Analyzing Differences Between Perceived and Objective Risk and Outcomes in Flood Mitigation

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Introduction

With the onset of more frequent and severe rainfall events due to man-made climate change, it has become ever-important for homeowners to guard themselves, both financially and physically, against the effects that these events can have on their property. An increased incidence of urban flooding events due to extreme rainfall has put pressure on homeowners to take such protection seriously, and yet, there remains a gap among homeowners between the perception of risk and actually taking action to protect themselves (Price et al., 2020). This report is primarily concerned with filling in a gap in the understanding of this issue. Previous research pertaining to this gap, while ultimately limited in its scope, demonstrates that this gap indeed exists in certain communities (Agrawal et al., 2020). The primary purpose of this report is to further identify and understand what contributes to the phenomenon. Time has been placed in developing an understanding of risk in order to help fill this gap, but also to increase our understanding of the evaluation methods used to estimate risk and protection against risk. To start, an initial review of previously used methods will be necessary in order to understand where past research on risk and evaluation of said risk has failed, but also to see what has worked in the past. Building on that foundation, our focus will then shift to current methods concerned with risk and evaluation. Finally, we shift forward into the development of new programs aimed at reducing risk and their efficacy at accomplishing such a task.

In our research, we have decided to explore factors that affect perceived risk in addition to factors that perceived risk influences in relation to flooding events across Canada. How these different factors both affect and are affected by perceived risk is important to understand as we believe it will be helpful in identifying why mitigation measures (including uptake of insurance) are/are not adopted by homeowners.

There seems to be a lot of conflicting evidence in previous studies as to whether there is a statistically significant correlation between the perceived risk and objective risk. Literature suggests that people will learn from previous destructive events and that when given information showing objective risk, they will increase their perceived risk, while others show that past experience causes people to believe it will not happen again (Dickie et al., 2020; Scolobig et al., 2012; Harries, 2012). To establish if there is a disconnect we ask: Is there a disconnect between the perceived risk of basement flooding and the objective risk of basement flooding? For our particular data, we hypothesize that objective risk of flooding will be significantly different from perceived risk of flooding.

To understand why people make the decisions that they do, it is imperative to understand the reasoning behind their perceived risk. Previous papers have highlighted many demographic factors as well as how previous experience will have an effect on people's perceived risk. There is also some conflict as to whether personal demographics are a statistically significant demographic determinant that affects perceived risks. (Wachinger et al., 2013; Kuligowski et al., 2021). It is generally concluded that further analysis must be done to determine if these factors truly affect perceived risk, so we wanted to examine this by asking; Do gender, household income, level of education received, and language spoken at home have a significant impact on perceived risk of basement flooding? Research done by Wachinger et al. (2013) where it was found that most factors are not statistically significant on their own, but only when combined with other factors, we hypothesize that these factors will be statistically significant when they are combined.

To further understand the reason behind people's decisions relating to perceived risk, it is necessary to understand what factors are influenced by perceived risk. We decided to ask; What factors influence one's perceived risk of flooding? Two factors that we expect to influence perceived risk are likelihood of buying insurance and willingness to pay for flood mitigation techniques. For the likelihood of buying insurance, we ask; How is perceived risk affected by the likelihood of buying insurance? Our hypothesis is that a household's perceived risk would have a positive correlation with the household's likelihood of buying insurance. For the willingness to pay, we ask; How is perceived risk affected by one's willingness to pay? Our hypothesis is that having a higher perceived risk of residential flooding will increase a household's willingness to pay for various flood mitigation techniques. Data suggests demand for insurance is relatively inelastic and therefore the willingness to pay for insurance may have a large range (Shively, 2017). This would mean that while perceived risk may have an impact on willingness to pay, price would not matter as much.

Understanding the gap between perceived risk and actions taken to manage said risk involves understanding the methods used to evaluate and therefore manage risk. As anthropogenic climate change increases the frequency and severity of rainfall events, the importance of proactively adopting risk mitigation strategies increases as well. Bridging gaps between perceived and objective risk is imperative in protecting communities against the effects of natural disasters. In addition to closing the gap, getting people to invest in flood mitigation measures to protect their homes from flooding has been troublesome and understanding why they are not investing is another important issue. The survey conducted to analyze both of these issues and potential reasons for why they are happening was collected in 2016, with Canadians that were 18 years and older all over Canada. The questionnaire included household income, level of education, gender, language spoken at home, the perceived risk of flooding, and questions on if they have various methods for dealing with flooding (mitigations or insurance).

Comparing these variables with each other and the objective risk of basement flooding allows us to examine potential correlations in regards to why people are not investing in mitigation methods or why they believe they do not need them.

Literature Review

To understand the factors affecting household demand for risk reduction, it is important to examine historical methods and their effectiveness. Risk reduction, specifically for flooding, has been a concern throughout the historical record The first documented civilization, Sumer, used floodplains as a form of agricultural irrigation; similar to what was done in ancient Egypt (Crawford, 1988; Mays, 2010). Since humans have been dealing with flooding for millenia, many management strategies have been attempted and analyzed. When examining more recent methods, the majority of these strategies can be categorized as land-use regulations, construction specifications, structural flood protection, and encouragement of behavioural changes (Chang et al., 2020). We examine factors affecting demand for risk reduction across these strategies.

Two major factors, which have historically increased demand are: household size and recent experience with a major flood event (Kreibich et al., 2005). The increase in demand is augmented by informational programs and financial incentives (Kreibich et al., 2005). This is especially true if these are implemented during the immediate aftermath of a flood at the same time as reconstruction (Kreibich et al., 2005). A study, conducted across the Canadian prairie provinces found that while risk reduction preferences vary by province, management was most likely to be valued at the highest willingness to pay when residents mitigated a perceived risk to health and human life (Morrison et al., 2019).

Current methods for flood risk management and prevention in Canada can vary by province and city, it's reliant and is reliant on the perceived risk by homeowners and overall risks of flooding in their neighborhood (Nastev and Todorov, 2013). Previous literature on flood risk management analyzed how effective tools and programs implemented by governments are, how other natural disasters, such as wildfires, effect decisions homeowners make, and how the risk is perceived based on area and knowledge of flooding events. Communication of risk is also explored as not all residents may be aware of the procedures governments employ to reduce risk, and there is a lack of communication between residents, authorities, and government which leads to a skewed perception of risk by residents (Stewart and Rashid, 2011). The methods governments are currently using are centralized on reacting - there is little focus on preventing floods from happening, at the outset which may explain the skewed risk perception of residents (Raikes et al., 2019). There is also debate about whether to make risk management services delivered by the public or private sectors. While there is currently a mix of both public and private, having some services designated as private goods can interfere with residents being able to access the service (Geaves and Penning-Rowsell, 2016; Thistlethwaite and Henstra, 2017). While many new buildings are built with floods risk in mind, and are up to code with government policy, a big problem will be getting residents in older buildings to update their homes to prevent flooding (Chang et al., 2019). Homeowners might not realize that their home is at risk, other natural disasters, such as wildfires, might be a bigger concern for them, or there is confusion about government policy and the increasing frequency of natural disasters (Agrawal et al., 2020). Residents need to be more aware of the risk to their homes; for example the Hazus program operated by the federal government, allows communities to educate themselves about the risks and the consequences of those risks (Nastev and Todorov, 2013).

In order to help residents reduce damages from floods and, by extension, dependence on insurance as a primary management practice, there are several risk reduction practices and strategies that have been adopted in different parts of North America. These flood risk reduction methods often emulate existing methods and strategies in place for other natural disasters such as wildfires. For wildfires, risk reduction methods are often done by private homeowners and landowners and include using fire resistant materials and creating 'defensible space around their homes and businesses' (Talberth et al., 2006). This is primarily to compensate for shortfalls in insurance coverage (Talberth et al., 2006). With risk reduction for floods, the aim is typically the same. With this, there are differences in methods for commercial buildings, residential and multi-use areas, and farmland as the functions and purposes of these areas differ. For commercial areas and buildings, contingency plans and funds, for critical equipment and retrofitting are the primary risk reduction strategies (Moudrak & Feltmate, 2019). The retrofits typically include elevating and flood-proofing critical equipment and supplies, protecting server rooms and other critical areas, and upgrading electrical panels to allow for remote shut off (Moudrak & Feltmate, 2019). Some of the critical equipment includes sump pumps, air moisture sensors, portable generators and battery operated lighting. These combined are intended to reduce the expected damage from floods, while also accounting for increased risk due to climate change (Moudrak & Feltmate, 2019).

For residential buildings and areas, efforts could be by individuals or by communities. Individual methods are typically influenced by an individual's perception of risk, both perceived probability and perceived severity (Mann & Wolfe, 2016). The methods include adopting public flood prevention methods (Mann & Wolfe, 2016) and flood proofing through retrofitting. Community methods often include methods that follow the protect/accommodate/retreat/avoid framework (PARA) and vary from place to place within Canada (Doberstein et al., 2019). In the BC Lower Mainland, which is located along the Fraser River Valley Delta, a system of dikes and pumping stations are in place to protect the area from major destruction from floods (Doberstein et al., 2019). This uses the ‘protect’ approach. Other communities such as the Red River Valley of Winnipeg, used the ‘accommodate’ approach, through use of a ring dike, (e.g. the 2011 flood); while others have used ‘retreat’ methods such as in 1954 with flooding from Hurricane Hazel in Toronto. Yet others have used 'avoid' approaches such as in the Calgary flood of 2013 (Doberstein et al., 2019).

Understanding the gap between perceived flood risk and preventative measures taken, involves understanding historical and current methods of risk reduction, management, and analysis. Since the dawn of human civilization, floods have posed risk to settlements and infrastructure, giving rise to preventative and reactive measures. Flood risk management strategies encompass many types of mitigation, including land-use regulations, construction specifications, structural flood protection, and communication strategies to influence behaviour (Chang et al., 2020). In more recent times, communication strategies include government communication of procedures. Residents’ perception of risk can be altered by a lack of communication between themselves and authorities and government (Stewart & Rashid, 2011). Retrofitting older homes is of great concern as new homes are built with risk reduction measures already in place (Chang et al., 2019). Perceived risk, concerns about other types of disasters, and understanding of government policy play a role in the acceptance of retrofitting (Agrawal et al., 2020). Flood mitigation strategies tend to be related to gaps in insurance, which relates to property type (Talberth et al., 2006; Moudrak & Feltmate, 2019). Therefore, residential, commercial, and farm areas have differing risk reduction strategies.

Methods

To examine the potential gap between perceived and objective risk, the following procedures were executed. Firstly, the dataset was revised to omit responses from participants who spent less than ten minutes on their surveys, as it was felt that this was too short of a time to give meaningful responses to all questions. In addition to this step, the hazard scores for objective risk that were calculated from proximity and elevation indices were multiplied by 4, as they were out of 25, to align with the estimates of perceived risk which were answered as percentages. Using the revised dataset, statistical tests were performed on the values for perceived risk and objective risk, looking at the comparisons of objective risk and perceived risk of basement flooding. The statistical tests performed were comparison of means, frequency analysis, and bivariate correlations. The objective of these tests was to examine the relationship between objective and perceived risk, identifying potential correlations and trends. Additionally, two cases were identified in the dataset that showed vast differences between the discussed variables to exemplify situations where the objective risk index is much greater than perceived risk and vice versa.

From there, a multivariate linear regression was conducted to analyze the relationship between perceived risk of basement flooding and gender, household income, the language spoken at home and the level of education. The objective risk of basement flooding was also included in this analysis to see how it interacted with perceived risk in relation to our chosen demographic variables. In order to run this linear regression, we re-coded gender and language spoken at home so that they became dummy variables; Gender was converted to a binary scale with female having a value of 1 and male having a value of 0, for language spoken at home, english, being the primary language spoken in Canada, was given a value of 1 and all others were given a value of 0 (Statistics Canada. 2017). The perceived risk of basement flooding was used as the dependent variable, and was tested against the independent variables. The objective of the linear regressions was to compare the effects of objective risk of basement flooding, gender, income, language and education level on the perceived risk of basement flooding. We hypothesized that together, these factors would have a significant impact on people's perceived risk of flooding, with objective risk, gender, and level of education having the greatest effect, based on the literature we had read.

In order to determine the relationship between perceived risk of basement flooding and various mitigation methods and the cost associated with said methods, bivariate correlation tests were carried out. Utilizing the results from the correlations, multivariate regressions for different combinations of the mitigation methods and associated costs were performed in order to identify any significant combination of mitigation methods. For the correlation tests, our hypotheses were that we would see a significant correlation (i.e. above 0.500) between perceived risk of basement flooding and mitigation methods. We also expected to see a significant correlation between perceived risk and the willingness to pay for mitigation techniques and a significant correlation between perceived risk and insurance related methods. For the regressions, we expected to see high R-values and high significance among complimentary mitigation methods based on the correlation results.

Results

Resultant from the generation of descriptive statistics, the mean objective risk index was around 30, while the mean perceived risk of basement flooding was 14%. The standard deviations were 27% and 21%, respectively. The comparison of means provided a deeper analysis of the means, using objective risk index as the independent variable and perceived risk as the dependent variable to analyze the mean perceived risk within each level of objective risk. For the lowest indices of objective risk (4-8), the mean perceived risk was overestimated, around 15%. In the range of objective risk indices between 12 and 32, the mean perceived risk was relatively aligned, ranging from around 14% to 26%. In the range of objective risk index above 32, however, the mean perceived risk becomes much more variable and much less accurate. The mean perceived risk in the objective risk index range of 36 was 8%. The mean perceived risk values for the 40-100 range of objective risk indices stayed within the range of 10%-26%. The results of the frequency analysis explain these results. The frequency distribution of perceived risk estimates shows that 33% of responses were of 0% risk. 50% of responses were of perceived risk under 10% and 70% of responses were of perceived risk under 15%. Given that the vast majority of responses for perceived risk fell into the 0%-15% range, this explains why the mean perceived risk was so low compared to the mean objective risk index. The majority of objective risk indices were in the 12-20 range, as 66% of scores fell into this range. The standard deviations, though similar, are congruent with these findings, as there was a slightly more even distribution of values for objective risk than perceived risk. The values for objective risk had more values on the high-end of the spectrum, leading to the higher mean of 30. **Figure 1** shows the frequency of responses for objective and perceived risk to represent these findings visually.

The bivariate correlation test revealed that there is a -0.014 correlation between objective risk and perceived risk of basement flooding. This result was not statistically significant, though it should be noted that the correlation coefficient is negative. **Figure 2** shows a scatterplot of perceived risk estimates vs objective risk indices, highlighting the lack of correlation between these variables.

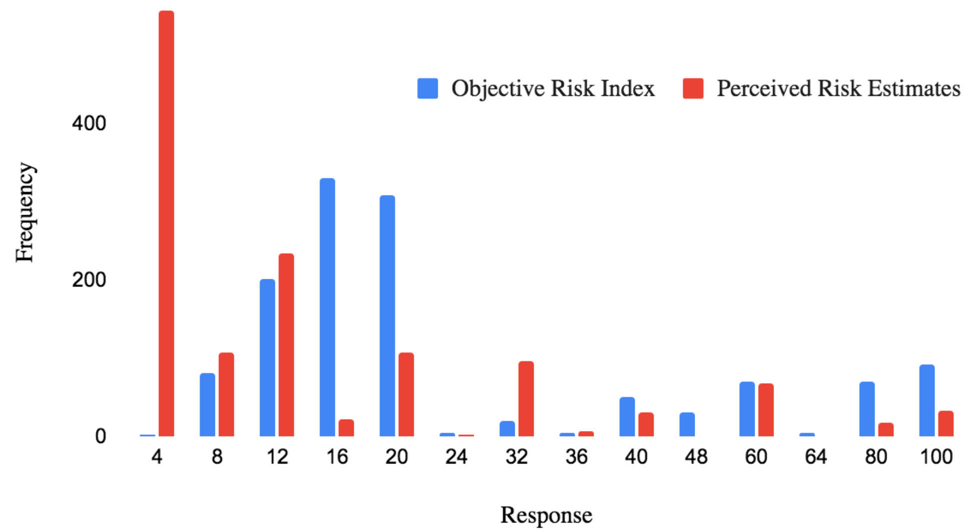

Figure 1. *Note*. This figure shows the number of responses for each level of perceived and objective risk. Values for perceived risk were grouped to align with the values for objective risk index for the purpose of this chart.

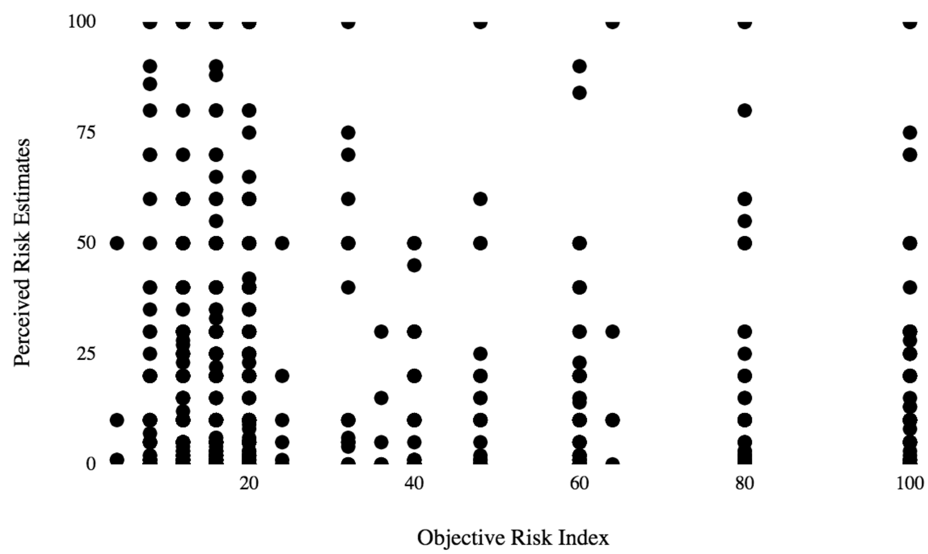

Figure 2. *Note*. This figure shows the responses of perceived risk vs the respective objective risk indices.

When examining the results of our multivariate regression analysis looking at demographic factors as well as the objective risk of basement flooding, we see an R squared value of 0.019, indicating that 1.9% of the variation of perceived risk of basement flooding can be explained by our independent variables (level of education, gender, objective risk of basement flooding, language spoken at home, and household income). The ANOVA analysis gave an F value of 4.830 and a p-value of 0.000, indicating that there is a significant relationship and allowing us to disprove the null hypothesis that there is no correlation between our independent variables and the perceived risk of basement flooding. This supports our hypothesis that level of education, gender, objective risk of basement flooding, language spoken at home, and household income will interact and have a significant impact on a person's perception of risk. When referring to the coefficients of each of the actors individually, we see that gender and language spoken at home are the only two individually significant factors (at a confidence interval of 90% and alpha=10) with t-values of 3.041 and 1.886 and p-values of 0.002, and 0.060, respectively. This indicates that people who identify as female and people who live in households where english is the primary language spoken are more likely to have higher levels of perceived risk than those who identify as male or speak other languages at home. The objective risk of basement flooding had a t-value of 0.137 and a p-value of 0.891, household income had a t-value of -0.065 and a p-value of 0.948, and level of education had a t-value of 0.769 and a p-value of 0.442 (**Table 1**). We had hypothesized that gender, objective risk, and level of education would have the highest impacts on perceived risk, so it is interesting to note that language spoken at home seems to be the most closely correlated, with gender having the next largest impact, with the rest having relatively small impacts, if any, on a person's level of perceived risk.

From the analysis of flood mitigation techniques, the correlations produced minimally significant results. Perceived risk of basement flooding did not correlate well with the mitigation methods themselves nor the cost associated with the methods, which did not support our hypothesis related to the correlation. However, several mitigation methods did produce statistically significant correlations with perceived risk. These included making architectural adjustments (.100), installing anti-backflow valves (.077), and use of sump pumps or power generators (.172) (**Table 8**). It is important to note that the methods themselves were significantly correlated with perceived risk of basement flooding; not the cost (willingness to pay) of the methods. Insurance decisions also did not correlate well with perceived risk, ultimately showing no significance and does not support our hypothesis of a positive correlation between insurance uptake and perceived risk (**Table 9**).

These results informed our direction with our regression analysis regarding the WTP for mitigation methods. The results of several multivariate regression analyses were in line with our hypothesis regarding the cost of these methods. The regression with architectural adjustments, movement of electrical appliances and installation of anti-backflow valves as variables had a high r-value (0.705) although none of the variables themselves displayed high significance with perceived risk (**Table 2**). The second regression takes out the anti-backflow valves and shows the lowest r-value (0.497), while continuing to lack significance among the variables (**Table 3**). The highest r-value from the multivariate regression was with sandbags and other protective barriers, and architectural adjustments as variables (0.874), with no significance among variables (**Table 5**). The regression with sump pumps, anti-backflow valves, and architectural adjustments as variables also displayed a lower than expected r-value (0.485), with no significance among variables. The regression with architectural adjustments and sump pumps also has a high r-value (0.517), and also gave the only statistically significant result, showing that architectural adjustments and use of sump pumps or power generators inform perceived risk better than other mitigation methods (**Table 4**).

Discussion and Conclusions

We hypothesized that objective risk of flooding would be significantly different from perceived risk of flooding. While the correlation between these variables was not statistically significant, it was noted that the means differed and that there was a notable difference in the general trends **(Figure 1)**. We hypothesized that gender, household income, level of education received, language spoken at home, and objective risk of flooding would be statistically significant when they are combined. This hypothesis was confirmed, the aforementioned factors were significant when combined in a regression. However, language spoken at home and gender were the only significant variables, which was not hypothesized. Lastly, we hypothesized that a household's perceived risk would have a positive correlation with the household's likelihood of buying insurance and that having a higher perceived risk of residential flooding would increase a household's willingness to pay for various flood mitigation techniques. These hypotheses were not supported by the results. There was no correlation between insurance decisions and perceived risk. Out of the mitigation methods examined, willingness to pay for architectural adjustments and sump pumps/power generators were the only significant results. The willingness to pay regression did align with the hypothesis, though the statistical significance of the results should be noted.

To highlight the complexity of the gap between perceived risk and objective risk, two respondents from the survey have been identified for the puzzling responses of their perceived risk that vastly differed from their objective risk index.

Respondent 1085 was selected because they greatly overestimated their risk. This Albertan woman claimed that she was confident in her perceived risk of 100% odds of basement flooding, though her objective risk index was only 12. This person had not been inconvenienced by flooding and had not made any architectural adjustments to their home, which they own, but did report that their insurance covered sewer backup. Other demographic information received from the respondent was that she grew up in an urban area, spoke English at home, and that the highest level of education she had obtained was high school.

Respondent 884 was selected because they greatly underestimated their risk. This woman, located in Newfoundland and Labrador, claimed that she was confident in her perceived risk of 15% odds of basement flooding, though her objective risk index was 100, the maximum possible hazard score. This person had been significantly inconvenienced by flooding and had made architectural adjustments to their home, which they own, but did not specify what adjustments had been made. They reported that their insurance covered both sewer backup and overland flooding. Other demographic information received from the respondent was that she grew up in a rural area, spoke English at home, and that the highest level of education obtained was a college/technical school degree.

These two cases exemplify the complex nature of the issue at hand: the difference between perceived and objective risk is not always in the same direction. Some overestimate their risk while others underestimate their risk. Both of these respondents spent an average of 20 to 25 minutes on their survey, and both were females who owned their homes, so these factors were controlled for in this comparison. These observations lead to more questions than answers, most importantly considering what factors these respondents used to formulate their estimates of perceived risk, as they both felt that they were confident in their answers. It is counterintuitive that someone who had not been inconvenienced by a flood would think that they were at 100% risk of one occurring. A potential explanation for respondent 884's underestimation of their risk could be that they have made architectural adjustments to their property that they feel are adequate enough to protect their basement from flooding, and that their insurance would cover damages. However, due to the fact that they did not specify what adjustments had been made, we cannot confidently assume that they have made adequate adjustments to reduce their risk of flooding from the objective index of 100 to the perceived score of 15%. Further, the age of the house itself may play a role in how perception of risk is formed. A newer house may have flood mitigation methods built into it, while older homes might not, and therefore perceptions of risk could vary depending on age of the home. This survey did not ask participants to specify the age of their home, something that could contribute to flood risk perceptions greatly. Further research could explore how this overlooked factor contributes to formation of perceived risk among homeowners. However, despite the age of the home or architectural adjustments made, given the severity of the risk that respondent 884 faces, their low estimates of perceived risk are still concerning.

Thus, further research is required to provide more conclusive answers for the reasons behind this disconnect between perceived and objective risk. While the existence of the disconnect has been observed, the reasons for it, scale, and direction were not clearly identified as these factors varied throughout the sample. As exemplified in the case studies of respondents 1085 and 884, people confidently over and underestimate their risk. This complex relationship could be part of the reason why objective risk was also not significant in our multivariate regression analysis. While most of the results were statistically insignificant, the finding that language spoken at home and gender is significant is notable. This leads to questioning if factors such as cultural norms or gender roles have an effect on perceived risk. However, because the multivariate regression only accounted for 1.9% of the variance, it is clear that there are other factors affecting perceived risk that were not identified in this study. If it was known why people perceived certain levels of risk, one could suggest methods for closing the gap between perceived and objective risk. Surveys such as the one used for this report could be used, though asking different questions that relate more closely to the factors that people use to determine the risk they face. For example, Kuligowski et al. (2021) found that receiving warnings from a trusted official source had a significant impact on risk perception of a nearby wildfire (Kuligowski et al., 2021). Ergo, avenues such as how and where people obtain information on risk, information on the age and features of homes, and relationships between language and cultural norms could be explored in further research. If the results of this analysis indicate anything, it is that the factors that determine a person's perceived risk as it relates to flooding are complex. Therefore, there is ample room for further research in this area to close the gap between perceived and objective risk and to examine the uptake of mitigation measures.

While future research into why people implement risk mitigation measures may be valuable, it is also important to discuss external factors which may have influenced our results. In regards to the WTP for mitigation measures, while money spent on architectural adjustments and sump pumps or power generators had significance, the lack of significance of uptake of insurance with perceived risk could be because flooding insurance is relatively recent in Canada. Flood insurance only started to become available after stakeholders started to pressure insurance companies on the need for it after large Canadian flooding events in 2013 (Thistlewaite, J. 2016). By 2016, when the survey was conducted, most agencies were still in the process of developing policies (Price, J. I. et al. 2019). It is likely that so early in the introduction of flood insurance, it had not become a societal norm to purchase insurance, nor was awareness of it that common. Additionally, the low uptake of insurance is an interesting finding in that it possibly is telling of the perceived risk individuals have with respect to floods. If they already have a low perception of risk, which is what the majority of survey participants indicated, then it's likely they wouldn't purchase insurance or other forms of mitigation measures anyway. On the other hand, what our results possibly indicate is what those who adequately assess their perceived risk are already doing to protect themselves from floods; making architectural adjustments and using sump pumps and/or power generators. It would be interesting to compare our findings to nations which have had flooding insurance for decades, as well as to do Canadian studies in the future to see if having a longer history of flood insurance popularized it and creates a significant correlation where people who have a high perceived risk invest in flood insurance to mitigate it.

Subsequently, further research can be done to determine the reasoning behind why people take certain risk mitigation measures and what sort of factors affect their willingness to pay for these measures. Developing a questionnaire asking people why they have certain levels of perceived risk and why they take certain risk mitigation measures could help us further develop answers to our research questions. We had asked three separate questions prior to conducting our analysis;

> Is there a disconnect between the perceived risk of basement flooding and the objective risk of basement flooding? Do gender, household income, level of education received, and language spoken at home have a significant impact on perceived risk of basement flooding? What factors influenced one's perceived risk of flooding?

For our first question, we did not find a simplistic yes or no answer. Comparing the means did not give us a significant result, which would have allowed us to reject the null hypothesis, however, there were clear differences. The objective risk measure and perceived risk measure had essentially zero correlation, indicating that there is a lack of connection between the two measures. Having an open ended survey might help us understand if there is truly a disconnect between the two, as learning the reasoning behind the way people think might bring up new ways that we could quantitatively analyze it. We learned that this question was a lot more complex than originally thought.

As for our second question, “do gender, household income, level of education received, and language spoken at home, and objective risk values have a significant impact on perceived risk of basement flooding?”, we were able to find a significant answer. Together all of these factors have an effect on the perceived risk of basement flooding, however as stated above, they only account for 1.9% of its variance. This means that there are other factors which need to be examined as to why people have certain levels of perceived risk. Further research into the interrelationship between various demographic and cultural factors is suggested to further define the relationship between said factors and perceived risk. A few interesting topics of discussion which presented in our results include the fact that language spoken at home was the most closely correlated factor to perceived risk that we found. From previous literature, we did not come across anything discussing this and there could be many potential reasons for this. One likely explanation could be cultural norms which tend to be closely associated with language spoken at home. For example, perhaps households located in Quebec, who are a lot more likely to speak french, may have certain cultural factors that cause them to have relatively lower levels of perceived risk. Another interesting result was that although it was not significant, there was a negative trend presented between household income and perceived risk of basement flooding. It would be interesting to look into if this is because they have already invested in mitigation measures, they are generally less worried about instances because they know they can afford it, or if they have a less accurate idea of risk compared to their objective risk because they haven’t worried enough to look into it. Lastly, we expected level of education to be one of the most influential factors, however it was not significant. There could be many reasons for this, but it could lead to some interesting research about if there is a difference in where people get information about risk based on their level of education

Lastly, we split up our third question asking what factors influence one’s perceived risk of flooding into how perceived risk is affected by one's likelihood of buying insurance and their willingness to pay for mitigation techniques. The only significant result of willingness to pay determined that architectural adjustments inform perceived risk better than other mitigation methods. Insurance uptake, surprisingly, was not a good determining factor for perceived risk. Again, this seems to indicate a lack of information as to why people make the decisions they do. Perceived risk seems to be the most obvious explanation for having mitigation measures, but it should be examined as to if previous experience, advertising, and a number of other factors perhaps have a more significant effect. Further research should focus more directly on adjustments made to the house itself as well the age of the house itself.

Appendix A: Tables

Table 1: Multivariate Regression of Perceived Risk of Basement Flooding vs Objective Risk of Basement Flooding, Education, Income, Language, and Gender

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	panel_education -- Level of education, Gender__Female, Objective Hazard Level converted to scale/100 (score*4), Language__English, panel_income -- Household income[b]	.	Enter

a. Dependent Variable: Perceived Risk of Basement Flooding

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.136[a]	.019	.015	20.95

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10640.829	5	2128.1662	4.83	.000[b]
	Residual	561794.492	1275	440.623		
	Total	572435.321	1280			

a. Dependent Variable: Perceived Risk of Basement Flooding

b.Predictors: (Constant), panel_education -- Level of education, Gender__Female, Objective Hazard Level converted to scale/100 (score*4), Language__English, panel_income -- Household income

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.299	2.400		3.041	.002
	Gender__Female	2.221	1.177	.052	1.886	.060
	Language__English	6.035	1.398	.122	4.316	.000
	Objective Hazard Level scaled to 100 (score*4)	.003	.022	.004	.137	.948
	panel_income -- Household income	-.013	.204	-.002	-.065	.390
	panel_education -- Level of education	.243	.316	.022	.769	.442

Table 2: Abbreviated Multivariate Regression of Perceived Risk of Basement Flooding vs Money Spent on Anti-backflow valves, Raising Electrical Components, & Architectural Adjustments

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.705[a]	.497	-.005	24.921

a. Dependent Variable: Perceived Risk of Basement Flooding
b. Predictors: (Constant), q39 -- Installing anti-backflow valves: Approximately how much money has your household spent on the following items?, q38 -- Raising the electricity meter, power sockets, and major appliances: Approximately how much money has your household spent on the following items?, q37 -- Architectural adjustments to protect your home from flooding: Approximately how much money has your household spent on the following items?

Table 3: Abbreviated Multivariate Regression of Perceived Risk of Basement Flooding vs Money Spent on Raising Electrical Components & Architectural Adjustments

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.497[a]	.247	.122	19.952

a. Dependent Variable: Perceived Risk of Basement Flooding
b. Predictors: (Constant), q38 -- Raising the electricity meter, power sockets, and major appliances: Approximately how much money has your household spent on the following items?, q37 -- Architectural adjustments to protect your home from flooding: Approximately how much money has your household spent on the following items?

Table 4: Multivariate Regression of Perceived Risk of Basement Flooding vs Money Spent on Sump Pumps/Power Generators & Architectural Adjustments

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	q41 -- Sump pump and power generator: Approximately how much money has your household spent on the following items?, q37 -- Architectural adjustments to protect your home from flooding: Approximately how much money has your household spent on the following items?[b]	.	Enter

a. Dependent Variable: Perceived Risk of Basement Flooding

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.517[a]	.267	.230	20.838

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6182.323	2	3091.161	7.119	.002[b]
	Residual	16934.749	39	434.224		
	Total	23117.071	41			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	9.384	4.327		2.169	.036
	q37 -- Architectural adjustments to protect your home from flooding: Approximately how much money has your household spent on the following items?	.001	.000	.377	2.666	.011
	q41 -- Sump pump and power generator: Approximately how much money has your household spent on the following items?	.007	.003	.274	1.939	.060

Table 5: Abbreviated Multivariate regression of Perceived Risk of Basement Flooding vs Money Spent on Architectural Adjustments & Sandbags/Protective Barriers

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.874[a]	.763	.290	11.652

a. Dependent Variable: Perceived Risk of Basement Flooding
b. Predictors: (Constant), q40 -- Sandbags and other protective barriers: Approximately how much money has your household spent on the following items?, q37 -- Architectural adjustments to protect your home from flooding: Approximately how much money has your household spent on the following items?

Table 6: Abbreviated Multivariate regression of Perceived Risk of Basement Flooding vs Money Spent on Architectural Adjustments, Anti-Backflow Valves, & Sump Pump/Power Generator

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.485[a]	.235	.044	17.044

a. Dependent Variable: Perceived Risk of Basement Flooding
b. Predictors: (Constant), q41 -- Sump pump and power generator: Approximately how much money has your household spent on the following items?, q39 -- Installing anti-backflow valves: Approximately how much money has your household spent on the following items?, q37 -- Architectural adjustments to protect your home from flooding: Approximately how much money has your household spent on the following items?

Table 7: Correlation of Perceived Risk of Basement Flooding vs. Money spent on flood mitigation methods (Willingness to pay)

	1.	2.	3.	4.	5.	6.	7.
1. Perceived Risk of Basement Flooding	-						
2. $ Spent on: Architectural Adjustments	.021	-					
3. $ Spent on: Raising electric components	-.052	.757**	-				
4. $ Spent on: Installing Backflow valves	.013	-.073	.422	-			
5. $ Spent on: Sandbags/Protective Barriers	.016	.103	1.000**	.500	-		
6. $ Spent on: Sump pump/Power generator	-.040	.244	.146	.204	.534	-	
7. $ Spent on: Emergency Kits	.000	-.112	.397	.698**	-.245	.561**	-

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed)

Table 8: Correlation of Perceived Risk of Basement Flooding vs. Flood Mitigation Action Taken

	1.	2.	3.	4.	5.	6.	7.
1. Perceived Risk of Basement flooding	-						
2. Architectural Adjustments	.100**						
3. Raising electric components	.036	.172**	-				
4. Backflow valves	.077**	.124**	.139**	-			
5. Sandbags/Protective Barriers	.054	. 062*	.053	.019	-		
6. Sump Pump/ Power Gen.	.172**	.166**	.161**	.236**	.072**	-	
7. Emergency Kit	.125**	.089*	.119**	.149**	.050	.113**	

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 9: Correlation of Perceived Risk of Basement Flooding vs. Insurance Policy Type

	1	2	3	4
1. Perceived risk	-			
2. Sewer backup in home insurance policy	0.055	-		
3. Overland flooding damage in home insurance policy	-.076*	-.526**	-	
4. Consulted provider about purchasing overland flood insurance	-0.035	-.160**	.293**	-

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed)

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