

Watch or warning? Perceptions, preferences, and usage of forecast information by members of the Canadian public

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ABSTRACT: Environment Canada is responsible for monitoring weather conditions and developing associated forecast products for millions of Canadians. Although it is clear that these forecasts are reaching many different end-users, it is less certain how these products are perceived or used by the Canadian public. This research investigated the way(s) in which individual end-users in southern Ontario obtained, interpreted, and used weather forecasts in their every-day decision-making. Semi-structured interviews ($n = 35$) and close-ended questionnaires ($n = 268$) were conducted with residents from Huron and Perth Counties in Ontario, Canada, between October 2011 and March 2012 as part of a larger research project. It was found that most respondents used weather products for pragmatic reasons (e.g. deciding appropriate clothing or planning a trip). These individuals typically did not pay attention to ambient weather conditions unless they were inconvenient or threatening. Despite this, many respondents displayed relatively high levels of weather salience, in terms of familiarity with and awareness of local weather patterns. While most participants had a general understanding of the difference between a weather watch and a weather warning, a substantial portion of the sample were unable to differentiate between the two products. Lastly, many respondents also indicated that they trusted and valued Environment Canada weather forecasts, and they sought this information actively to help in their decision-making.

KEY WORDS weather forecast; Environment Canada; end-user; weather salience; decision-making

Received 28 May 2013; Revised 25 October 2013; Accepted 6 January 2014

1. Introduction

Numerous private and governmental agencies are responsible for the creation and/or dissemination of a variety of weather products, including daily forecasts, marine forecasts, special weather statements, and severe weather watches and warnings. Meteorologists employ a complex monitoring infrastructure that includes surface weather stations, weather radars and satellites, weather buoys and lightning detection sensors to aid in the creation of these weather products. By using available technology and information, meteorologists across the world are able to develop tens of thousands of unique forecasts *per* day. The ultimate objective of these forecasts is to provide timely and accurate information that may be used to aid decision-making by various end-users.

However, despite the substantial amount of research conducted on the operational aspects of meteorology such as forecast verification, accuracy and implementation, there has been much less written on the societal aspects of weather forecasts (Doswell, 2003). Internationally, there is a growing body of literature that examines how individuals respond to severe weather products, including general watches and warnings (Wong and Yan, 2002; Silver and Conrad, 2010), tropical cyclone warnings (Baker, 1979; Anderson-Berry, 2003; Moore *et al.*, 2004), tornado warnings (Balluz *et al.*, 2000; Hammer

and Schmidlin, 2002; Drost, 2013), flood warnings (Hayden *et al.*, 2007; Burningham *et al.*, 2008), and heat warnings (Changnon *et al.*, 1996; Sheridan, 2007). These studies often examine how and when end-users obtained warning information, and how this information was used during severe weather events. In particular, many studies examine the influence of weather warnings on risk perception and/or decision-making before, during and after high-risk events (e.g. Comstock and Mallonee, 2005; Zhang *et al.*, 2007; Sherman-Morris, 2010). Many recommendations suggested in these articles are concerned with optimizing the communication of risk information between meteorological agencies and end-users for the purposes of reducing morbidity and mortality (e.g. Brown *et al.*, 2002; Sheridan, 2007; Schmidlin *et al.*, 2009).

In contrast, there has been much less peer-reviewed research that seeks to understand end-users' preferences for and usage of non-severe weather information. For example, short-range weather forecasts are among the most common weather products issued by meteorological agencies, and yet there exists little research on how these forecasts are being used by end-users. Notable exceptions include the research conducted by Morss *et al.* (2008), Lazo *et al.* (2009), and Demuth *et al.* (2011) on the sources, uses and perceptions of weather forecasts. These studies examined a national survey of American citizens regarding the ways that they obtained and used weather products. Findings from this research illustrate the significant economic value of weather forecasts, as well as their integral role in the daily lives of many American citizens (Lazo *et al.*, 2009).

A related and emerging area of research examines the relationship between weather salience and forecast usage (e.g. Stewart, 2009; Stewart *et al.*, 2012). Weather salience was

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defined initially by Stewart (2009) as the 'degree to which individuals attribute psychological value or importance to the weather and the extent to which they are attuned to their atmospheric environments'. The findings of this research suggest that weather salience is related to the ways that individuals obtain and use weather information (Stewart *et al.*, 2012). Similarly, recent research on forecast uncertainty has investigated how individuals' comprehension of uncertainty influences their perception and use of various weather products (e.g. Morss *et al.*, 2008; Joslyn and Savelli, 2010; Morss *et al.*, 2010; Ramos *et al.*, 2010). As with previous work on weather salience and the sources, values and uses of forecast information, this research aims to improve meteorologists' understanding of how end-users perceive, obtain and use their forecasts, which may allow for reduced ambiguity and improved comprehension of these products.

Although these studies provide valuable insights on the usage and comprehension of weather forecasts by end-users, most of this research has been written from an American perspective. When compared with the United States, there is much less publicly available research conducted on the human dimensions of hydro-meteorological hazards in Canada, and almost nothing published on the preferences, usage and perception of general weather forecasts by Canadian citizens. With regard to the societal aspects of weather hazards within Canada, examples of publicly available research include: tornado perception (Blanchard-Boehm and Cook, 2004; Silver, 2012; Silver and Andrey, 2014), flood perception and mitigation (Rashid, 2011; Oulahan and Doberstein, 2012), and forest fires (Zaksek and Arvai, 2004). There also exists a growing body of literature that examines the influence of climate change on hazard and disaster risk in Canada (e.g. Etkin, 1995; McBean, 2005).

In contrast, little attention has been paid to general forecast usage and preferences within Canada. Although Environment Canada has commissioned several internal reports that examine similar issues, these documents are not widely available to the general public. Occasionally, information on forecast usage and preferences can be gleaned from articles that focus on severe weather hazards; for example, one study conducted on public perception of and response to severe weather warnings in Atlantic Canada also asked questions regarding respondents usage of weather information (Silver and Conrad, 2010). The results of this study found that the weather and weather-related information played a major role in the lives of many respondents (Silver and Conrad, 2010). However, there is not nearly enough understood about how individuals, particularly within Canada, obtain, interpret and use weather information. As with research on weather salience and forecast uncertainty, this information may be used to improve the communication of weather information from meteorologists to end-users.

The primary purpose of this paper is to explore three broad research questions related to forecast usage and preferences among Canadian citizens, specifically:

1. From where and how often do respondents access weather information?
2. Is weather salience related to forecast perception and/or usage?
3. Are respondents typically active or passive consumers of weather information?

By answering these questions it may be possible to understand better the way(s) that end-users consume and interpret weather information. Accordingly, the next section of this

paper outlines the study area and methods used in this research project. Results from the interviews and the questionnaires are reported in Sections 3 and 4, respectively. Implications of this study are then discussed in relation to the research questions outlined above, and opportunities for future research are suggested.

2. Methods

2.1. Research background

This paper stems from a larger research project on the F3 tornado that impacted the community of Goderich, Ontario, on 21 August 2011. This project investigated how individuals obtained, interpreted and responded to risk information during both the tornado event and a subsequent severe storm of 24 August 2011. To achieve the research objectives of this project, semi-structured interviews ($n = 35$) and close-ended questionnaires ($n = 268$) were conducted with residents of Huron and Perth Counties in southern Ontario, Canada. These sample sizes are consistent with other studies on hazard perception and/or response that incorporated in-person interviews (e.g. Zeigler *et al.*, 1996; Moore *et al.*, 2004; Donner, 2007) and close-ended questionnaires (Hammer and Schmidlin, 2002; Wong and Yan, 2002; Comstock and Mallonee, 2005; Zhang *et al.*, 2007; Silver and Conrad, 2010) in their methodology. This blended approach allowed for a fuller understanding of participants' complex mental constructs (e.g. perceptions, beliefs and preferences), and also provided the opportunity to examine how findings from the interviews were reflected in a larger sample.

The interview script contained questions pertaining to individuals' general weather knowledge, their usage, and perception of forecast information, the 21 August 2011 tornado and the 24 August 2011 storm system. The questionnaire script was not only structured similarly to the interview script in terms of themes and questions, but also included 19 additional questions on long-term impacts and recovery. This paper explores the results of questions relating to general weather knowledge and forecast preferences from both the interviews and the questionnaires. A detailed analysis of the interviews can be found in Silver (2012), while a thematic analysis of the questionnaires is available in Silver and Andrey (2014). It was found that the preferences and perspectives reported by the interview participants were corroborated by the questionnaire results, particularly in terms of weather salience, trust, and general weather knowledge. With this in mind, the interview results may be used to contextualize the questionnaire results reported in this paper.

2.2. Interview recruitment, data collection, and analysis

Interview participants were recruited using a purposive sampling framework. First, the research project was advertised across a variety of media, including thematic *Facebook* groups and electronic mailing lists. Next, the primary researcher was interviewed about the project by several media outlets, including a radio station and print newspaper located in Goderich, Ontario. A second wave of recruitment was completed using a snowball sampling framework; this subsequent recruitment was successful in garnering the participation of individuals who had been previously unaware of the research project. The interviews took place between October and November 2011 in Goderich, Ontario. The sessions lasted between 25 and 80 min, with most interviews lasting approximately 45 min. The interviews were transcribed verbatim into word documents by

four undergraduate students shortly after the interviews were concluded. Random transcripts were chosen from each student and reviewed fully to ensure accuracy and completeness. The transcripts were then analysed by coding various themes relevant to the research topic. These themes included: general weather knowledge; protective action decisions; risk perception/awareness; risk communication (to participant); risk communication (from participant); and cell phones/social media. Once the transcripts had been broken out into these themes, the information was analysed using methods similar to those outlined by McCormack (2000), whereby transcripts are reviewed multiple times to pick up patterns from different 'lenses' (such as language, context and narration).

2.3. Interview participants' demographics

A total of 35 participants were interviewed during 32 sessions between 4 October and 17 November 2011. The sample was composed of 20 females and 15 males, which is a more balanced gender ratio than was present in the questionnaire sample. This discrepancy may be explained partially by the request of three participants to be interviewed with their opposite-sex partners. The remaining socio-demographic characteristics of the interview participants (outlined below) are reasonably similar to those of the questionnaire respondents.

The ages of the participants ranged from 20 to 74 years, with the median being 47 years. In terms of employment status, most participants were employed either full- or part-time. Five individuals indicated that they were unemployed, and five respondents were outside of the workforce (either retired or student status). The occupations of the interview participants were diverse, and included positions from a wide range of industries (e.g. health care, educational services, construction, business services, finance and real estate, retail trade, and tourism). The gross household income for participants ranged from <\$20 000 to >\$150 000 annually, with a median value of \$70 000, which is similar to the 2010 Canadian median household income (Statistics Canada, 2012). The majority of interview respondents indicated that they have lived at their current address for over 5 years, with many participants having lived in the same community for most of their lives.

2.4. Questionnaire recruitment, data collection, and analysis

As with the interviews, the questionnaires were advertised throughout Huron and Perth Counties. First, an electronic version of the questionnaire was created and advertised through both the Internet and local media channels. Hard copies of the questionnaire ($n = 27$) were also distributed concurrently through a door-to-door systematic random sample in February 2012. After the closing date, data from the questionnaires were formatted for analysis in the *Statistical Package for the Social Sciences* (SPSS). Percent frequencies were calculated and statistical significance was determined using Pearson's chi-squared test.

2.5. Questionnaire respondents' demographics

By the closing date in March 2012, a total of 268 completed questionnaires were received and included in the data analysis. As the number of responses varied *per* question from 217 to 268, the denominator for all of the percentages stated in this paper was determined based on the number of responses to each question. A summary of the questionnaire sample's

Table 1. Socio-demographics of the questionnaire sample ($n = 268$) in comparison to the census area (Statistics Canada, 2007).

	Present study (2012)	Statistics Canada (2007)
Gender (% female)	66	51
Age (median)	40–49	42.3
Household income (median)	\$50 000–\$74 999	\$57 845
Education (% high school diploma)	22	28
Education (% university or college diploma)	36	38
Mobility status (% resident >5 years)	60	69

socio-demographics can be found in Table 1. In general, the socio-demographics of the sample are similar to the Statistics Canada census survey for the census area (Statistics Canada, 2007). Although women are over-represented in this sample, this is a common trend among social science studies that use questionnaires in their methodology (e.g. Sax *et al.*, 2003).

3. Interview results

3.1. Thematic analysis

Most participants indicated that they checked the weather forecast for pragmatic reasons, such as deciding weather-appropriate clothing or planning a trip. A few respondents checked the weather multiple times *per* day, but most of these individuals agreed that they did so because of their inherent interest in the weather. These 'weather enthusiasts', who accounted for approximately one-fifth of the sample, also tended to use higher-level weather products such as radar and operational analysis charts. They were also more likely to access a variety of weather products and websites to assist with their weather-related decision-making. In contrast, typical weather consumers tended to check the Environment Canada website, the Weather Network television station, or the local radio station for weather information.

Most participants had a general understanding of the difference between a weather watch and a weather warning. Many people indicated that a weather watch was 'less severe' than a warning, and that a weather warning was 'more urgent'. As one participant explained:

Um, a watch is just to, you know, be aware that there's something that could be going through. A warning is a little bit more severe, I do believe . . . A watch is just, you know, 'Pay attention', and a warning is 'Now it's coming so just be careful'.
(Female, 25 years old)

A few interviewees were able to define both terms completely, but 10 of the 35 respondents were unable to differentiate between the two. Several participants also acknowledged that they did not realize Environment Canada issued both watches and warnings. The majority of participants said that they were very familiar with local weather patterns, and most agreed that they were used to severe weather blowing in off Lake Huron:

When you live on the lake, you know, when fronts come across, it's not a big deal. In fact, in this town a lot of times, if you know there's a good storm coming, people will go down to the lake to

watch the storm come across . . . We all do it.
(Male, 44 years old)

Most participants also agreed that they were more aware of winter severe weather than summer severe weather. Many people cited the snow squalls that are a common hazard in Huron and Perth Counties as the reason for this differential awareness.

Participants were also asked about the best way(s) to disseminate a weather warning. Although there were various suggestions (e.g. radio broadcast, television broadcast, cell phone 'app' notification), most people said that a text message or an automated telephone call would be their most preferred method of warning communication. As one respondent explained:

So many people carry cell phones . . . There's nothing else that in today's society anybody carries with them, because everything else you've got to turn on, go seek out. If it's a computer, you gotta turn it on or go look for it. If it's a radio, you've gotta either be in your car with the radio on or, you know, in a building with that. And TV, you gotta wait for a time [that the weather is] gonna be on. A cell phone is with you no matter where you go. No matter what phone it is, [a text message] will come.

(Male, 44 years old)

When asked about the best way for officials to disseminate warning information, several participants said that they wanted their communities to install outdoor warning sirens. Although this finding was not entirely unexpected given the impacts of the F3 tornado in the community of Goderich, Ontario, several months prior to data collection, the question was in fact worded so as to apply to weather warnings in general. Finally, no one indicated that a weather radio was his or her preferred method of warning communication. This is unsurprising, given that only eight individuals knew about Environment Canada's Weatheradio programme, and only two had weather radios on their properties.

4. Questionnaire results

4.1. General weather questions

Respondents were first asked about their preferences for and usage of specific weather products. Approximately 80% of respondents indicated that they checked the weather at least once *per day*, which is comparable to previous research conducted in the United States (Lazo *et al.*, 2009), but is substantially higher than a study conducted in Atlantic Canada (Silver and Conrad, 2010). As shown in Table 2, the local

radio station was the most frequently accessed communications medium, with 54% of respondents using the radio at least once *per day*. In-person communication (48%) and local television stations (34%) were also used daily by many respondents. Internet sources were checked at least once *per day* by approximately one-fourth of the respondents, with 28% of respondents accessing Environment Canada's website daily and 25% of respondents accessing The Weather Network's website daily. This figure matches closely with previous research that found approximately 27% of respondents accessed weather information through the Internet at least once *per day* (Lazo *et al.*, 2009). Although the majority of respondents checked the weather at least once *per day*, 24 people (9%) indicated that they 'rarely or never' checked these weather media.

When broken down by socio-demographic variables, it was found that gender, age, household income and residential status influence weather product preferences. In terms of gender, it was found that women were more likely than men to obtain weather information by talking to other people (p -value = 0.0029), while men accessed the local radio station more often than women (p -value = 0.0314). Age also influenced how often respondents checked particular media in ways that are consistent with previous research (e.g. Silver and Conrad, 2010). Specifically, respondents 50 years and older checked the television more often than younger respondents (p -value = 0.0002), and respondents aged 18–39 used cell phone applications more often than older respondents (p -value = 0.0015).

Household income appears to influence weather product preferences in complicated ways. For example, respondents with a household income of <\$35 000 checked The Weather Network website more often than expected, while respondents in higher income brackets checked this source less often (p -value = 0.0014). Household income also influenced how often individuals obtained weather information from cell phone 'apps'. Those respondents in low income families (<\$35 000 annual income) and high income families (>\$100 000 annual income) used cell phone apps more often than other income brackets (p -value = 0.0485). There was also a statistically significant association between household income and access of local radio stations (p -value = 0.0356), although the nature of the relationship between these variables was unclear.

Finally, there was also a relationship between residential status and usage of The Weather Network. Those respondents with a residential status of 5 years or longer at the same address accessed The Weather Network television station more often than expected (p -value = 0.0378), while newer residents tended to access The Weather Network television station less often. Interestingly, residential status was not found to be associated with preference for or usage of either local television stations or local radio stations.

Table 2. Responses to the question: 'In a typical week, how often do you access the following to learn about the weather?'

Source	At least once <i>per day</i> (%)	A few times <i>per week</i> (%)	Once <i>per week</i> (%)	Rarely/never (%)	<i>n</i>
Environment Canada (website)	28	27	13	33	243
The Weather Network (website)	25	24	14	37	231
The Weather Network (television)	29	18	16	37	233
Local television station(s)	34	14	9	43	219
Local radio station(s)	54	15	7	24	236
Cell phone 'app'	24	12	4	61	217
Talk to people	48	27	10	15	227
Other	11	4	7	79	76

Values are rounded to the nearest percent.

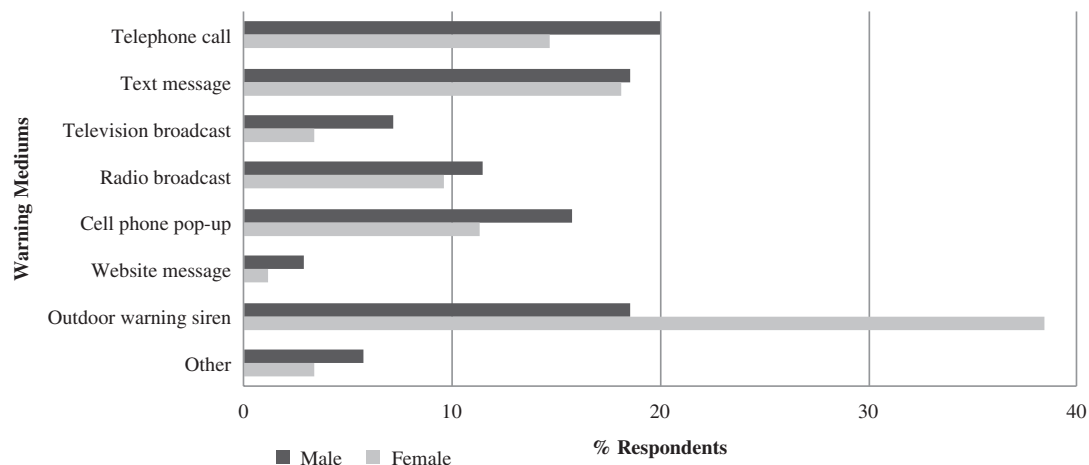


Figure 1. Responses to the question: 'If an Environment Canada weather warning was issued for your area, what would be the best way to make this information available to you?' The results of this question illustrate respondents' preference for automated communications mediums. Values are rounded to the nearest percent.

Next, respondents were asked to choose the best way for Environment Canada to communicate a weather warning to them (Figure 1). The greatest number of respondents chose an outdoor warning siren as their preferred communications medium. This result was not unexpected, given the responses provided during the in-person interviews regarding the F3 Goderich tornado. After an outdoor warning siren, respondents selected text messages, telephone calls and cell phone pop-up notifications as their most preferred communications media, a pattern that was true for both men and women. Non-mobile and/or non-automatic communications media, such as television broadcasts and website messages, were less popular. Finally, 10 respondents indicated that there was no 'best' communications medium, and that weather warnings should be disseminated across many outlets.

4.2. Weather salience, trust, and preparedness

In addition to questions on weather products, respondents were also asked a series of general questions that explored weather

salience, trust and preparedness. In terms of weather salience, respondents were asked five questions that investigated familiarity, awareness and interest in the weather (Figure 2). In general, these results show that respondents reported relatively high levels of weather salience. Most respondents indicated that they check the weather regularly even if there is not a special reason for them to do so, and over half agreed that they find the weather to be interesting. Given this, it is unsurprising that only 12% of respondents felt that the weather did not affect them very often.

When asked about their familiarity with weather, the majority of respondents agreed that they were familiar with local weather patterns. It is not surprising, then, that 67% ($n = 178$) of respondents said that they usually pay more attention to severe winter weather than severe summer weather, because snow squalls and winter storms are a common hazard in Huron and Perth Counties. However, when broken down by socio-demographics, it was found that residential status was not correlated positively with perceived familiarity with weather patterns. In other words, length of residency (<5 years *versus*

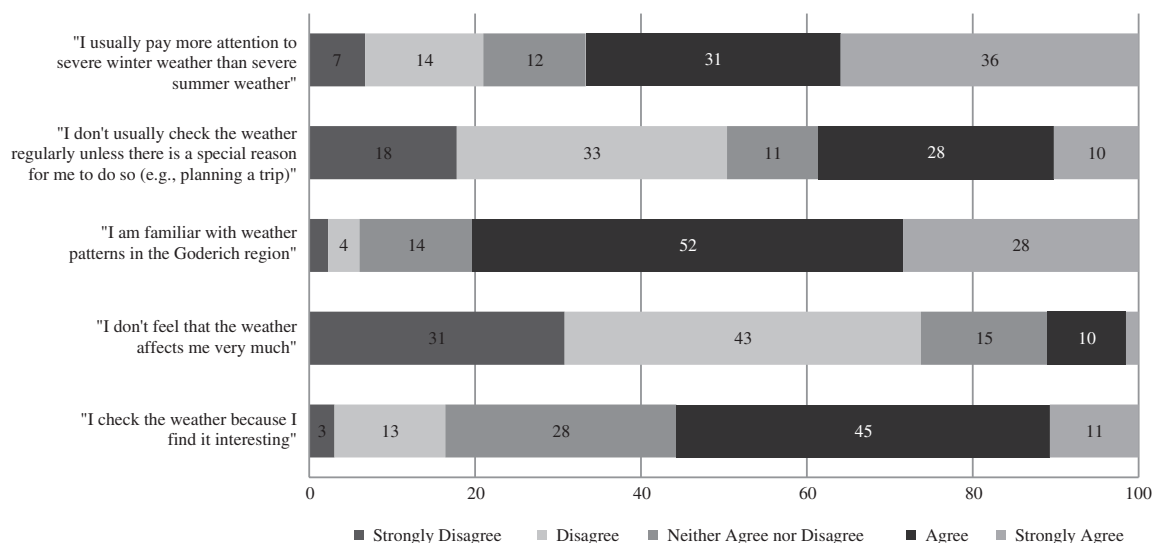


Figure 2. Responses to five questions that probed weather salience. Values are rounded to the nearest percent.

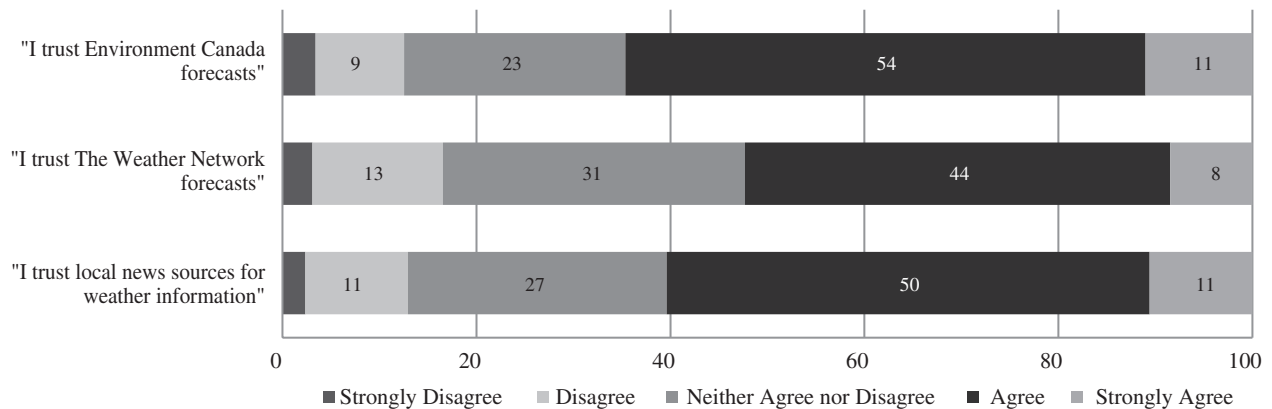


Figure 3. Responses to three questions that probed issues of trust. Values are rounded to the nearest percent.

>5 years) did not appear to influence weather salience. Other socio-demographics factors, such as gender, age and education, similarly were unrelated to weather salience. This result was surprising, as previous research suggests that women are typically more salient than men (e.g. Stewart, 2009; Stewart *et al.*, 2012) and older persons are often more salient than younger persons (Stewart *et al.*, 2012).

Participants were also asked three questions regarding trust in issued forecasts (Figure 3). In general, individuals reported relatively high levels of trust in the weather information they received. Environment Canada was the most trusted weather source, with 65% ($n = 170$) of respondents indicating that they trusted the forecasts issued by this agency. Respondents also indicated a high level of trust place in local news sources (60%, $n = 154$) and The Weather Network forecasts (52%, $n = 136$). When sorted by gender, men chose Environment Canada as their most trusted source of weather information over either local news sources or The Weather Network (p -value = 0.009).

Finally, respondents were asked four questions that probed risk aversion and preparedness. First, respondents were asked about whether they had reliable access to an Environment Canada weather radio. Although only about one-fourth of the respondents indicated that they did have reliable access to a weather radio, this number is higher than expected based on interview data, as well as previous studies that found weather radios are not a popular warning communications medium in Canada (Durage *et al.*, 2013). Interestingly, approximately one-third of the respondents indicated that they were unsure whether they had reliable access to a weather radio. This finding

suggests that many respondents have a poor understanding of the Environment Canada Weatheradio programme or of weather radios in general.

Next, respondents were asked whether they had enough food, water, and supplies to last 72 h in the event of an emergency. The majority of respondents answered this question in the affirmative. When broken down by gender, men were more likely to answer this question in the affirmative than women (p -value = 0.014). These results are surprising, and are much higher than expected. One potential explanation may be found in previous studies on actual *versus* perceived preparedness. For example, Paton *et al.* (2000; 2008) found that many respondents reported high levels of preparedness, when in actuality their supplies were insufficient for the needs of a potential future disaster.

Lastly, respondents were asked about their tendencies during severe weather warnings (Figure 4). Approximately 87% ($n = 225$) agreed that they check the weather more often before and during severe weather, while 69% ($n = 181$) agreed that they try to avoid travelling if there was a severe weather warning posted for their area. Results indicate a correlation between how often individuals checked the forecast and their willingness to alter travel arrangements during severe weather (p -value = 0.000). Specifically, those individuals who were prone to check the forecast more frequently during severe weather were also more likely to alter travel arrangements. The opposite was also true: individuals who did not check the forecast more frequently during inclement weather were less likely to alter travel arrangements.

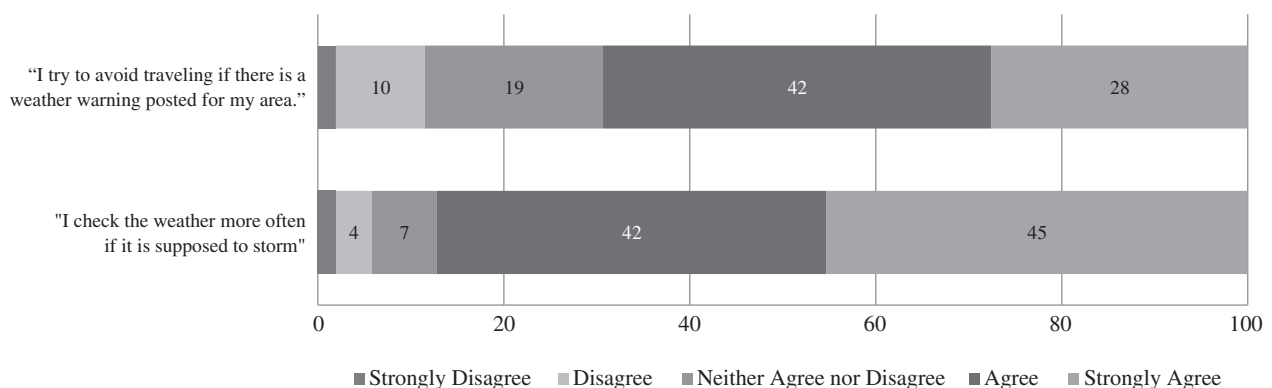


Figure 4. Responses to two questions that probed issues of preparedness and risk aversion. Values are rounded to the nearest percent.

5. Discussion

Although meteorologists and forecasters have an intuitive and/or anecdotal understanding of how their forecast products are being used, there are few empirical studies that explore the ways that end-users obtain, interpret and respond to weather information, particularly from a Canadian perspective. This research, which examined forecast preferences for and usage of weather information among Ontario residents, supports the conclusions from previous studies that found end-users interact with weather information in a variety of complex ways (e.g. Lazo *et al.*, 2009; Demuth *et al.*, 2011; Stewart *et al.*, 2012). In particular, socio-demographic factors, such as gender and age, and contextual factors, such as impending severe weather or travel plans, were found to influence whether and how often end-users sought out weather information.

As with the study conducted by Lazo *et al.* (2009), this research found that individuals obtain weather information both actively (i.e. when they choose to seek this information out) and passively (i.e. when the information is delivered to them). The results of this research found that active forms of weather consumption, such as visiting the Environment Canada website or turning on The Weather Network television station, account for a considerable portion of individuals' weather information consumption. However, when asked how individuals would prefer to obtain weather information, a strong preference emerged for mobile and/or automatically delivered information, especially for weather watches and warnings. In particular, both men and women expressed the desire for information to be delivered automatically through outdoor warning sirens, text messages, telephone calls and mobile phone pop-up notifications.

This finding is particularly informative when compared with the research conducted by Lazo *et al.* (2009), which found that only 5% of respondents used cell phones or other portable electronic devices to obtain weather information; approximately 90% of the respondents from that study indicated that they 'rarely or never' used cell phones to access forecasts. Given that this research was conducted in late 2006, the results of the present study suggest a dramatic increase in the proliferation and use of cell phones to access weather information.

In terms of awareness, the results from this study suggest that respondents display typically high levels of weather salience. Specifically, a large number of questionnaire respondents self-reported that they checked the weather at least once *per day*; they were familiar with the weather patterns in their region; and that they felt the weather played a large role in their lives. Results from the interviews also highlight the influential role that interest can have in increasing weather salience. Specifically, individuals who displayed high levels of weather salience also typically self-reported high interest in the weather and its extremes. Weather salience was also correlated with the frequency with which individuals checked the weather, as well as the sources that individuals accessed. While the preliminary findings corroborate previous research on weather salience and the consumption of weather information (e.g. Stewart *et al.*, 2012), it is important to note that the present study used a different measure to assess weather awareness. This may explain partially why gender and age did not intersect with weather salience as anticipated (e.g. Stewart, 2009; Stewart *et al.*, 2012). Future research on weather salience may benefit from incorporating more sensitive and/or comprehensive measures into its methodology.

5.1. Study limitations and opportunities for future research

It is important to note that participants in both the interviews and the questionnaires were selected using non-probability sampling techniques (i.e. convenience and snowball sampling). It is possible that this sampling framework encouraged self-selection by those individuals who were inherently interested in the weather; thus, the results from this survey may represent a sample that is more 'weather savvy' than the general population of Canada. Self-selection also may explain partially the relatively high levels of weather salience reported in this study, as well as the ability of most interview respondents to differentiate generally between a weather watch and a weather warning. For example, previous research has found a significant relationship between weather salience and the knowledge of weather watches and warnings (Stewart, 2009). Future research may benefit by incorporating a systematic random sampling framework to reduce the potential for self-selection bias.

Given the findings of this exploratory study, there are several avenues of future research that may contribute to the growing understanding of the use of weather forecasts by end-users. Specifically, the few empirical studies that have been conducted on the values, perceptions and uses of forecast information have focused generally on end-users. Future research on the utility of weather forecasts may benefit by expanding the methodology to incorporate research on the attitudes, behaviours and perceptions of meteorologists and forecasters. While recent research has begun to address aspects of this problem (e.g. Morss and Ralph, 2007; Demuth *et al.*, 2012; Heinselman *et al.*, 2012), not nearly enough is known about the evolution of weather products from conceptualization by the forecaster to use by the end-user. By examining a weather product from its creation, through dissemination and consumption, it may be possible to understand better how weather information is used.

Finally, issues of trust, satisfaction and confidence arose frequently throughout the interviews. Although the questionnaire explored briefly the end-users' trust in specific agencies, questions on satisfaction and confidence were not included. Not nearly enough is known about each of these three constructs, particularly how they relate to and influence one another. As noted by Demuth *et al.* (2011), these issues appear to be distinct and highly influential, and future research would benefit from exploring these concepts.

6. Conclusions

The primary objective of this paper was to explore issues relating to forecast usage and preferences among Canadian citizens. This research has value in broadening the empirical literature on the sources, perceptions and uses of forecast information, which in turn may allow forecasters and meteorologists to improve the comprehension and usefulness of their weather products. Although this research was exploratory in nature, the findings suggest that individuals interact with weather information in many complex ways, and that weather forecasts play a substantial role in the daily decision-making process of many individuals. Although the sampling framework limits the ability to generalize these results to the broader population, this research contributes to an improved understanding of issues relating to the perception, preference, and usage of forecast information. As such, the results of this paper may help inform future research on this important and understudied topic, in both Canada and abroad.

Acknowledgements

The author would like to thank Jean Andrey from the University of Waterloo and Brian Mills from Environment Canada for their feedback on the initial draft of this manuscript. She also thanks the two anonymous reviewers, whose thoughtful and detailed comments have allowed the final version of this paper to be much improved.

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