96 for factor 2 (two items), 0.68 for factor 3 (three items), and 0.65 for factor 4 (three items). The item 'I know that the road(s) will be closed when it is unsafe to drive' was kept for factor 4 despite loading on two factors in the PCA. The reliability analysis showed that the Cronbach's alpha for the factor increased when the item was included. Additionally, the item was a good fit within the factor.

## Results

Approximately 26% of the respondents reported that they lived alone, 46% lived only with a spouse or partner, and 18% lived in households with children younger than 18 years of age. About one-third (35%) of the respondents stated that they had a job or attended school outside their village or area. In Jøvik/Olderbakken, almost half of the respondents (48%) were retired, compared with 24% in Senjahopen/Mefjordvær. Most respondents had not remaining living in their home areas, as 76% had lived in other areas for two years or more. As many as 93% of the respondents in Jøvik/Olderbakken had resided in the area for 10 years or more, compared with 75% in Senjahopen/Mefjordvær (Table 1).

About 75% of respondents reported that some important reasons to reside in their area was the proximity of

good friends, good neighbours, and family members; this is an indication of social capital and place attachment that was present in both areas. The large majority of respondents (c.75%) who expressed positive attitudes towards their place of residence also answered that local social networks were important to them.

Principal Component Analysis (PCA) was employed to explore the main patterns of subjective personal experiences of winter challenges. A four-factor solution yielded a quite clear pattern describing subjective perceptions and experiences of road-closure aspects. The eigenvalues were 3.8, 2.3, 1.6, and 1.2, respectively, and this solution explained 74% of the variance (Table 2). The factors were named as follows:

1. General travel worries
2. Worries about disabled and sick persons not receiving assistance
3. True personal adjustment
4. Social trust.

Factor 1 (general travel worries) was associated with people's worries about ill relatives and/or neighbours when roads were closed, worry about falling ill themselves, a dislike of not being able to travel at will, and an uneasiness about travelling in periods of avalanche risk. Factor 2 (worries about not receiving assistance) was associated with concerns about not receiving home help and community care nursing. Factor 3 (true personal adjustment) correlated with adjusting and making arrangements in line with the winter weather, experience in assessing weather and snow conditions when deciding to travel, and not seeing periodic lack of access as a problem. Factor 4 (social trust) was associated with seeing the local council or municipality as skilful in helping when the roads were closed, that the staff were capable to keep the roads open during winter, and an understanding that the roads would be closed if it were not safe to drive along them (Table 2).

## Experiences

Only 5% of respondents did not care about road closures caused by avalanches, all of whom resided in Senjahopen/Mefjordvær. Further, 21% found such road closures to be impractical, 37% thought that the closures could be frustrating, and another 37% reported that road disconnections usually led to problems (Table 3). In Jøvik/Olderbakken, larger proportions of respondents perceived road closures as leading to problems and/or frustrations, while more people in Senjahopen/Mefjordvær thought such interruptions were impractical ( $\chi^2 = 14.26$ , d.f. = 3,  $p < 0.003$ ). In Jøvik/Olderbakken, only

**Table 1.** Key sample characteristics (percentages)

Sample characteristics	Jøvik Olderbakken	Senjahopen Mefjordvær	Total	N
<i>Gender</i>				
Female	43	46	45	88
Male	57	54	55	107
<i>Age (years)</i>				
18–25	16	9	11	21
26–40	0	16	11	22
41–55	10	40	31	60
56–70	52	23	31	61
71 or older	22	13	15	30
<i>Social status or occupation</i>				
Working	35	58	51	99
Pupil or student	5	12	10	19
Homemaker	3	4	4	8
Retired	48	24	31	60
Other	9	2	4	8
<i>Duration of living in village or area</i>				
Less than 1 year	0	4	3	5
1–2 years	2	10	7	14
3–5 years	2	4	4	7
6–9 years	3	7	6	12
10 years or more	93	75	81	157
<i>Experience with living in other areas, for two years or more</i>				
Yes	74	77	76	146
No	26	23	24	46
<i>Work or attend school outside village or area</i>				
Yes	27	38	35	59
No	73	62	66	112



**Table 2.** Rotated four-factor solution

	F1	F2	F3	F4
I am worried about sick relatives/neighbours when the road(s) might be closed	<b>0.907</b>	0.018	−0.045	−0.060
I am worried about getting ill when the road(s) might be closed	<b>0.890</b>	0.199	−0.178	0.012
I resent not always being able to travel when I want	<b>0.556</b>	0.322	−0.101	−0.520
I am uneasy about travelling when there is a risk of an avalanche	<b>0.542</b>	0.384	0.095	−0.242
I am worried that I will not get home help	0.180	<b>0.935</b>	−0.062	0.081
I am worried that I will not get community care nursing	0.192	<b>0.929</b>	−0.046	0.088
I make arrangements in line with winter weather and adjust	−0.048	−0.197	<b>0.806</b>	0.109
I am used to assessing weather and snow conditions when I will travel	0.072	0.350	<b>0.777</b>	−0.156
I do not experience periodic road closure as a problem	−0.256	−0.091	<b>0.743</b>	0.335
I think the local council/municipality is skilful in helping when the road is closed	−0.007	0.074	0.013	<b>0.826</b>
I think the staff are capable of keeping the road(s) open during winter	−0.145	0.174	0.118	<b>0.759</b>
I know that the road(s) will be closed when it is unsafe to drive	−0.059	−0.264	0.481	<b>0.533</b>

Notes: Factor loadings >0.40 are shown in bold font; maximum likelihood with Varimax rotation; total explained variance = 74%.

11% of the respondents did not experience disturbances to access as a problem, compared with 42% in Senjahopen/Mefjordvær ( $\chi^2 = 18.68$ , d.f. = 4,  $p < 0.001$ ).

The most common personal impacts of winter road closures were not being able to run personal errands, not being able to receive planned visits from kin or friends, and not being able to get to and return from health services and/or medical practitioners (Table 4). Other quite common impacts were not receiving important mail at the right time, not getting to or from work or school, and not being able to send important mail at the right time. Some 7% did not obtain medicines at the right time and 1% did not receive community care nursing.

Interruptions to access affected people differently in the two study areas. In Jøvik/Olderbakken, as many as 79% of the respondents reported that they had not been able to run personal errands due to road closures, compared with 39% in Senjahopen/Mefjordvær ( $\chi^2 = 25.96$ , d.f. = 1,  $p < 0.001$ ). There were also differences in the effects on the areas' postal services. In Jøvik/Olderbakken, as many as 35% stated that they did not receive important mail at the right time, compared with 17% in Senjahopen/Mefjordvær ( $\chi^2 = 7.42$ , d.f. = 1,  $p < 0.006$ ). Some 29% in Jøvik/Olderbakken reported that they were unable to get to/from work or school, compared with 17% of the respondents in Senjahopen/Mefjordvær ( $\chi^2 = 3.92$ , d.f. = 1,  $p < 0.048$ ). There was only one gender difference in this context: 51% of the female respondents reported that they did not receive planned visits from

family members or friends, compared with 24% of the male respondents ( $\chi^2 = 15.02$ , d.f. = 1,  $p < 0.001$ ).

### Anxieties

Large majorities of the respondents reported feeling uneasy about travelling if there was risk of avalanche (70%), worried about becoming ill when the roads might be closed (66%), and worried about sick relatives or neighbours when the roads might be closed (60%). Some 29% were worried that they would not get to or from work or school during lifeline cut-offs (Table 5). Compared with respondents in Senjahopen/Mefjordvær, those in Jøvik/Olderbakken were significantly more worried that they would not get to or from work or school (Table 5). The only gender difference was that considerably more women than men were worried about sick relatives or neighbours when there was a chance that the roads might be closed ( $\chi^2 = 14.51$ , d.f. = 4,  $p < 0.006$ ). Some 7% of the respondents were worried that they would not receive community care nursing, and a further 7% – mostly the same people – were worried that they would not receive home help.

Either the Norwegian Public Roads Administration or the police are responsible for deciding when to close a highway that they consider unsafe. However, respondents in the two areas had different perceptions of safety based on the public authorities' decisions. In Senjahopen/Mefjordvær, as many as 82% agreed with the statement 'I know that the road(s) will be closed when it is unsafe to drive', compared with only 35% in Jøvik/Olderbakken ( $\chi^2 = 40.17$ , d.f. = 4,  $p < 0.001$ ). In Jøvik/Olderbakken, 92% of the respondents resented not being able to travel whenever they wanted, compared with 70% in Senjahopen/Mefjordvær ( $\chi^2 = 11.52$ , d.f. = 4,  $p < 0.021$ ).

Some 30% of the respondents agreed either fully or partly with the statement 'I think the municipal authorities are skilful in helping when the road is closed', while 45% disagreed either fully or partly with the statement.

**Table 3.** Personal perceptions of road closures due to avalanches during winter (percentages)

Perception	Jøvik/ Olderbakken	Senjahopen/ Mefjordvær	Total	N
I don't care	0	8	5	10
It can be frustrating	43	35	37	71
It may be impractical	9	26	21	40
It usually leads to problems for me	48	32	37	70
Totals	101	101	100	191

**Table 4.** Personal impacts of road closures during winter (percentages)

Impact	Jøvik/Olderbakken	Senjahopen/Mefjordvær	Total	N
Did not manage to run personal errand(s) (e.g.visits/shopping)	79	39	51*	100
Did not receive planned visit(s) of kin/friends	38	36	36	71
Did not get to/from health service/medical practitioner	38	28	31	60
Did not receive important mail at right time	35	17	22*	43
Did not get to/from work/school	29	17	21*	40
Could not send important mail at right time	26	15	18	35
Did not get medicines at right time	5	8	7	14
Did not receive community care nurse	2	1	1	2

Notes: \*statistically significant difference between the two study areas, calculated by chi-square statistic ( $\chi^2$ ),  $p < 0.05$ ; more than one response alternative was possible.

**Table 5.** Subjective worries related to road closure(s) during winter because of avalanche or avalanche risk (percentages) and mean scores (scale 1 (disagree) to 5 (agree))

Subjective worry	Disagree 1	2	Neither/nor 3	4	Agree 5	Mean score	Mean S/M*	Mean J/O**	N
I am uneasy about travelling when there is risk of an avalanche	7	3	10	16	66	4.3	4.3	4.5	168
I am worried about getting ill when road(s) might be closed	11	3	10	9	67	4.2	4.1	4.4	168
I am worried about sick relatives/neighbours when road(s) might be closed	10	3	12	12	63	4.2	4.1	4.4	156
I am worried that I will not get to/from work or school	31	4	18	3	43	3.2	3.0	3.9***	121

Notes: \*Senjahopen/Mefjordvær; \*\*Jøvik/Olderbakken; \*\*\* $p < .05$ , calculated by *t*-test.

As many as 68% of the respondents in Jøvik/Olderbakken disagreed with the statement, compared with 36% in Senjahopen/Mefjordvær ( $\chi^2 = 19.88$ , d.f. = 4,  $p < 0.001$ ). The sentiment was related to local responsibilities during life-line disruptions, such as caring for people with disabilities and/or ill health. A total of 53% of the respondents agreed either fully or partly with the statement 'I think the staff are capable of keeping the road(s) open during winter', while 26% disagreed.

### Adaptations

Some 82% agreed partly or fully with the statement 'I am used to assessing weather and snow conditions when I want to travel', while 71% agreed partly or fully with the statement 'I make arrangements in line with winter weather and adjust' (Table 6). Further, as many as 77% agreed partly or fully with the statement 'I dislike that I cannot always travel when I want.'

The survey included a request for respondents to appraise how 'innovative' the locals were in adjusting to lack of access and 79% agreed partly or fully with the statement 'I think people here are skilful at adjusting to road closure.' In this self-evaluation of their community, as many as 83% of the respondents in

Senjahopen/Mefjordvær thought that the locals were skilful at adjusting, compared with 67% in Jøvik/Olderbakken ( $\chi^2 = 9.53$ , d.f. = 4,  $p < 0.049$ ).

Of the respondents, 40% reported that they did nothing special to prepare for possible winter road closures. Typical preparations included stockpiling extra food (54%), having extra firewood or fuel (39%), and storing extra medicines (26%) (Table 7). A total of 26% endured interruptions to access with help from their family members or friends, and almost as many (22%) were able to count on help from neighbours.

There were some differences in the preparations for possible road failures in the two study areas (Table 7). A total of 47% of the respondents in Senjahopen/Mefjordvær reported that they did nothing special, compared with only 24% in Jøvik/Olderbakken ( $\chi^2 = 8.66$ , d.f. = 1,  $p < 0.003$ ). Some 85% of the respondents in Jøvik/Olderbakken stocked up on extra food, compared with 42% in Senjahopen/Mefjordvær ( $\chi^2 = 30.20$ , d.f. = 1,  $p < 0.001$ ). Conversely, a larger proportion of the respondents in Senjahopen and Mefjordvær prepared for interruptions to access by ensuring that they had extra firewood or fuel (45% and 24%, respectively) ( $\chi^2 = 7.16$ , d.f. = 1,  $p < 0.007$ ).

**Table 6.** Subjective experiences of road closures due to avalanches or the probability of avalanche during winter (percentages)

Experience of road closures	Disagree 1	2	Neither/nor 3	4	Agree 5	N
I am used to assessing weather and snow conditions when I want to travel	6	1	10	14	68	156
I think people here are clever at adjusting to road closure	2	3	16	21	58	160
I dislike that I cannot always travel when I want	9	4	10	8	70	161
I make arrangements in line with winter weather and adjust	7	8	14	16	55	153
I know that the road(s) will be closed when it is unsafe to drive	16	2	12	10	60	155
I think the staff are capable of keeping the road(s) open during winter	17	7	22	13	40	167
I think the local municipality is skilful in helping when road is closed	38	7	25	7	24	162

**Table 7.** Personal and household preparations for possible road closure(s) due to avalanches (percentages)

Preparation	Jøvik/Olderbakken	Senjahopen/Mefjordvær	Total	N
I do nothing special*	24	47	40	78
Have extra food*	85	42	54	106
Have extra firewood/fuel*	24	45	39	75
Have extra medicines	31	23	26	50
Get help from family/friends if needed	19	29	26	50
Get help from neighbours if needed	22	21	22	42
Other	5	7	6	12

Notes: \*statistically significant difference between the two study areas, calculated by chi-square statistic ( $\chi^2$ ),  $p < 0.05$ ; more than one response alternative was possible.

## Discussion

In focusing on winter season climate-related lifeline disconnectivities, this study has highlighted not only the experiences and anxieties but also the factors that may contribute to reducing personal vulnerabilities and risks.

### *Anxieties and other experiences*

The survey revealed that many respondents were subject to frustrations, worries, risks, and problems due to avalanche risks and road closures. In this respect, the highways were perceived as lifelines upon which safety, health, and various socio-economic activities were dependent (Holand 2014). Most residents were able to adjust to such sudden winter climate-related road disruptions, and several personal consequences were quite similar in the two study areas, although larger proportions of respondents were affected in Jøvik/Olderbakken than in Senjahopen/Mefjordvær. A small percentage of respondents with incapacities or ill health were considerably more vulnerable than were healthy ones, and this finding is similar to that reported by Skinner et al. (2009) in a study of the geographies of care and caregiving in the context of Canadian winter weather-induced problems.

A large majority of respondents stated that they were accustomed to assessing weather and snow conditions when they wanted to travel, which indicated prevalent risk appraisal. This result was more or less in accordance with Grothmann & Patt's (2005) study of personal proactive adjustments among people living in flood-prone areas in Germany. This and several other adjustments implied both reactive and anticipatory adjustments, similar to the reasoning of Smit et al. (2000). Furthermore, these results pointed towards a general cognitive approach to the possible effects of natural hazards, including risk assessments.

Despite the fatal dangers of avalanches that may hit the roads, the majority of respondents' perception of their situation was characterised almost as much by worries about interruptions to access as by the fear of being

directly exposed to hazardous events. A large majority reported that they were uneasy about road travel at times of heightened avalanche risks, a finding that partly supports Pelling's (2011) argument that people worry about vulnerabilities despite claiming that they are used to hazards. The results also supported O'Brien et al.'s (2004) contention that although many Norwegians are familiar with the effects of extreme weather and climate-related hazards, some of them are nevertheless vulnerable.

### *Disconnection times and available services*

Although quite a few findings were in accordance with earlier research on experiences of other types of natural hazards, our results also demonstrated considerable differences between the residents in the two study areas. A larger proportion of the respondents in Jøvik/Olderbakken reported vulnerabilities, worries, frustrations, or problems related to road closures, while more people in Senjahopen/Mefjordvær found such interruptions to be impractical. In other words, the impacts of winter weather hazards were greater in Jøvik/Olderbakken than in Senjahopen/Mefjordvær, partly because the inhabitants in Jøvik/Olderbakken were more exposed to fatal avalanche risks and commonly experienced longer lifeline discontinuations. More stockpiling of extra food and medicines in Jøvik/Olderbakken than in Senjahopen/Mefjordvær was presumably due to disconnection durations, temporary lack of locally accessible services such as home help, community care nursing, and grocery shopping, but also because of the inhabitants' age and health dissimilarities. These results were consistent with an aspect shown in Weinstein's (1989) overview of self-protective behaviour in various contexts including natural hazards, namely that people's preparedness has augmented with the severity of previous impairments. Moreover, a search and rescue boat stationed in Senja during the winter season and the local ambulance station could also have affected the lower levels of perceived worry and risk in Senjahopen/Mefjordvær. These findings provided

fruitful support to Holand et al.'s (2011) concept of social vulnerability; that is, available service functions in the communities affected the extent of social vulnerability.

Interestingly, a larger proportion of the inhabitants in Senjahopen/Mefjordvær than in Jøvik/Olderbakken did not undertake any extraordinary activities to adjust. This may reflect a general acceptance of periodic lack of access for persons with no need for everyday travel. Besides, many people did not need to consider making special arrangements; they were habitually equipped for such situations. Furthermore, there seemed to be little explicit risk denial, although a few respondents in Senjahopen/Mefjordvær claimed that they did not care about road closures related to avalanche risks and a large proportion did nothing special to adjust. These findings pointed towards a passive acceptance of lifeline cut-offs and avalanche and extreme weather risks among people who would commonly not experience personal effects of such events, akin to the arguments of Horlick-Jones & Jones (1993) and Horlick-Jones (1995).

### **Social and human capital**

The residents of the two areas responded similarly to questions related to social capital, suggesting that social capital was important to many people's adjustments in both areas, as quite a few residents could count on help from friends, family and/or neighbours. Such local social networks can be palpable buffers during stressful events, as Cohen & Wills (1985) have shown. However, as social capital was well developed and practised in both areas, it did not explain why respondents in Jøvik/Olderbakken reported more problems than did people in Senjahopen/Mefjordvær. Interestingly, such differences were rather a consequence of the different avalanche hazards in the areas, the duration of lifeline disconnections and availabilities of local services. In contrast to other studies that have emphasised the importance of human and social capital when aiming to understand social vulnerability (Nakagawa & Shaw 2004), the results here underlined that certain types of locally available services (e.g. health personnel, paramedics and grocery shopping) are vital.

In addition, the findings indicated a notable connection between social networks and place attachment. Important reasons to reside in the study areas included having good friends, good neighbours and family/kin nearby. The respondents who expressed positive attitudes to their place of residence also responded that local social networks were important to them. This was consistent with literature suggesting an association between place attachment and adjustments to other types of natural hazards (King & MacGregor 2000;

Fresque-Baxter & Armitage 2012). As large majorities of respondents had resided in their locales for a decade or more, they had long experience with avalanches and other weather-related events leading to sudden lifeline cut-offs. Such preparedness of long-term residents corroborated the results from a study of wildfire exposure and preparedness in rural Australia, concluding that '[i]t's just a natural way of life' (McGee and Russell 2003, 1).

Yet another noteworthy aspect was confidence in authorities. A large majority in Senjahopen/Mefjordvær assumed that the roads would be closed when it was unsafe to drive, thus trusting the local authorities and the Public Roads Administration – an indication of high levels of social capital in the community. The same amount of trust was not found in Jøvik/Olderbakken. Interestingly, inhabitants in the larger municipality of Tromsø (i.e. Jøvik/Olderbakken) were less satisfied with the local authorities than were the respondents in the smaller municipality of Berg (i.e. Senjahopen/Mefjordvær), possibly indicating that the institutions were not present in Jøvik/Olderbakken in the same manner as they were in Senjahopen/Mefjordvær.

### **Conclusions**

This study has given novel insights into experiences of climate-related lifeline interruptions in advanced societies by uniquely using a natural experiment approach and by contrasting the results with research on how people grapple with other types of natural hazards. The results were mainly in line with earlier studies of other weather- and climate-related effects showing that community-level hazard experiences have a bearing on individuals' preparedness (Weinstein 1989). Most persons who were exposed to lifeline cut-offs were skilful in their adjustments, indicating a quite high level of human or personal capital. Additionally, the finding that most respondents could turn to friends, family members, and/or neighbours denoted a high level of social capital in both areas.

In contrast to several other studies, this contribution emphasised the importance of human and social capital when aiming to understand social vulnerability. As social capital was equally abundant in both study areas, stress and worry variations could partly be explained by differences in hazard severities and commuting prevalence. Moreover, the survey indicated that locally available services were important, particularly medical and emergency services but shopping for everyday necessities was also important.

The study lent some credence to a saying in many seaside communities in Northern Norway, namely that people stand tall despite the stormy weather (Eidheim 1993).

The challenge was not so much that people in these communities were not able to resume their everyday life after access interruptions, but rather that in periods with high avalanche probability, inhabitants' worries and problems increased with hazard occurrences and dangers. Commuters and persons with ill health were especially worried and stressed, despite being attuned to living with winter risks and interruptions.

Future research could delineate the experiences of life-line cut-offs also by utilising qualitative approaches. As this survey focused on personal experiences, a potential research avenue might be micro-historical studies that could provide more detailed insights into people's long-term modifications, risks and worries, such as possible relocations and changes in livelihoods, as well as enhanced understanding of differences between communities in terms of demography, social capital, and place attachment. Future studies could additionally explore perceptions and interests of enterprises, which are dependent on transport in different ways than most residents.

## Notes

1. E. Stakhiv, 'Evaluation of IPCC adaptation strategies', draft report dated 1999, prepared for the Institute for Water Resources, U.S. Army Corps of Engineers, in Fort Belvoir, VA.
2. The statistics were based on Kompas Statistics Norway, and provided by a representative of Tromsø Municipality.
3. The statistic was provided by a representative of Berg Municipality.

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