RESUME Group

RESILIENT AND SUSTAINABLE MOBILITY & EVACUATION GROUP

Resilience Hubs and Evacuations: Preparing Edmonton for Extreme Events and Climate Change

February 2024

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Acknowledgements

This final report fulfils the requirements of the Cities Intergovernmental Panel for Climate Change (IPCC) Legacy Research Grant and the Mitacs Accelerate Grant. Funding for this research was generously provided by the City of Edmonton, the Alberta Ecotrust Foundation, and Mitacs.

We thank the many residents of the Edmonton metropolitan area who participated in the survey and focus groups. We thank Sincy Modayil, Danielle Koleyak, Stefanie Drozda, Enitan Daramola, and Trevor Wiltzen for their guidance and support of this research. We would also like to acknowledge the City of Edmonton's Office of Environment and Climate Resilience and Edmonton's Office of Emergency Management. Thank you also to the Edmonton Community League Federation, the Africans & African Descendants Friendship Club of St. Albert (AADCF), the Edmonton Mennonite Centre for Newcomers, Ribbon Rouge, and the Sinkunia Community Development Organization for their assistance in the research.

We thank students from the Resilient and Sustainable Mobility and Evacuation (RESUME) Group for their help in this research. Thank you especially to Sarah Wan who contributed to the focus group data collection and data analysis. Thank you also to Syeda Narmeen Zehra and Mohammad Babaei for helping with the survey design.

Executive Summary

A changing climate is placing significant strain on urban environments as communities are contending with intensifying and more frequent hazards. Communities are simultaneously facing ongoing and new societal challenges that centre around a need for critical services and resources. To help people not just survive but also thrive, resilience hubs have emerged as a possible solution. These hubs are locations that provide information, resources, and temporary shelter during a range of disasters, but also function in an equally important, everyday role in providing services or programs for the community. Existing guidance, recommendations, and lessons learned from existing resilience hubs offer strong design, programmatic, and development examples. However, transportation has not yet been thoroughly considered, which affects hub placement, infrastructure, and associated evacuation plans. Moreover, choice-making for urban evacuations within the Canadian context is generally sparse, which can inhibit the development of needs-centred evacuation plans and response strategies.

This research aims to provide an early exploration in both of these areas — transportation to/from resilience hubs and urban evacuation choice-making — using Edmonton, Alberta as a case study. To gain the perspective of residents, the research employed a mixed-method approach that collected data via two literature reviews, a large region-wide survey (n=950 people) and focus groups with underserved populations (n=52 people). Using these data, analyses were conducted to provide a holistic overview of transportation needs, behaviour, and guidance related to resilience hubs and urban evacuations.

Resilience Hub Summary

Descriptive statistics provided key results related to resident's opinions, perceptions, and needs associated with resilience hubs. Several key results included the following:

- Community/recreation centres, schools/universities, community leagues, and libraries were highly preferred locations for hubs with satisfaction ranging from 65% to 73%.
- 70% of residents would be somewhat/very likely to use a hub to gather disaster information.
- 64% would be very/somewhat likely to gather critical resources at a hub during a disaster.
- 61% would be very/somewhat likely to use a hub as a temporary evacuation shelter.
- A lower percentage of residents (41%) would use the hub during normal days.
- Shelter, backup power, family reunification, and an information desk were all considered important services by 67% or more of the residents.
- Water, restrooms, heat, a food bank, and urgent care were ranked as the top five most important basic resources.
- Over 50% of respondents expressed the importance of accessible transportation features, car parking, transit connections, and a hub within walking distance.
- 71% of respondents would use a personal vehicle to travel to a hub during normal conditions, while 79% would use it during a disaster.
- Walking was the second most popular mode with 15% during normal conditions and 9% during disaster conditions.
- Public transit would be used by 8% and 4% respectively in normal and disaster conditions.
- Shared mobility (e.g., carpool, ridesource, carshare) would be 6% and 7% of the mode split, respectively for normal and disaster conditions.

- The median distance from a respondent's residence to their preferred hub location was 1.7 km, dropping to 0.6 km for walkers but rising to 2.0 km for drivers and 2.5 km for transit users.

Discrete choice modeling yielded several important results related to the people who would be more or less likely to use resilience hubs or certain modes of transportation. Together, the results point to the importance of leveraging the social cohesion benefits from hubs and the criticality of the hub in providing resources for a range of different underserved groups. Key results included the following:

- Across models, social cohesion and social capital (e.g., trust/compassion) variables were associated with a higher likelihood of using resilience hubs.
- Larger households, lower-income households (less than $50K CAD), and members of community organizations/groups were more likely to use a resilience hub during normal conditions.
- Households with children, visible minorities, individuals with a disability, and people with home Internet were all more likely to use a resilience hub as a temporary shelter.
- Individuals with a disability, people with home Internet, and women were more likely to gather critical resources at a resilience hub. Full-time and part-time workers, young adults (35 and under), and active mode users were also likely to use the hub in this way.

Focus groups with underserved populations uncovered that sufficient transportation services and resources would be needed to ensure easy access to resilience hubs. Key results included the following:

- Participants in underserved groups indicated a preference for centrally located resilience hubs in well-utilized community spaces (e.g., community leagues and recreation centers).
- Participants highlighted the importance of transit connectivity and walkability to resilience hubs during normal conditions and emergency scenarios.
- Basic needs, accessibility features, and spaces for children were identified as essential for resilience hub functioning.
- Social infrastructure within resilience hubs (e.g., mental health services and volunteer opportunities) was regarded as crucial for building community cohesion and resilience.
- Participants particularly from the racial and ethnic minorities group discussed the need for informational services at resilience hubs directed towards recent immigrants to Canada.

Urban Evacuation Summary

Descriptive statistics help understand key choices for urban evacuations, especially in managing demand and supplying sufficient capacity for transportation and sheltering. Key results include the following:

- 76% of respondents expect to receive an emergency or mandatory evacuation order by text message.
- Communications of orders were also highly expected via Alberta emergency alerts (66%), television (52%), radio (49%), and social media (43%).
- The range of communication channels indicates that people will seek information from more than one source.
- Just 21% of respondents feel very or mostly prepared for an evacuation.
- 32% of respondents would evacuate immediately after learning about a hazard.

- 26% of respondents would wait to evacuate until receiving a voluntary evacuation order (15% would wait until a mandatory evacuation order).
- 20% of respondents would want to gather their family before evacuating.
- Just 2% would defend their residence and an additional 2% would not evacuate at all.
- Evacuees would be relatively fast at departing, with 60% evacuating within 30 minutes of deciding to evacuate and an additional 25% between 30 minutes and 1 hour.
- Background traffic may cause congestion as 45% would take one vehicle trip prior to evacuating and 47% would take two or more vehicle trips.
- Most participants would evacuate by personal vehicle (91%).
- 61% would stay with a family member or a friend as their final shelter.
- The need for government-operated shelters was sizable as 8% would use a public shelter and 6% would go to a community centre.
- 60% of evacuees would stay within the Edmonton Metropolitan area.

Through a series of discrete choice models, factors were found that influenced key urban evacuation choices. Key results include the following:

Evacuation

- Past evacuees are more likely to evacuate immediately or after receiving a voluntary order.
- Larger households and women are more likely to evacuate immediately and after they gather their family, respectively.
- Those with 2+ vehicles and those sheltering with friends/family are more likely to evacuate but not until receiving a voluntary evacuation order.

Shelter Type

- Visible minorities and carless households are more likely to go to a public shelter.
- Lower-income households are more likely to go to a hotel/motel/Airbnb.
- Previous evacuees, and homeowners are more likely to go to a hotel/motel/Airbnb or to a secondary resource.
- Individuals with a disability and fast evacuees are less likely to go to a hotel/motel/Airbnb.

Mode/Route/Departure

- Variables are likely more associated with attributes of the alternatives (options) than demographics, as evidenced by low model fit.
- Fast evacuees are more likely to use active modes or shared mobility compared to public transit or a personal vehicle.
- Carless households and fast evacuees do not prefer highways, while previous evacuees prefer local roads or a mixture of roads.
- People who have never evacuated before are more likely to take longer to evacuate, while homeowners and people who take fewer pre-evacuation trips are typically faster.

The underserved population focus groups identified several key transportation needs for urban evacuations, centred mostly on public transit. While infrastructure improvement questions were asked, respondents did not generally discuss these elements, focusing more so on operations during disasters. Key results include the following:

- Reliability of transit services and accessibility/assistance features were the most prevalent transit themes during the focus group discussions.
- Some of the focus group participants indicated a preference for using transit during emergency evacuations as it would bring communities together and reduce feelings of anxiety and panic that come with evacuating alone. This was a particularly common theme among older adults.
- Focus group participants called for fare-free transit services during emergencies, especially for individuals from lower-income households.
- Participants expressed a general lack of emergency preparedness and showed a willingness to share information with emergency registries to receive evacuation assistance.

Primary Recommendations

Resilience Hub Recommendations

Recommendation 1: Jurisdictions need to assess community needs related to resilience hubs to determine optimal locations, placement, transportation resources, and hub design.

Recommendation 2: Resilience hubs should be placed in well-known, trusted locations that centre resources around neighbourhoods.

Recommendation 3: While retrofitted buildings are generally sufficient to meet needs and cost less, new buildings should be pre-designed to meet key resilience hub criteria and characteristics.

Recommendation 4: When resources are constrained, a hybrid network that connects several larger hubs with multiple smaller, less-equipped hubs, could be effective in still meeting some community needs.

Recommendation 5: Hubs should be placed in close proximity to frequent transit services and/or services should be augmented to the location, especially during emergency events.

Recommendation 6: Transportation services and infrastructure design should be multi-modal (including pedestrian-friendly) to meet the diverse needs of residents, especially those most underserved.

Recommendation 7: Information resources, volunteer opportunities, basic services, and hazard-specific elements (e.g., heating, cooling, air filtration, backup power) will help resilience hubs function during emergency events.

Recommendation 8: Jurisdictions can leverage resilience hubs for a range of other community needs during normal conditions, especially in fostering social cohesion, preparing residents for hazards, and providing key social services.

Urban Evacuation Recommendations[1]

Recommendation 1: Communication of evacuation orders (voluntary and mandatory) and hazard information will need to be consistent, accurate, accessible, and widely distributed across different sources.

[1] Recommendations are designed for the Edmonton context, though elements could be effective in other cities with similar population sizes, demographic characteristics, or hazard types.

Recommendation 2: Edmonton will require a concerted campaign and resources to help prepare individuals for an evacuation, including setting household evacuation plans and providing information on Edmonton's likely response.

Recommendation 3: Edmonton will need sufficient resources, buildings, and staff to successfully shelter a relatively large number of diverse evacuees.

Recommendation 4: Edmonton Transit Service will need to deliver responsive and frequent public transit for an urban evacuation in Edmonton, especially for underserved populations who will be likely to use transit.

Recommendation 5: Emergency registries, fare-free transit, and additional staff support on transit are recommended to boost equitable outcomes for underserved populations.

Recommendation 6: Transportation response strategies will need to prepare infrastructure for a large surge of evacuees within the first hour of an evacuation order.

Recommendation 7: Interagency collaboration before, during, and after a disaster in Edmonton can be further strengthened, especially in preparing evacuation routes, training staff, arranging pickup points, managing registries, and conducting exercises.

Recommendation 8: The evacuation planning and distribution process in Edmonton should be transparent, include diverse perspectives, and involve a wide range of community-based organizations to ensure its usefulness and applicability across city residents.

View of Edmonton Downtown (Source: Alex Pugliese / Unsplash)

Table of Contents

Publications from Research

This report provides a research summary. For detailed results and analysis, the following published and working papers are open-access and available.

- Ciriaco, T. G., & Wong, S. D. (2022). Review of resilience hubs and associated transportation needs. Transportation Research Interdisciplinary Perspectives, 16, 100697. https://www.sciencedirect.com/science/article/pii/S2590198222001579
- Ciriaco, T. G., & Wong, S. D. (2023). Travel Behavior and Community Needs for Resilience Hubs. Working Paper. https://era.library.ualberta.ca/items/07ee12ef-aee7-4829-b7d5-30e0681c9c49
- Ciriaco, T. G., Zehra, S. N., Wambura, V., & Wong, S. D. (2023). Equitable Transportation and Resilience Hubs: Analysis of Underserved Population Needs, Usage, and Travel. Working Paper. https://era.library.ualberta.ca/items/2a114610-6de2-4035-9625-e53b3ccdca29
- Wambura, V., & Wong, S. D. (2023). Strengthening Public Transit Equity in Evacuation Planning through a Community-Centered Approach. Working Paper. https://era.library.ualberta.ca/items/806cce34-20bf-4543-a837-3c528a3d1458
- Wambura, V., & Wong, S. D. (2024). Equitable Public Transit Evacuation Planning: A Systematic Review. Working Paper. https://era.library.ualberta.ca/items/2bdb719b-c2e0-4be7-91f8-4e03e94c8812
- Wan, S. & Wong, S. D. (2024). Equity in Resilience Hub Design and Transportation through Community Discussions. Resilience Findings. https://doi.org/10.32866/001c.91270

NOTE: This document has been updated several weeks from the original release to clarify language in the Executive Summary, Section 4, and Section 5 regarding the discrete choice models. Several variables have also been changed to reflect a paper in peer-review. One recommendation has been removed. These changes have been made to keep documents consistent.

1) Introduction

Over the coming decades, the City of Edmonton will experience an increase in the frequency, intensity, and size of hazards due to climate change. The Edmonton river valley and surrounding neighbourhoods are particularly vulnerable to wildfires and flooding, requiring significant mitigation and adaptation strategies to protect infrastructure, property, and human life. In addition to resilient design, the City of Edmonton will also need to develop resilient operations to protect lives, particularly those most vulnerable, through responsive and effective evacuations of neighbourhoods. Extreme weather events — including blizzards, heat waves, and unhealthy air quality (typically from wildfire smoke) — also pose significant challenges for long-term climate adaptation. Beyond the City of Edmonton, other communities across Canada and globally will face similar challenges, requiring new adaptation strategies.

Consequently, this project, funded by the City of Edmonton and the Alberta Ecotrust Foundation, aims to: 1) prepare Edmonton officials and residents to evacuate from both wildfires and flooding and 2) inform planning for resilience hubs that can act as evacuation shelters and resource centres. Moreover, through additional funding from Mitacs, the project also serves to develop recommendations for climate adaptation as it relates to evacuations and resilience hubs for Canadian communities. To achieve these goals, the project employed a mixed-method approach that collected data via household surveys with the general population and focus groups with at-risk communities in Edmonton (as a case study). A specific focus was made on collecting data from disadvantaged populations who are most adversely impacted by disasters.

1.1) Background

Climate change will continue to disrupt urban systems through both acute shocks (e.g., disasters) and chronic disruptions (e.g., more regular flooding). Recent research on the impact of a changing climate in the Prairie Provinces has uncovered a concerning future related to these shocks and disruptions. Climate models indicate that extreme weather events, in particular flooding, wildfires, and drought, will be amplified in severity beyond recent devastating events in the Prairie Provinces (Sauchyn et al., 2020). On a local level, the City of Edmonton and surrounding areas will also experience a shift in the frequency and severity of certain hazards as a result of climate change such as extreme heat (City of Edmonton, 2022). Recent research by Elshabrawy (2022) found that the fire risk in the City of Edmonton will increase by 20% between 2021 and 2050, with significant exposure to neighbourhoods along the North Saskatchewan River valley and associated drainages. Edmonton has also determined there will be a likely increase in flooding in the city due to climate change (City of Edmonton, 2022).

In these events, transportation plays a critical role in safely moving populations out of hazards, while simultaneously moving in supplies and relief. Canada is expected to face growing disaster threats in the coming decades (Public Safety Canada, 2022). With lives at risk, evacuations remain a critical mechanism to safeguard lives in disasters. In addition to the need to protect lives, resilient communities and infrastructure can reduce the overall cost of disasters. In Canada, insured losses from disasters are often above one billion dollars per year (Public Safety Canada, 2022). As climate emergencies grow, resilient transportation systems – for the movement of people and goods – are increasingly necessary and critical for Canada's future. However, work remains on preparing transportation systems, infrastructure, and operations for the unique effect of certain hazards (e.g., wildfires) on highly urban environments (see Casello and Towns, 2016 for an overview of risks of hazards on Canada's transportation systems). For

example, most work for wildfires has focused on the urban-wildland interface (Intini et al., 2019; Folk et al., 2019), not on highly dense city centres that have large areas of parkland. Transportation choice-making for evacuations, which can inform response strategies, has only been studied in Fort McMurray (a low-density population area) (e.g., Woo et al., 2017) or rural places in Canada (e.g., McGee and Christianson, 2022). Regarding urban flooding and other events, many Canadian cities do not have publicly facing evacuation plans, disaster response plans, or sheltering plans, making it difficult to leverage lessons learned. While research has been conducted on the choice to evacuate or stay for urban flooding in Canada (e.g., Rashid et al., 2007), more work is needed to identify transportation choices that can affect evacuation outcomes (e.g., congestion) and point to specific transportation response strategies for the hazard (Wong, 2020).

Research to improve evacuation outcomes has grown in recent years, first to improve hurricane evacuations and more recently wildfire evacuations (see Lindell et al. 2019 for a review). Present-day wildfire work has employed post-disaster analyses of evacuations to build strategies for governments and organizations (e.g., Wong et al., 2020a; Kuligowski et al., 2020; Wong et al., 2021; McGee and Christianson, 2021). Moreover, some cities and counties in North America are beginning to develop more robust evacuation plans that focus on safely moving disadvantaged populations away from the hazard to other geographies (e.g., City of New Orleans, 2019; County of Sonoma, 2021). Building resilient communities is also a growing goal for long-range plans to combat climate change (City of Edmonton, 2018; Baja, 2019).

However, severe gaps remain in local understanding, generalizability, and resilience hub development. First, the City of Edmonton does not provide evacuation information to its residents prior to an event. Despite work on traffic safety in Edmonton (e.g., El-Basyouny and El-Bassiouni, 2013; Klassen et al., 2014; Contini and El-Basyouny, 2016), no research has been conducted on transportation safety or operations during a disaster in Edmonton. Second, most evacuation research lacks generalizability, which inhibits the usage of conclusions for most contexts. Indeed, suburban or rural research for wildfires in the United States and Australia is not highly relevant to the urban Canadian context. The structure, policies, and design of Canadian cities must be considered in research to develop more localized policies and strategies. Finally, resilience hubs are still a nascent concept and have not been fully tested or developed, making it difficult to understand their functionality, feasibility, and location. Resilience hubs have the potential by providing access to resources and services during both every day and disaster conditions. Despite some earlier guidance developed by Baja (2019) on how to design hubs, key gaps remain in their placement, characteristics, and accessibility via transportation.

2) Research Objectives

The objectives for this research were divided into three key areas – identification of the problem and literature, collection and analysis of data, and knowledge exchange.

Objective	Task/Activities	Deliverable or Actions
Objective 1: Identify research gaps, limitations, strategies, policies, and methods in urban evacuation and resilience hub planning	Task 1: Conduct a literature review and background study of current strategies that describe and help design resilience hubs and public transit in evacuations	Ciriaco and Wong (2022) Wambura and Wong (2023a)
	Task 2: Conduct meetings with the City of Edmonton and community-based organizations (CBOs) to exchange ideas on research development, methods, and design	Multiple meetings for exchange of ideas with research partners
	Task 3: Work with City of Edmonton decision-makers to review current evacuation and disaster response plans	Exchange of materials and meetings with City of Edmonton partners
Objective 2: Develop empirical analyses, models, and understanding that directly inform the development of evacuation, disaster response, and resilience hub plans	Task 4: Create and finalize survey and focus group design, questions, and sampling procedures	Final survey design, which included input from City of Edmonton partners
	Task 5: Recruit participants for the study and collect empirical data	Panel-based recruitment (via Qualtrics) and convenience sample (via City of Edmonton and CBOs)
	Task 6: Conduct the analysis of the empirical data including: 1) descriptive statistics; 2) discrete choice modeling; 3) text-based coding; and 4) thematic analysis.	Ciriaco and Wong (2023) Ciriaco et al. (2023a) Wambura and Wong (2023b) Wan and Wong (2024)
Objective 3: Provide decision-support to the City of Edmonton and beyond based on empirical evidence to increase city, community, and resident resilience to extreme events and long-term climate change	Task 7: Develop a policy brief that highlights key findings, offers prioritized recommendations for Edmonton on actions to take, and generalizes results across Canada	Ciriaco et al. (2023b)
	Task 8: Develop a final report and associated journal publications to provide a full description of the research, results, and recommendations for Edmonton, other global cities, and the broader research community	Ciriaco et al. (2024) (this document)
	Task 9: Facilitate a webinar and a workshop to share the research with a broader audience, including CBOs, to enhance knowledge and decision-making.	Completion of a workshop to improve the policy brief and a webinar to share the final research outcomes

3) Methodology

The research leverages a mixed-method approach for data collection and analysis. The methodology is presented below with details about the different approaches.

3.1) Systematic Literature Reviews

First, the research conducted two systematic literature reviews that focused on the current state of resilience hubs and transportation (Ciriaco and Wong, 2022) and urban evacuations with a focus on public transit and equity (Wambura and Wong, 2023). Summaries of these two journal articles are provided in this report. Further details can be found in the documents, which are both open-access.

3.2) Survey and Data Analysis

Second, the research developed a unique survey that focused on choices and needs related to 1) resilience hubs and 2) urban evacuations. The survey included questions on risk perceptions, resilience hub usage, preferred locations and resources for resilience hubs, transportation choices, and demographic characteristics. The dataset was collected through a market research panel (conducted by Qualtrics) and a convenience sample through the assistance of the City of Edmonton and local community-based organizations (CBOs). Departments and partners were encouraged to share the survey link through a variety of communication methods including (but not limited to): Facebook, Twitter (now called X), websites, and email lists. Data were collected from the end of September 2022 to the end of January 2023 for residents aged 18 or older in the Edmonton Metropolitan Region. Data cleaning was conducted to remove participants that:

1) Did not meet eligibility (e.g., 18+, living in the Edmonton Metropolitan Region)
2) Failed to complete the survey (as required by the ethics protocol)
3) Provided minimal information (missing key or most questions); or
4) Provided suspected fraudulent responses (e.g., highly repetitive answers, similar answers for all scaled questions, unintelligible comments)[2].

The final sample consisted of 950 residents, with most coming from the panel dataset since a minimum quota from Qualtrics was contracted and achieved. Survey data were analysed using simple descriptive statistics and discrete choice models. The discrete choice models identify variables or factors that influence a specific decision. In other words, these models help statistically determine what variables would increase or decrease the likelihood of a choice. For this study, decisions included:

- Usage of resilience hubs (e.g., as a shelter, to gather resources, to find information);
- Transportation mode to resilience hubs for both regular conditions and disaster conditions;
- Evacuate or stay; and
- Transportation choices in an evacuation (e.g., mode choice, shelter type, etc.).

3.3) Focus Groups and Data Analysis

Finally, the research conducted focus groups with underserved and vulnerable Edmontonians to gather their resilience hub opinions and evacuation plans. A focus group methodology was chosen to directly hear from residents who would likely need resilience hubs the most. Eligible focus group participants were

[2] Responses were considered valid unless severe issues were found. Our approach assumed that participants would be generally truthful and trustful in their responses.

first gathered from the survey for the first five groups (seen in Table 1) on a first-come-first-serve basis via an email address. For the final three groups (recent immigrants, parents/guardians of young children, and women) and groups not filled to eight people, several local CBOs were contacted to share the focus group information with known participants. Focus groups were again filled on a first-come-first-serve basis. Some groups were not filled to eight participants due to last-minute cancelation and insufficient interest. All focus groups were conducted in February 2023 in English via Zoom. While an online platform may have inhibited some individuals with access to Internet from participation, the flexibility of the platform helped decrease scheduling and transportation issues that arise from in-person focus groups. Questions were asked in a semi-structured way to allow for moderator prompting. To ensure high data quality, the audio was recorded and subsequently transcribed by TranscriptGo. Filler words were largely removed from the transcript for ease of analysis.

Prior to and following the focus groups, a codebook was developed that described key themes, topics, and research interests. The codebook consisted of a total of 26 parent codes, 148 codes, and 1994 coded segments on resilience hub features, potential resilience hub locations, emergency preparedness, and evacuation modes. Using the codebook, a research assistant read each of the focus group transcripts and highlighted blocks of text that corresponded to each code. For example, if a participant started talking about the reliability of public transit, the text and sentences surrounding the text would be labelled as "Reliability." Text could contain multiple codes. A thematic and content analysis was conducted using these codes for both resilience hubs and transit-centred evacuations.

Table 1 - Focus Group Populations, Eligibility, and Participants

Focus Group Population	**Focus Group Eligibility**	**Number of Participants**
Carless Residents	Without a vehicle or reliable access to transportation	7
Individuals with Disabilities	Have physical or mental disabilities or have a family member with a disability	8
Older Adults	65 years or older	6
Lower-Income Households	Household annual income below $50,000 in Canadian Dollars	4
Racial and Ethnic Minorities	Not in a dominant ethnic group and may suffer discrimination based on physical and/or cultural traits	7
Recent Immigrants	Immigrated to Canada in the last 3 years	8
Parents/Guardians of Young Children	Parent/guardian of at least one child the under the age of 18	6
Women	Identify as a woman	6

Table 2 - Summary of Mixed-Method Approach

Approach	Method	Analysis	Data Overview
Literature reviews	Systematic review of existing literature	Discussion of key takeaways, gaps, and future research directions	Not applicable
Survey	Panel data set and convenience sample to obtain a general population sample	Descriptive statistics and discrete choice models	N = 950 residents, age 18+ in the Edmonton Metropolitan Area
Focus groups	Semi-structured discussions within key underserved groups	Thematic and content analysis	N = 52 residents across eight focus groups of underserved populations

3.4) Survey Data Overview

The sample from the survey contained a relatively good mixture of participants, though some groups were overrepresented and others were underrepresented. Almost half of the respondents were young adults (≤ 35 years) and 4% were older adults (≥ 65 years). The average age was 38 years, with the highest being 84 years and the lowest being 18 years. Moreover, 54.4% identified as women, 43.3% as men, 0.9% as other genders (e.g., non-binary, two-spirit, transgender), 0.7% as more than one gender, and 0.6% preferred not to answer (Figure 1). Regarding race and ethnicity (Figure 2), the majority of respondents were white (54.3%), 26.5% were visible minorities (following the Employment Equity Act specification), and 10.9% were Indigenous (First Nations, Inuit, Metis, or Indigenous outside Canada). It is noteworthy to mention that participants could select more than one option in the race and ethnicity question. A relatively high cross-section of the sample had a disability, which included visible and non-visible disabilities (30.0%) (Figure 3). From those that reported having a disability, the highest percentages were related to mental health (11.1%), pain (9.2%), and mobility (3.8%). Regarding employment, 69.4% of the respondents were employed full-time and 9.6% were employed part-time (Figure 4).

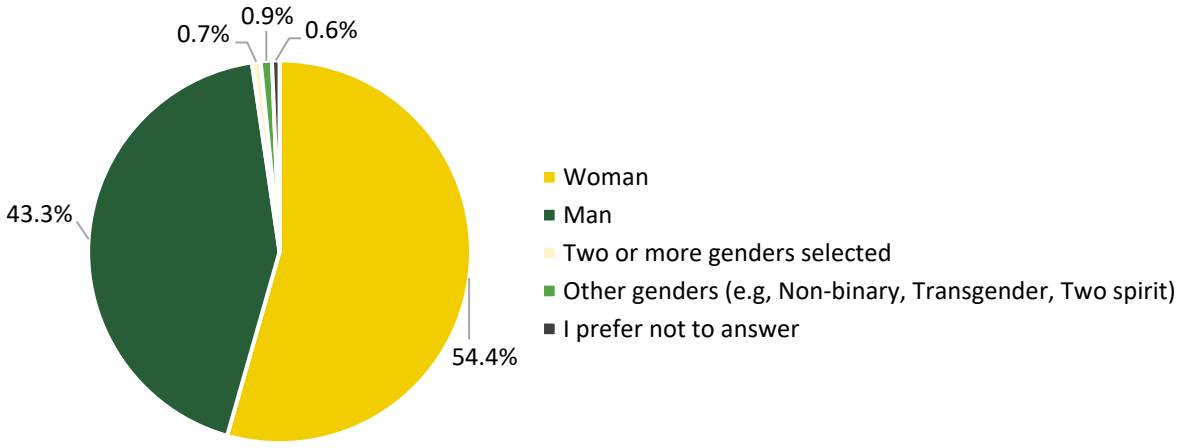

Figure 1 - Gender identity (n=950)

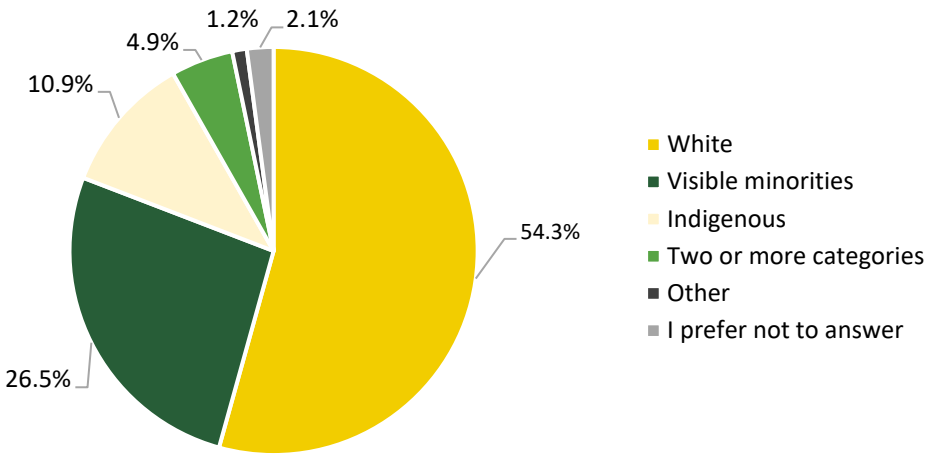

Figure 2 - Racial and ethnic identity (n=950)

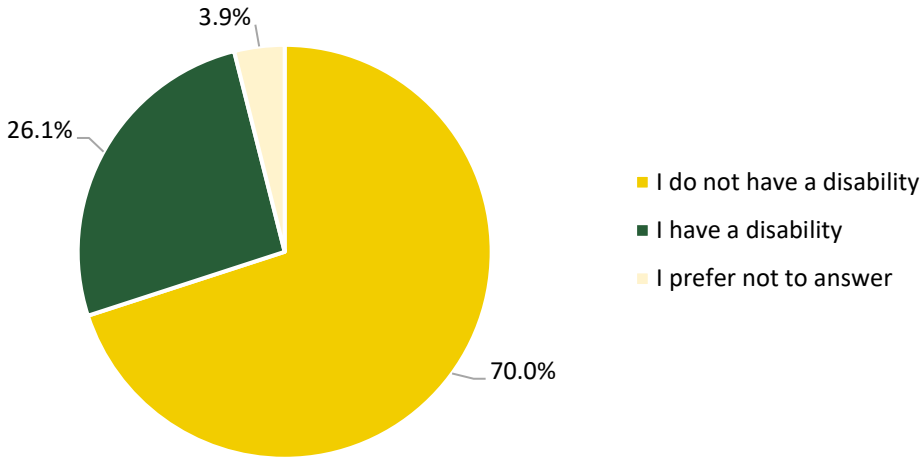

Figure 3 – Disability status (n=890)

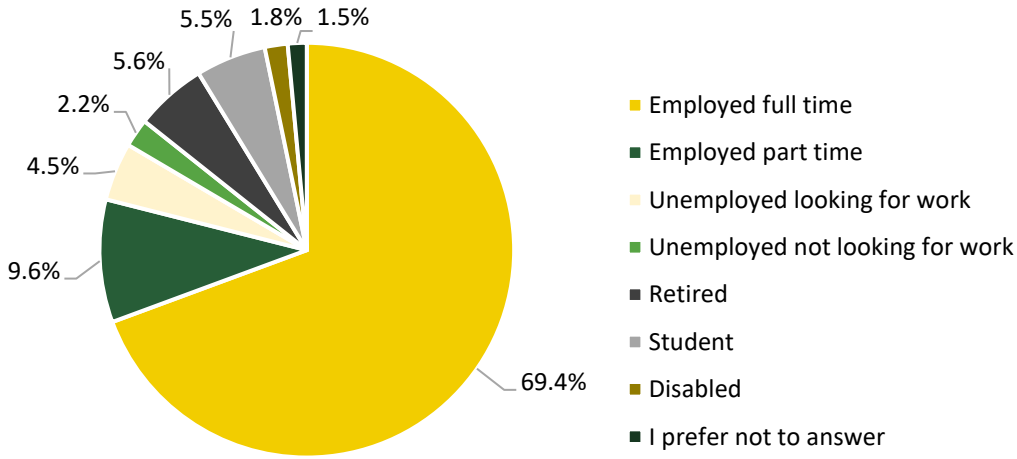

Figure 4 - Employment status (n=950)

Focusing on household composition, the median household size was three individuals, with a minimum of one individual and a maximum of nine individuals. Additionally, half of the households had a child under the age of 18 and 20% had at least one older adult (≥ 65 years) in the household. For household income (in 2021), 22.7% had an income under $50,000, 43.3% an income between 50,000 and $99,999, and 29.1% an income of $100,000 or more (Figure 5). More than half of the respondents lived in a single-family home (58.2%), and 63.9% owned their residence. Moreover, half of the residents had one automobile, 44.1% had two or more automobiles, and 4.9% did not have an automobile (i.e., carless). Additionally, 71.3% had at least one bicycle in their household. Regarding internet access, 97.8% of the households had regular access to home internet.

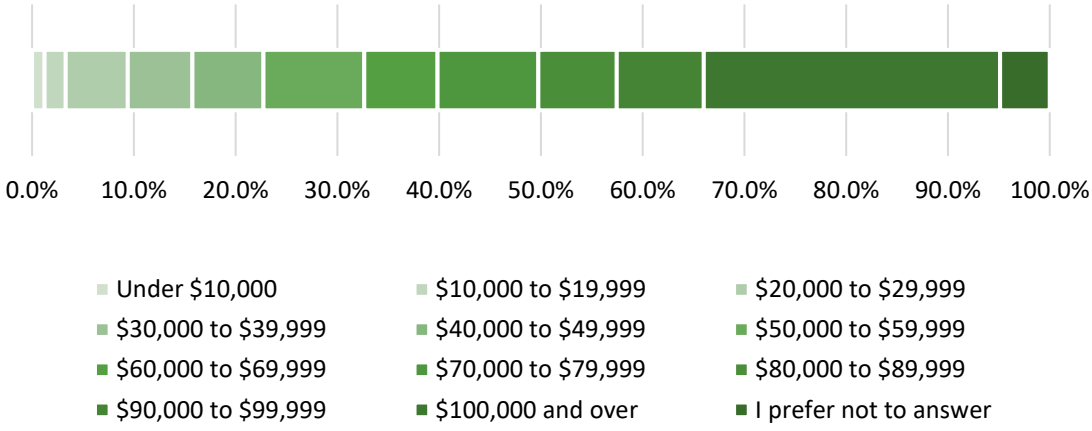

Figure 5 – Household income in 2021 (n=818)

Overall, the main demographic characteristics of the sample have some representativeness, based on data from the 2021 Canadian census data of the Edmonton Metropolitan Area (Government of Canada, 2019, 2022a, 2022b, 2022c, 2022d). The similarities were found in the categories presented in Table 3. The focus group dataset consisted of transcripts and coding from the underserved groups shown in Table 1. Specific demographic information, beyond the identification of the underserved group, was not collected. Codes are presented in the following section as results.

Table 3 – Comparison between sample and census

Category		**Sample**	**Census 2021**
Average age		38 years	38.8 years
Visible minorities		26.5%	33%
Average household size		3.0 individuals	3.0 individuals
Household income *(sample income in 2021 and census income in 2020)*	Under $10,000	1.2%	1.4%
	$10,000 to $19,999	2.1%	1.7%
	$20,000 to $29,999	6.1%	5.7%
	$30,000 to $39,999	6.4%	5.0%
	$40,000 to $49,999	7.0%	5.8%
	$50,000 to $59,999	9.9%	12.1%
	$60,000 to $69,999	7.2%	6.2%
	$70,000 to $79,999	9.9%	6.0%
	$80,000 to $89,999	7.7%	5.8%
	$90,000 to $99,999	8.6%	5.4%
	$100,000 and over	29.1%	44.9%
Gender Identity	Woman	54.4%	50.3%
	Man	43.3%	49.3%
	Other	0.9%	0.4%
Employment (Full-time and part-time)		78.9%	60%
Home ownership		63.9%	68.9%
Persons with disabilities		26.1%	23.0% (in 2017)

4) Resilience Hub Results

4.1) Overview of Resilience Hubs

Resilience hubs are community-serving locations that provide services and resources during normal conditions and disaster conditions to increase safety, well-being, and quality of life (Baja, 2018; Ciriaco and Wong, 2022). First promoted by the Urban Resilience Directors Network (URDN) in Baja (2017), the concept has further developed in both practical guidance (Baja, 2022; Vibrant Hawai'i, 2024) and academic research (de Roode and Martinac, 2020; Kirwan et la., 2021; Mardis et al., 2021). Resilience hubs have three key functioning modes:

1) Regular, where social services, information, and/or education are provided;

2) Response, where resources, shelter, and/or services are provided during a disaster; and

3) Recovery, where the hub provides support for ongoing relief activities following a disaster.

One important conceptual component of resilience hubs is that they are adaptable and flexible in a disaster such that they can meet community needs across diverse hazards and across varying levels of severity (e.g., acute, chronic). To clarify, resilience hubs are not synonymous with evacuation shelters/centres and may not have sufficient space for short- or long-term sheltering, depending on their design. Resilience hubs are designed to be regularly operating spaces to assist residents for various community needs depending on the situation.

Figure 6 - Resilience hub (Source: Kristin Baja/USDN)

While resilience hub design, resources, and services have been discussed and documented in the literature, less work has been conducted on resilience hub placement. Focusing on transportation, only Baja (2019) discussed the connection of transportation and resilience hub design/placement by suggesting the need for walking accessibility and locations along evacuation routes. Transportation is a vital component for resilience hubs since residents need to travel to/from hubs to receive resources and services. Moreover, transportation facilitates the movement of relief supplies and resources to the hubs for broader distribution. Within this context, Ciriaco and Wong (2022) conducted a systematic review of transportation needs and resilience hubs. The research identified five key takeaways related to the concept of resilience hubs:

1) Practical guidance and research have produced sufficient descriptions of the characteristics and functions of resilience hubs, which have been implemented across multiple jurisdictions in North America.
2) Resilience hubs should be placed in locations that are well-known and trusted by the community, including pre-existing buildings.
3) The specific location of resilience hubs and how people will travel to/from these hubs has not yet been defined or optimized, creating a key gap in meeting transportation needs of hub users.
4) Key performance indicators have not been implemented to assess or evaluate the effectiveness of resilience hubs, including metrics for equity or accessibility.
5) The co-location of resilience hubs with mobility hubs and community hubs could produce significant co-benefits, especially in facilitating effective transportation services to/from hubs.

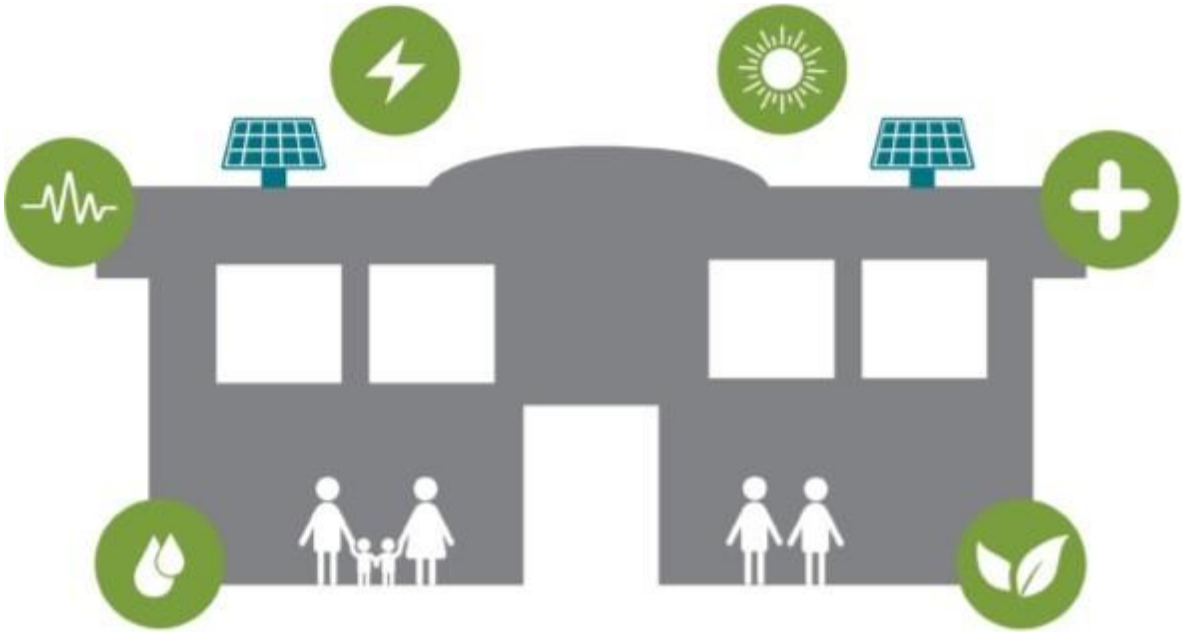

Figure 7 - Resilience hub resources (Source: Fulton County)

Ciriaco and Wong (2022) also focused on transportation and accessibility to determine pathways for improved research and successful implementation. Key takeaways are included below:

1) Transportation and accessibility needs are generally missing from most discussions of resilience hubs in the academic and practical literature.
2) Resilience hub design has not yet integrated transportation needs of underserved and vulnerable populations who are likely to use resilience hubs the most.
3) The evacuating public lacks information on how to travel to/from hubs, and resilience hubs have not yet been incorporated into evacuation planning.
4) The logistics of moving goods and resources to resilience hubs has not been explored or assessed, creating possible gaps for disaster recovery and relief distribution.

Taken together, resilience hubs could be a tool for climate adaptation, disaster response/recovery, and social services. The overall concept of resilience hubs has been developed and implemented in multiple

jurisdictions, though their effectiveness is not known due to minimal evaluation. Moreover, the transportation needs of residents have not been considered when planning or designing hubs, suggesting that transportation could be barrier in accessing resources. Further discussion and details can be found in Ciriaco and Wong (2022).

Figure 8 - Example resilience hub design (Source: Drawing by Carolyn Carlberg, permission provided)

4.1) Descriptive Statistics

The following sections provide an overview of the descriptive statistics for resilience hubs. The values are reported for the entire sample, with some additional questions reported for specific underserved groups.

4.1.1) Full Sample

Descriptive statistics provide an understanding of participants' characteristics and needs. Starting with knowledge of resilience hubs, the survey asked whether the participants had heard about resilience hubs before, revealing that most had never heard about hubs (77.7%). Subsequently, respondents selected characteristics that would best describe resilience hubs (Figure 9). Provide emergency sheltering was the option most selected, followed by community-serving physical space, a place to offer response services during disasters, and a central location to access a variety of services. Respondents were generally satisfied with a range of hub locations (Figure 10), ranking community centres (recreation centres) as the number one option (73.4% as very satisfied or satisfied). This was closely followed by schools/universities, libraries, and community leagues.

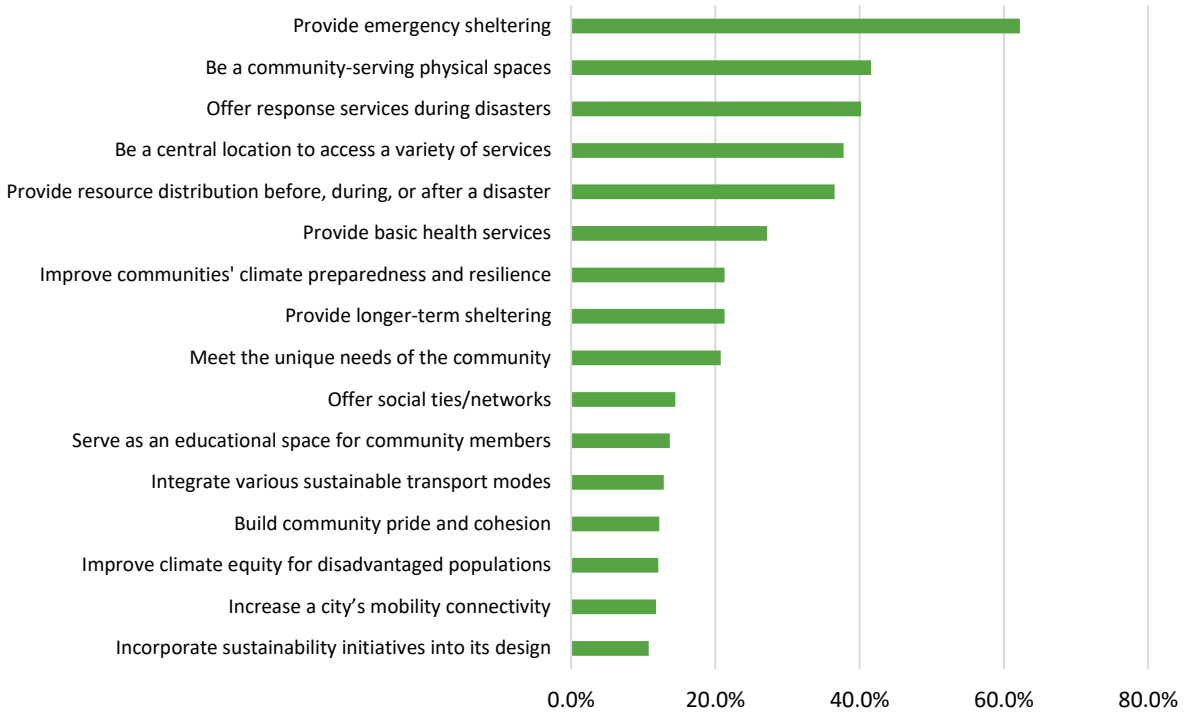

Figure 9 – Which of the characteristics below do you think best describes a resilience hub? (select all that apply, n=950)

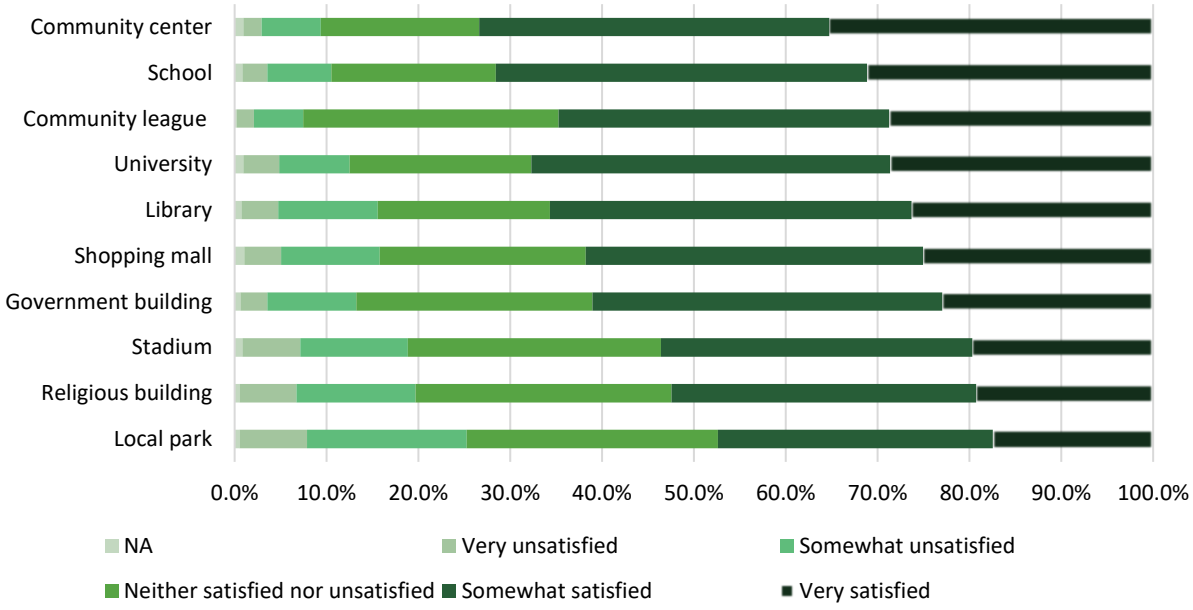

Figure 10 - How satisfied would you be with the following locations as a resilience hub in your community? (n=950)

Resilience hubs were considered very (25.5%) or mostly (27.8%) important by more than half of participants. Moreover, 64.5% believed that resilience hubs would help their community be more resilient, 56.0% that it would meet the needs of their neighbours on daily basis, and 58.6% that it would increase social cohesion in their communities. Regarding resilience hub usage (Figure 11), people were very likely or somewhat likely to use it during normal conditions (41.4%) and as a temporary evacuation shelter (59.2%). Additionally, during a disaster, 69.8% would be very likely or somewhat likely to gather information about the disaster at the resilience hub and 63.9% would use a hub to gather critical resources. Respondents also indicated if they would volunteer at resilience hub during normal days and during relief efforts. The results suggest that they are more likely to volunteer during relief efforts (60.2% very or somewhat likely) than during normal days (44.4% very or somewhat likely).

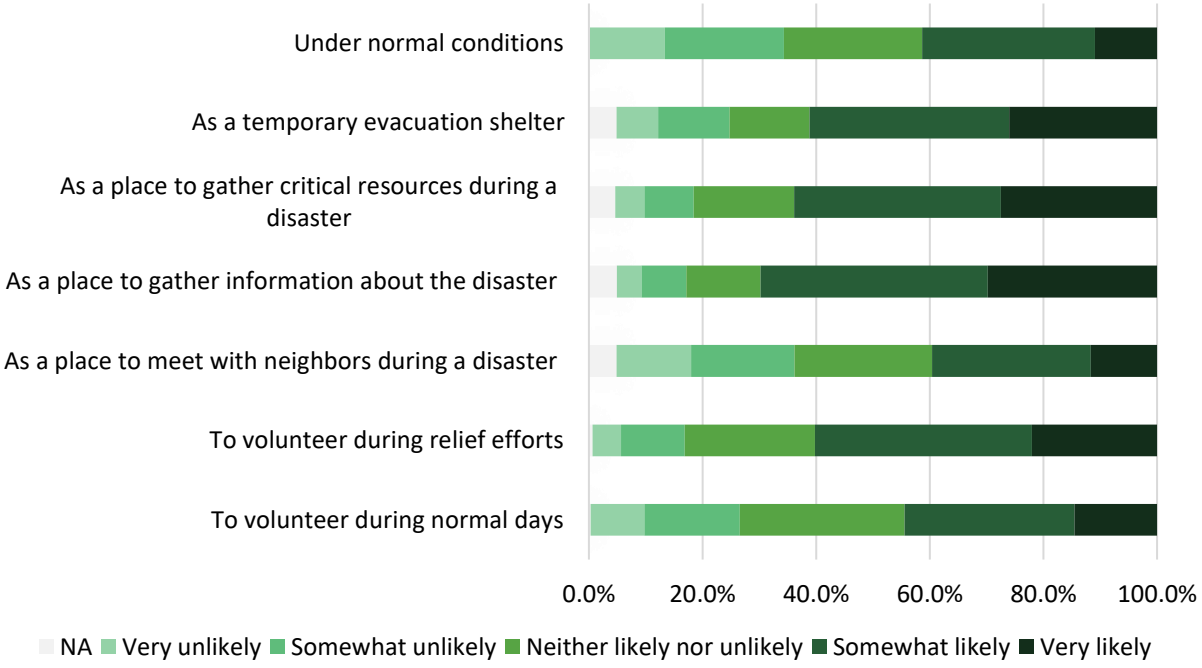

Figure 11 - Likelihood to use a resilience hub (n=950)

Furthermore, respondents indicated their preferences for emergency services and resources to be provided by resilience hubs (Table 4). Temporary shelter during a disaster was the most preferred, followed by backup/emergency power. Support for reuniting families and an information desk were also selected by a significant number of individuals, almost 70%. Community emergency response training was the service related to emergency management that had the lowest preference (61.7%). However, it was more preferred over some basic services such as Wi-Fi (58.3%), and services related to transportation (e.g., heated bus stop – 42.6%, bike parking – 31.2%). The primary basic resource selected by respondents was water (83.3%), followed by restrooms (81.5%) and heat/warming centres (81.1%). Focusing on food and health, 78.2% and 69.8% of respondents indicated that resilience hubs should provide food banks and market/grocery shops respectively, while 74.6% and 62% indicated the importance of providing urgent care and basic health services, respectively.

Table 4 – Services and resources to be provided by resilience hubs

Services and resources to be provided by resilience hubs		
Services and resources related to emergencies/disasters that are considered *very* or *mostly* important to be provided by resilience hubs	Shelter (temporary in disaster)	76.4%
	Back-up/emergency power	74.1%
	Support for reuniting families	68.9%
	Information desk	67.6%
	Community emergency response training	61.7%
Basic services and resources considered *very* or *mostly* important to be provided by resilience hubs	Water	83.3%
	Restrooms	81.5%
	Warming center	81.1%
	Food bank	78.2%
	Urgent care	74.6%
	Market/grocery	69.8%
	Showers	69.6%
	Cooling center	64.7%
	Basic health services	62.0%
	Wi-Fi	58.3%
Services and resources related to transportation that are considered *very* or *mostly* important to be provided by resilience hubs	Accessible for individuals with disabilities	68.4%
	Car parking	57.3%
	Transit connection	56.7%
	Resilience hub be within walking distance from residence	52.1%
	Heated bus stop	42.6%
	Parking for electric vehicles	38.3%
	Bike sharing	31.6%
	Bike parking	31.2%

Regarding transportation services offered by resilience hubs, the most popular choice was accessibility for individuals with disabilities (68.4%). When exploring vulnerable groups such as older adults and people with disabilities, accessibility features were even more important, with 82.1% of older adults and 76.7% of people with disabilities indicating it as very/mostly important. Car parking was the second most selected service, which is to be expected as 70.7% indicated that they would use a personal vehicle to go to a resilience hub under normal circumstances and 79.0% during an emergency condition (Table 5). Transit connections was the third most selected transportation service to be provided by a resilience hub, but within the carless group it was the second most important. For the general population, 8.1% would use public transit (e.g., bus, rail, microtransit) to reach a hub during normal days, while 27.3% of carless individuals would use public transit. The second most preferred mode of transportation to/from resilience hubs under normal or emergency conditions was walking (ranging from 8.5% to 14.8% depending on condition). About 5-6% of the population would choose to take shared mobility to a hub, such as via carpooling, ridesourcing, or carsharing. Additionally, the survey asked respondents to place a resilience hub in a preferred location in their community. The median distance between the respondents' residence and preferred hub locations selected was 1.7km, indicating the preference for closer places. As can be observed in Table 5, individuals who would walk to a resilience hub selected places very close to their residences (median of 0.6 km). Those who would use public transit were willing to travel 2.5 km (median), which was slightly greater than the median distance for drivers (2 km).

Table 5 – Modal choice and resilience hub distance

Distance between resilience hub and residence		
	Median (km)	**N**
	1.7	779
Distance between residence and resilience hub by mode		
	Median (km)	**N**
Personal vehicle	2	512
Public Transit (Bus, rail, microtransit)	2.5	57
Walk	0.6	113
Sharing mobility (Carpool, ridesource, carsharing, rental)	1.9	34
Others (motorcycle, bike, recreational vehicle)	5.2	6
Percentage of modal choice		
	Normal condition	**Emergency condition**
Personal vehicle	70.7%	79.0%
Public Transit (Bus, rail, microtransit)	8.1%	4.0%
Walk	14.8%	8.5%
Sharing mobility (Carpool, ridesource, carsharing, rental)	5.7%	6.5%
Others (motorcycle, bike, recreational vehicle)	0.7%	2.0%
Sample (n)	860	496

4.1.2) Underserved Groups

To further understand the unique needs and preferences of underserved groups (Ciriaco et al. 2023), a series of tables was constructed (Table 6-9) that divided responses between: visible minorities, people with disabilities, lower-income households, carless residents, women, households with children, and older adults. For preferred placement (Table 6), underserved groups followed similar patterns to the full sample by preferring community/recreation centres, with anywhere from 66% very/somewhat satisfied to 78.7% very/somewhat satisfied. Lower-income households and older adults both had higher satisfaction with schools, and older adults also preferred community leagues and religious buildings over community centres. Interestingly, older adults were generally satisfied with many locations, but lower-income households were generally the least satisfied group with placements. Schools, universities, libraries, and community leagues were generally satisfactory across groups.

More differences among groups arose when asked about their preferences for services and resources at hubs (Table 7). For example, while accessible design for individuals with disabilities was the most important transportation feature for all groups, three groups (older adults, individuals with disabilities, and carless residents) felt that these features were particularly important. In another example, car parking was rated as the second most important feature by visible minorities, people with disabilities, and women. However, older adults and lower-income households rated within walking distance as second. Carless residents and households with children rated transit connections as the second most important feature. These subtle differences point to varying needs. For emergency services, groups responded in similar ways, though older adults generally viewed services as more important than other groups. For basic services, people with disabilities and older adults rated characteristics generally higher than other groups, while visible minorities and lower-income households rated importance generally lower. Some services also had wide distributions in terms of importance such as restrooms, showers, and health services.

Table 6 – Resilience hub preferred placement by underserved group

Underserved Groups	Visible minorities	People with disabilities	Lower-income households	Carless Residents	Women	Households with children	Older adults
Places where a resilience hub could be located (top five locations) **(*Very and somewhat satisfied*)**	Community centre (77.6%)	Community centre (78.5%)	School (68.8%)	Community centre (78.7%)	Community centre (75.1%)	Community centre (76.1%)	School (84.6%)
	School (75.1%)	School (73.7%)	Community centre (66.1%)	University (72.3%)	School (74.6%)	School (74.3%)	Community league[3] (79.5%)
	University (71.9%)	University (70.3%)	Library (62.4%)	Library (72.3%)	University (68.6%)	University (69.1%)	Religious building (79.5%)
	Library (68.7%)	Library (66.8%)	University (61.8%)	Community league (68.1%)	Library (68.5%)	Library (66.7%)	Community centre (76.9%)
	Government building (66.9%)	Community league (66.0%)	Shopping mall (61.3%)	Government building (68.1%)	Community league (67.7%)	Community league (64.9%)	Shopping mall (74.4%)

Table 7 – Resilience hub services/resources by underserved group

		Visible minorities	People with disabilities	Lower-income households	Carless Residents	Women	Households with children	Older adults
Transportation services and resources at resilience hubs **(*Very and mostly important)***	Accessible for individuals with disabilities	65.5%	76.7%	69.4%	76.6%	71.9%	68.2%	82.1%
	Bike parking	28.5%	22.8%	34.4%	27.7%	28.1%	34.0%	20.5%
	Bike sharing	29.5%	25.4%	35.5%	27.7%	28.1%	34.6%	20.5%
	Car parking	54.4%	58.2%	54.8%	44.7%	60.6%	58.1%	46.2%
	Heated bus stop	42.7%	41.0%	40.3%	38.3%	39.2%	45.4%	28.2%
	Parking for electric vehicles	39.9%	35.3%	36.6%	31.9%	37.1%	39.7%	25.6%
	Resilience hub be within walking distance from residence	49.8%	52.6%	57.5%	57.5%	53.9%	52.9%	66.7%
	Transit connection	54.1%	56.0%	54.8%	61.7%	57.2%	59.4%	56.4%

[3] Community leagues are neighbourhood-based, non-profit organizations created under the Societies Act of Alberta, Canada, to meet community needs (Hairsine Community League, 2024).

		Visible minorities	People with disabilities	Lower-income households	Carless Residents	Women	Households with children	Older adults
Emergency services and resources from resilience hubs ***(Very and mostly important)***	Community emergency response training	60.9%	66.4%	66.7%	57.5%	65.8%	66.9%	64.3%
	Back-up/emergency power	71.2%	79.3%	71.0%	76.6%	77.2%	75.9%	92.9%
	Shelter (temporary in disaster)	71.2%	80.2%	77.4%	74.5%	81.6%	78.5%	89.3%
	Support for reuniting families	66.9%	72.4%	69.9%	68.1%	73.4%	74.1%	78.6%
	Information desk	65.8%	73.3%	67.7%	68.1%	70.6%	71.1%	82.1%
		Visible minorities	**People with disabilities**	**Lower-income households**	**Carless Residents**	**Women**	**Households with children**	**Older adults**
Basic services and resources from resilience hubs ***(Very and mostly important)***	Water	79.7%	85.8%	79.6%	78.7%	87.8%	86.6%	89.3%
	Food bank	74.0%	79.7%	77.4%	74.5%	82.4%	79.2%	82.1%
	Warming centre	77.2%	84.1%	78.5%	78.7%	84.5%	82.5%	85.7%
	Cooling centre	62.3%	68.1%	65.1%	61.7%	65.4%	64.7%	67.9%
	Wi-Fi	55.2%	50.9%	59.7%	68.1%	58.9%	59.0%	53.6%
	Restrooms	77.9%	38.4%	77.4%	51.1%	43.4%	82.2%	96.4%
	Showers	65.1%	84.9%	70.4%	85.1%	84.9%	69.7%	71.4%
	Basic health services	74.0%	82.8%	74.7%	78.7%	78.4%	74.8%	92.9%
	Market/ grocery	58.4%	65.1%	64.5%	72.3%	64.2%	63.4%	60.7%
	Urgent care	67.3%	77.2%	74.2%	72.3%	73.8%	68.2%	82.1%

For resilience hub usage and perceptions (Table 8), lower-income households, households with children, and visible minorities had the highest likelihood (very/somewhat) of using a hub during normal conditions (44.2%-51.1%). For emergency conditions, older adults exhibited a strong likelihood to use hubs across all four scenarios. Results also generally mirrored the full sample, since likelihood of using a hub was highest for gathering information about the disaster. Volunteer rates were generally consistent across groups, though carless residents had much higher rates during normal days but much lower rates during relief efforts compared to the other groups. When asked if a resilience hub would increase social cohesion in the neighbourhood, 71.6% of older adults said yes (highest), compared to 54.3% of lower-income households who said yes (lowest).

Table 8 – Resilience hub usage and perceptions by underserved group

Underserved Groups		Visible minorities	People with disabilities	Lower-income households	Carless Residents	Women	Households with children	Older adults
Likelihood to use a resilience hub ***(Very likely and somewhat likely)***	Under normal conditions	44.2%	40.5%	51.1%	34.1%	40.7%	45.4%	31.6%
	As a temporary evacuation shelter	66.5%	69.8%	62.9%	70.2%	64.1%	64.3%	76.9%
	As a place to gather critical resources during a disaster	63.0%	71.6%	67.2%	68.1%	67.9%	66.7%	74.4%
	As a place to meet with neighbours during a disaster	43.4%	38.4%	34.9%	34.0%	39.0%	43.4%	53.8%
	As a place to gather information about the disaster	73.0%	74.1%	66.7%	74.5%	72.8%	73.5%	84.6%
		Visible minorities	**People with disabilities**	**Lower-income households**	**Carless Residents**	**Women**	**Households with children**	**Older adults**
Volunteer at the resilience hub ***(Very likely and somewhat likely)***	During normal days	47.0%	41.8%	47.3%	57.5%	44.4%	48.5%	48.7%
	During relief efforts	61.9%	62.9%	64.0%	36.2%	62.7%	61.2%	82.0%
		Visible minorities	**People with disabilities**	**Lower-income households**	**Carless Residents**	**Women**	**Households with children**	**Older adults**
A resilience hub would help… ***(Yes)***	Increase social cohesion in my neighbourhood	62.6%	61.6%	54.3%	59.6%	58.7%	61.2%	71.6%
	Meet the needs of neighbours on a daily basis	55.9%	56.0%	52.7%	55.3%	55.8%	58.8%	48.7%
	Community to be more resilient	66.5%	66.0%	65.0%	63.8%	65.6%	65.6%	69.2%

Finally, underserved groups were also assessed based on their preferred location of a resilience hub along with their mode choice to/from hubs in normal and emergency conditions (Table 9). Carless residents and visible minorities exhibited the longest distance between their residence and a preferred hub at a median of 2.2 to 2.4 km. The other groups were between 1.5 and 1.7 km, preferring closer locations. Personal vehicles dominated mode choice for both normal and emergency conditions, except for carless residents (preference for walking and public transit). In normal conditions, older adults displayed a high willingness

to walk (44.7% of the group). It was also their second most chosen mode for emergency conditions (17.9%). In addition, public transit, walking, and shared mobility rates were usually higher for the underserved groups than for the full sample.

Table 9 – Median distance and mode choice to/from resilience hubs by underserved group

	Visible minorities	**People with disabilities**	**Lower- Income households**	**Carless residents**	**Women**	**Households with children**	**Older adults**
Distance (median in km) between resilience hub and residence	**2.2**	**1.5**	**1.7**	**2.4**	**1.5**	**1.7**	**1.6**
Sample size	*240*	*184*	*146*	*40*	*428*	*377*	*28*
Mode Choice - Normal condition							
Personal vehicle	72.2%	66.8%	71.2%	20.5%	71.1%	72.0%	51.6%
Public Transit (Bus, rail, micro-transit)	9.4%	10.9%	7.7%	27.3%	7.1%	9.2%	0.0%
Walk	11.4%	16.1%	15.3%	38.6%	17.9%	11.4%	44.7%
Shared mobility (Carpooling, Ridesourcing, Carsharing, rental car)	6.9%	6.2%	4.7 %	13.6%	3.8%	6.8%	2.6%
Other	0.0%	0.0%	1.2%	0.0%	0.2%	0.5%	0.0%
Sample size	*245*	*211*	*170*	*44*	*476*	*411*	*38*
Mode Choice - Emergency condition							
Personal vehicle	82.2%	75.5%	73.8 %	16.0%	81.1%	79.5%	78.6%
Public Transit (Bus, rail, micro-transit)	2.7%	6.4%	5.6 %	16.0%	4.0%	3.5%	0.0%
Walk	8.9%	11.8%	11.2%	48.0%	7.3%	5.7%	17.9%
Shared mobility (Carpooling, Ridesourcing, Carsharing, rental car)	4.8%	2.7%	9.4 %	12.0%	5.2%	8.7%	3.6 %
Other	1.4%	3.6%	0.0%	8.0%	2.4%	2.6%	0.0%
Sample size	*146*	*110*	*107*	*25*	*248*	*229*	*28*

4.2) Behavioural Modeling

This section presents a series of models that were developed using discrete choice analysis to determine the factors that influence choices related to resilience hubs usage made by individuals. Tables 10 to 12 presents the results of binary logit models with their associated coefficients, signs, p-values, and significance level. The first binary logit model developed explores the decision of whether or not to use a resilience hub during normal days (Table 10). Since the decision to not use a resilience hub during normal days is the base choice, a positive coefficient indicates that the variable increases the likelihood to use a resilience hub during normal conditions, while a negative coefficient indicates that the variable decreases the likelihood.

According to Table 10, all significant coefficients are positive, which means that these variables have a positive impact on the likelihood of using a resilience hub during normal conditions. The model results suggest that people who are already part of a community organization are more likely to use a resilience hub during normal conditions. This behaviour is consistent as a resilience hub is a community-serving physical space created to support the community during normal conditions and during disasters. Households that have two or more members and households with an income below $50,000 in 2021 are more likely to utilize a resilience hub during normal conditions. Moreover, individuals who think that a resilience hub would contribute to increasing social cohesion in their community are more likely to use it during normal conditions.

Table 10 – Discrete choice analysis – Use of resilience hubs during normal conditions

Use of resilience hubs during normal conditions: Binary Logit

Choice 1: Less likely to use not use – Base
Choice 2: Likely to use

	Use a resilience hub during normal condition			
Variable	*Estimated coefficient*	*Std. error*	*p-value*	
Constant	-1.71	0.17	0.000	**
Household Characteristics				
Household with more than 2 people	0.63	0.15	0.000	**
Household income less than $50,000 CAD (in 2021)	0.64	0.18	0.000	**
Income - prefer not to answer	-0.06	0.19	0.753	
Individual Characteristics				
Part of a community organization/group, not including a community league	0.41	0.15	0.007	**
Resilience hub				
A resilience hub would help increase social cohesion in my neighbourhood	1.18	0.15	0.000	**
Number of observations	950			
ρ2 (fit)	0.107			
ρ2 (adjusted fit)	0.10			
Final Log-Likelihood	-588.17			

* 95% significance **99% significance

Table 11 presents the results of the binary model that explores if individuals are likely to use a resilience hub as a temporary shelter during a disaster. The results indicate that individuals belonging to visible minority groups and those with disabilities are more likely to use resilience hubs as temporary shelters during disasters. Meanwhile, those employed either full-time or part-time are less likely to use these shelters. People who believe that having resilience hubs in their neighbourhoods would increase social

cohesion are more likely to use them during disasters as a temporary shelter. Additionally, those who trust their neighbours to help them during emergencies are more likely to use resilience hubs as shelters.

Table 11 - Discrete choice analysis – Use of resilience hubs as temporary shelters during a disaster

Use of resilience hubs as a temporary shelter during a disaster: Binary Logit

Choice 1: Less likely to use not use – Base
Choice 2: Likely to use

	Use a resilience hub during a disaster as a temporary shelter			
Variable	*Estimated coefficient*	*Std. error*	*p-value*	
Constant	-1.24	0.49	0.011	*
Household Characteristics				
Household has at least one child	0.31	0.14	0.031	*
Individual Characteristics				
Individual is employed full time or part time	-0.47	0.18	0.010	**
Individual is visible minority	0.40	0.16	0.010	**
Individual has a disability	0.46	0.17	0.008	**
Disability – prefer not to answer	-0.51	0.23	0.028	*
Individual has access to internet at home	1.06	0.47	0.025	*
Resilience hub				
My neighbours would help me in an emergency/disaster	0.45	0.14	0.002	**
A resilience hub would help increase social cohesion in my neighbourhood	0.86	0.15	0.000	**
Number of observations	950			
ρ2 (fit)	0.11			
ρ2 (adjusted fit)	0.10			
Final Log-Likelihood	-586.97			

* 95% significance **99% significance

A third model was developed to determine factors that influence the decision to use a resilience hub as a place to gather critical resources during a disaster (Table 12). According to the model's findings, people who are employed full-time or part-time and young adults (35 years and under) are less likely to use resilience hubs as a place to gather essential resources during a disaster. However, individuals with disabilities and women are more likely to use resilience hubs for gathering critical resources. In addition, those who would choose an active mode of transportation such as walking or biking to reach a resilience hub during an evacuation are significantly less likely to use the hub to gather critical resources. Those people stating that “one of the activities that provides me with the most meaning to my life is helping others in the world when they need help” (i.e., high helping compassion) are more likely to use a resilience hub as place to gather critical resources during a disaster. An interesting finding is that in all models, those

who believe that a resilience hub would help increase social cohesion in their neighbourhoods are more likely to use resilience hubs.

Table 12 - Use of resilience hubs as a place to gather critical resources during a disaster

Use of resilience hubs as a place to gather critical resources during a disaster: Binary Logit

Choice 1: Less likely to use not use – Base
Choice 2: Likely to use

	Use a resilience hub during a disaster as a place to gather critical resource			
Variable	*Estimated coefficient*	*Std. error*	*p-value*	
Constant	-1.49	0.54	0.006	**
Individual Characteristics				
Individual is employed full-time or part-time	-0.47	0.20	0.019	*
Individual with disability	0.41	0.19	0.026	*
Disability – prefer not to answer	-0.26	0.23	0.270	
Age under 35 years	-0.39	0.15	0.008	**
Individual has access to internet at home	1.38	0.48	0.004	**
Woman	0.37	0.15	0.015	*
Individual will use active mode (walk or bike) to go to a resilience hub during an evacuation	-0.93	0.34	0.006	**
Mode choice – prefer not to answer	-0.21	0.15	0.166	
Trust and compassion				
One of the activities that provides me with the most meaning to my life is helping others in the world when they need help (*very/somewhat true)*	0.59	0.15	0.000	**
It is possible to trust most people (*very and somewhat true)*	0.46	0.15	0.003	**
My neighbours would help me in an emergency/disaster (*very/somewhat true)*	0.29	0.15	0.052	
Resilience hub				
A resilience hub would help increase social cohesion in my neighbourhood (*very and somewhat true)*	0.85	0.15	0.000	**
Number of observations	950			
ρ2 (fit)	0.16			
ρ2 (adjusted fit)	0.14			
Final Log-Likelihood	-551.88			

* 95% significance **99% significance

In addition to the binary models, we have developed multinomial logit models to better understand the primary mode of transportation used by individuals when traveling to a resilience hub within their community, both during regular days and emergency situations. Table 13 presents the results of the normal conditions model and Table 14 the results of the emergency model.

Our multinomial model for normal conditions (Table 13) first looked into how household characteristics affect the mode of transportation chosen by individuals. We found that households with more than two individuals are less likely to opt for shared mobility or active modes of transportation and are more inclined towards public transit and personal vehicles. However, we also discovered that if a household has at least one child or one older adult, the individual is more likely to prefer using shared mobility. This suggests that households with dependents prioritize convenience and flexibility when it comes to transportation.

Table 13 - Multinomial Logit Model – Mode Choice Normal Conditions

Choice 1: Personal vehicle (one or more vehicles)
Choice 2: Public transit (bus, rail, microtransit) - **Base**
Choice 3: Sharing mobility (carpool, ridesource, carsharing, rental)
Choice 4: Active mode (walk, bike)

Variable	**Personal vehicle** *Estm. Coef.*	*p-value*		**Sharing mobility** *Estm. Coef.*	*p-value*		**Active mode** *Estm. Coef.*	*p-value*	
Constant	1.753	0.000	**	-0.213	0.494		1.427	0.000	**
Household characteristics									
Household with 2+ people	------	------		-1.374	0.001	**	-0.680	0.001	**
Household has at least one child	------	------		1.374	0.001	**	------	------	
Household has at least one older adult (65+)	------	------		0.758	0.036	*	------	------	
Individual characteristics									
Woman	0.461	0.024	*	------	------		0.907	0.001	**
Indigenous (i.e., First Nations, Métis, Inuit)	------	------		------	------		-0.783	0.063	
Age under 35 years	------	------		------	------		-0.594	0.007	**
Individual is employed full-time or part-time	------	------		------	------		-0.664	0.003	**
Long time resident (10+ years)	0.786	0.013	*	------	------		0.721	0.053	
Homeowner	------	------		-0.939	0.002	**	------	------	
Resilience hub									
Use a resilience hub during normal conditions (very or somewhat likely)	0.097	0.592		0.619	0.072		------	------	
Volunteer at a resilience hub during normal conditions (very or somewhat likely)	------	------		------	------		-0.642	0.003	**
Number of observations	856								
ρ2 (fit)	0.40								
ρ2 (adjusted fit)	0.38								
Final Log-Likelihood	-714.70								

* 95% significance **99% significance

Regarding individual characteristics, our model indicates that women prefer personal vehicles or active modes of transportation over public transit or shared mobility to travel to/from a resilience hub. Young adults (under 35) and those who work full-time or part-time are less likely to use active modes to travel to/from a hub during normal conditions. Individuals who have lived in the same residence for more than

ten years are more likely to use personal vehicles, possibly due to the availability of vehicles and bicycles at home. Additionally, those who own their residence are less likely to utilize shared mobility services.

Besides normal conditions, it is critical to understand travel behaviour in times of emergency, as individuals need a reliable mode of transportation to reach a resilience hub promptly. According to the results in Table 14, households with more than three cars are more likely to rely on their personal vehicles rather than public transit. However, they prefer public transit over shared mobility or active modes. Households with more than two people and those who own their residence are also more inclined towards using personal vehicles. Moreover, in emergency situations, young adults are less likely to use active modes of transportation when travelling to a resilience hub. People with disabilities are less likely to use shared mobility options. On the other hand, those who are inclined to volunteer at a resilience hub are more likely to use shared mobility services than other modes.

Individuals who feel very or mostly prepared for an evacuation are less likely to choose an active mode of transportation to reach a resilience hub during an emergency. On the other hand, those who are comfortable using a resilience hub as a shelter during a disaster are less likely to use a shared mobility service. Additionally, people who are likely to use a resilience hub as a place to gather critical resources during a disaster are less likely to use an active mode of transportation.

These insights on travel behaviour during normal conditions and emergencies can help policymakers and transportation planners design more effective and efficient transportation systems that cater to the unique characteristics of different demographic groups and ensure that they meet the needs of the community.

Table 14 - Multinomial Logit Model – Mode Choice Emergency Conditions

Choice 1: Personal vehicle (one or more vehicles)
Choice 2: Public transit (bus, train, microtransit) - **Base**
Choice 3: Sharing mobility (carpool, ridesource, carsharing, rental)
Choice 4: Active mode (walk, bike)

	Personal vehicle			**Sharing mobility**			**Active mode**		
Variable	*Estm. Coef*	*p-value*		*Estm. Coef*	*p-value*		*Estm. Coef*	*p-value*	
Constant	2.21	0.000	**	0.34	0.558		1.80	0.000	**
Household characteristics									
Household with 2+ people	0.78	0.007	**	0.72	0.143		------	------	
Household with 3+ automobiles	12.93	0.000	**	-2.01	0.000	**	-2.55	0.000	**
Household with 1+ bike	------	------		------	------		0.53	0.127	
Individual characteristics									
Indigenous (i.e., First Nations, Métis, Inuit)	------	------		------	------		-0.90	0.176	
Age under 35 years	------	------		------	------		-1.47	0.000	**
Woman	------	------		-0.46	0.223		------	------	
Individual with a disability	------	------		-1.36	0.020	*	------	------	
Disability – prefer not to answer	------	------		-13.1	0.000	**	------	------	

Visible minority	------	------		-0.52	0.260		------	------	
Homeowner	0.54	0.031	*	------	------		------	------	
Preparedness for an emergency									
Prepared for an evacuation (very or mostly)	------	------		------	------		-1.17	0.028	*
My household will be impacted by a disaster in the next 5 years (very or somewhat likely)	------	------		0.61	0.129		------	------	
Resilience hub									
Feel comfortable to use a resilience hub as shelter (very and somewhat)	------	------		-0.90	0.040	*	------	------	
Use a resilience hub as a place to gather critical resources during a disaster (very or somewhat likely)	------	------		------	------		-0.85	0.009	**
Volunteer at a resilience hub (very or somewhat likely)	------	------		1.04	0.031	*	------	------	
Volunteer at a resilience hub -prefer not to answer	------	------		1.39	0.097		------	------	
Number of observations	492								
ρ2 (fit)	0.53								
ρ2 (adjusted fit)	0.50								
Final Log-Likelihood	-316.04								

* 95% significance **99% significance

4.3) Focus Groups

Conducting focus group discussions alongside the survey results enabled us to gain an in-depth understanding of the evacuation needs and challenges of particularly vulnerable populations in Edmonton. The focus group discussions were conducted among carless residents, people with disabilities, older adults, low-income households, visible minorities, recent immigrants, parents/ guardians of young children, and women.

During the discussions, participants offered their insights into what existing locations can be retrofitted to serve as resilience hubs. We coded a total of 95 instances where potential locations were mentioned or discussed. We present a summary of the results in Figure 12. Community leagues/halls ranked highest, followed by recreation centres, universities/schools, and worship centres. This follows similar trends to the descriptive statistics. Participants particularly favoured community leagues and recreation centres since they are often centrally located and are already well utilized by communities. Schools also garnered much discussion due to the availability of essential amenities such as dining halls and restrooms as well as the presence of playgrounds already catered for children. Finally, worship centres such as churches and mosques were discussed as potential resilience hub locations due to being spacious, which would make them suitable to serve as shelters during emergencies.

Overall, we found that participants prioritized locations that already serve communities and where people generally meet to socialize or receive services.

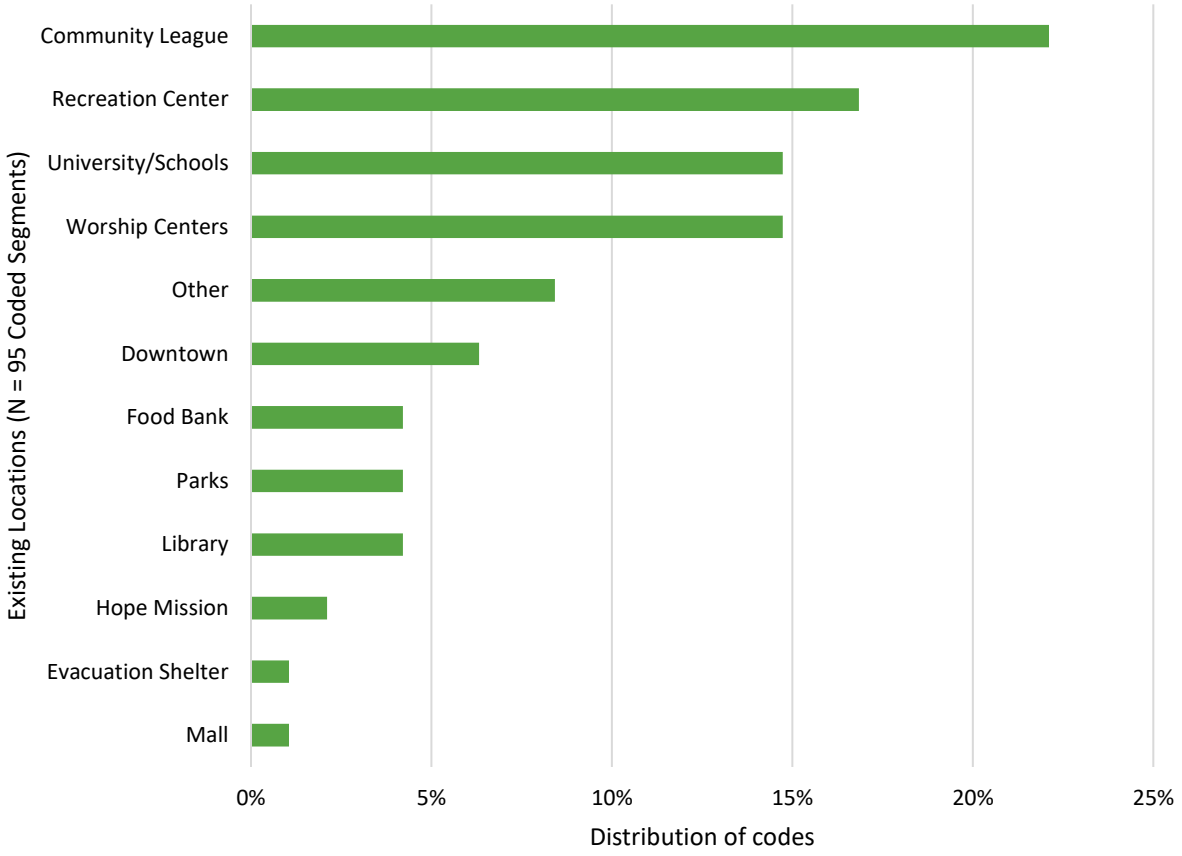

Figure 12 - Existing locations that can serve as resilience hubs (n=95 coded segments)

During the focus group discussions, participants further gave recommendations on services that can be offered by resilience hubs both during disasters and during normal conditions. 385 instances were identified where specific resilience hub services/features were discussed. Participants indicated a strong preference for having resilience hubs close to neighbourhoods. This was a particularly favoured opinion among the people with disabilities who recommended that resilience hubs should be placed close to residences and have special accommodation features to enable ease of access. Basic needs such as food, water, and shelter, were also strongly advocated for, especially during emergency situations. Participants further called for spaces adequately designed for children as well as safety features to maximize security at resilience hubs. Table 15 offers a summary of resilience hub features that were discussed more than 10 times during the focus group discussions.

Table 15 - Distribution of codes related to resilience hub features with more than 10 mentions

Parent Code: Resilience Hub Features (N = 385 Coded Segments)		
Code	**Code Frequency**	**Percentage of Segments**
Close to neighbourhoods/residences	42	10.9%
Basic needs (food, water, clothing, shelter)	39	10.1%
Ease of reach	36	9.4%

Special needs accommodation	30	7.8%
Spaces for children	22	5.7%
Safety	22	5.7%
Spacious	20	5.2%
Parking spaces	17	4.4%
Emergency preparedness training	16	4.2%
Staff/volunteers	15	3.9%
Services for newcomers	13	3.4%
Familiarity	13	3.4%
Information/communication centers	12	3.1%
Comfort	12	3.1%
Close to public transit stops/routes	10	2.6%

In addition to resilience hub placement and features, participants also discussed transportation modes they would use to access resilience hubs (see Figure 13). We observed that 38% of the coded segments were focused on public transit, followed by walking (28%), and driving a personal vehicle (19%). Public transit was the most discussed mode of transportation to access resilience hubs during both normal conditions and emergency scenarios. Participants noted that having resilience hubs in close proximity to transit stops would likely increase usage among community members. Walking was particularly favoured among carless residents who called for neighbourhood-centred resilience hubs. On the other hand, driving was a popular choice among parents/guardians of children who further discussed the need for adequate parking spaces at resilience hub locations (see Table 16).

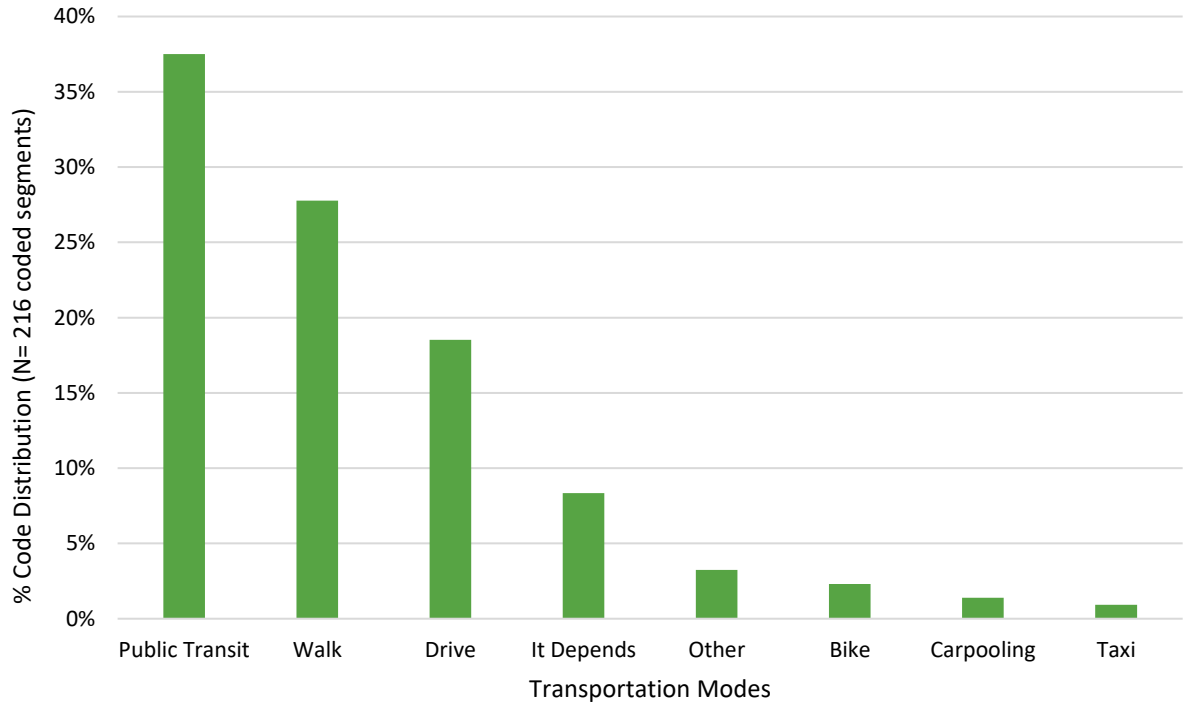

Figure 13 - Distribution of codes related to transportation to resilience hubs (n=216 coded segments)

Table 16 - Distribution of codes related to transportation modes by group (n=216 coded segments)

	Public Transit	Walk	Drive	It Depends	Bike	Other	Carpooling	Taxi
Older Adults	16	2	3	4	0	1	0	0
Children in Household	15	8	11	3	0	2	0	1
Recent Immigrants	15	1	6	0	4	0	0	0
Carless Residents	10	14	4	0	0	3	0	0
Lower-Income Households	7	6	4	1	0	0	1	0
Racial and Ethnic Minorities	7	13	5	4	0	0	2	0
Individuals with Disabilities	6	3	5	6	0	0	0	0
Women	5	13	2	0	1	1	0	1

During normal conditions (see Figure 14), 40% of the coded segments centred around using public transit, followed by walking (28%) and driving (20%). For example, participants discussed accessibility to resilience hubs both by buses and light rail. This was particularly favoured among racial and ethnic minorities who further called for amenities such as heated shelters at transit stops closest to resilience hubs. A preference for walking to resilience hubs during normal conditions was noted among recent immigrants and lower-income households whereas a preference to drive was observed among households with children and people with disabilities.

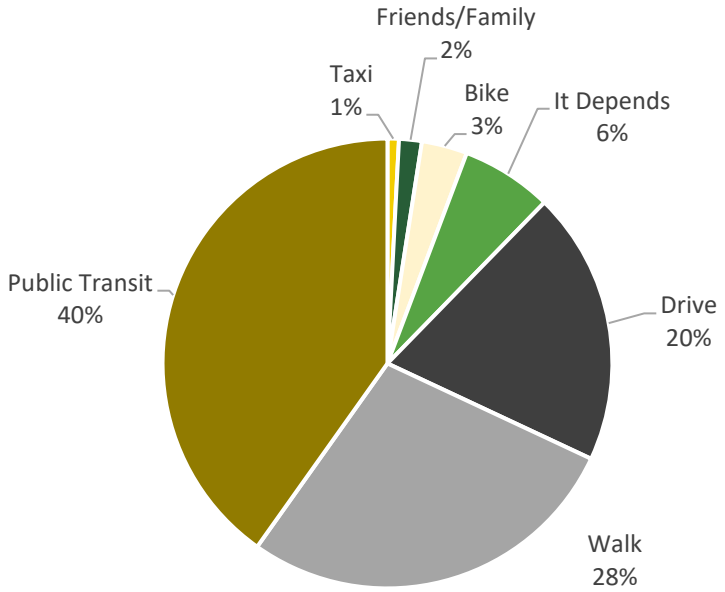

Figure 14 - Transportation mode to resilience hubs during normal conditions (n=122 coded segments)

During emergencies (Figure 15), a similar discussion pattern was observed with transit ranking highest (34%), followed by walking (28%) and driving (17%). Interestingly, public transit use during emergencies was most discussed by parents/guardians of children who indicated a preference for transit due to its availability to transport many people at once and reduce congestion. Participants from the carless residents and people with disabilities groups further considered the need for free transit services to resilience hubs during emergencies as well as coordination with paratransit services to especially provide transportation assistance for those with disabilities and the medically fragile. Walking to resilience hubs during emergencies was primarily discussed among carless residents and recent immigrants. Participants from these groups discussed the flexibility that comes with walking particularly in congestion scenarios. In all, participants acknowledged that transportation plays a key role in accessing resilience hubs both during normal conditions and during emergencies. Particularly in relation to public transit, they called for reliable schedules, sufficient capacities, free services during emergencies, and accessibility features for those with disabilities.

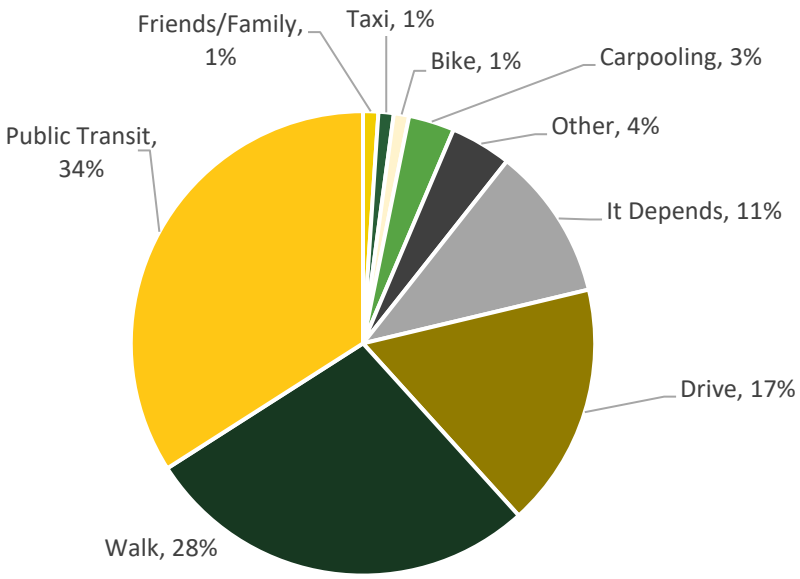

Figure 15 - Transportation to resilience hubs during emergency conditions (n=94 coded segments)

In addition to addressing the physical aspects of resilience hub infrastructure, participants also discussed the necessity of incorporating social infrastructure in building community cohesion. For example, participants advocated for mental health services offered by counsellors or trained staff at resilience hubs. This was a particularly common theme among the carless residents' group who spoke of the possibility of being affected by anxiety and stress during emergency scenarios. Participants further recommended having assistance services for people with disabilities and older adults in the neighbourhood. These could include transportation services, as well as help with yard maintenance and snow clearance in the winter. Finally, participants, particularly from the racial and ethnic minorities group highlighted the need for informational services at resilience hubs targeted towards newcomers. These would enable them to adapt quickly to Canada as well as their specific neighbourhoods. In all, participants highlighted that the integration of social infrastructure into resilience hubs would be instrumental in fostering community cohesion as well as building community resilience during normal conditions and emergency scenarios. Additional results and information are available in Wan and Wong (2024).

5) Urban Evacuation Results

5.1) Overview of Public Transit in Evacuations

While urban evacuation plans typically work effectively for those with access to automobiles, underserved and transit-reliant populations such as carless residents, older adults, people with disabilities, and low-income households, often face considerable challenges evacuating and are most negatively affected by disasters. During Hurricane Katrina, for example, a contraflow system was implemented on all major highways in New Orleans, enabling car-owners to flee the city (Renne et al., 2009). However, those who did not have access to personal transportation struggled to evacuate and accounted for the highest numbers of fatalities (Milligan and Company, 2007). Excessive reliance on automobiles during an evacuation can further cause congestion and subsequently increase difficulty in fleeing a disaster. During Hurricane Rita, almost 3 million people attempted to evacuate the Texas Gulf Coast by personal vehicles. This led to traffic gridlocks, fuel shortages, and restricted access for emergency vehicles (Hess, 2013; Abdelgawad and Abdulhai, 2012).

Integrating public transit into evacuation planning is therefore necessary, both for the evacuation of underserved groups and for the mitigation of congestion during emergencies. As a positive example, during the 2017 Northern California Wildfires, transit agencies aided the evacuation of residents from assisted living facilities and hospitals and ensured the presence of wheelchair-equipped vans for those with disabilities (Wong et al., 2020b). Moreover, during Hurricane Sandy, while New York City experienced extensive gridlock, commuter vans remained in operation and assisted in the evacuation of vulnerable residents in low-lying, flood-prone areas (Kaufman, 2012). Finally, during the 2023 wildfires in Alberta, jurisdictions such as Drayton Valley and Yellowhead County successfully implemented bus evacuations for those without access to personal transportation (CTV News, 2023). Experiences from previous disasters underscore the need for comprehensive approaches to transit evacuation planning in urban environments.

Our review of current evacuation plans in Canada found that, while major cities such as Toronto, Edmonton, Vancouver, and Montreal, have evacuation plans, public availability and integration of transit considerations vary. For example, Toronto's emergency plan outlines the transportation responsibilities of agencies such as the Toronto Transit Commission. However, the evacuation plan does not provide specific information for transit users (e.g., information on pick-up/drop-off locations, transit resources for people with disabilities) (Toronto, 2017). Conversely, while we could not find a public-facing transit evacuation plan for Montreal, we observed that the city has an Emergency Evacuation Assistance Program for residents with reduced mobility to register voluntarily and receive free evacuation assistance (Ville de Montreal, 2023). Similarly, we found that while the City of Edmonton does not have a public-facing transit evacuation plan, the city utilizes a self-registration online platform that enables emergency officers and first responders to provide personalized support as needed during an emergency (City of Edmonton, 2023). Overall, our review found that transit evacuation planning in Canada is primarily ad hoc rather than pre-planned (Lindsay, 2018). While this approach has been effective in the past (Scanlon, 2003), it may hinder preparedness in the future and lead to an inadequate allocation of transit resources required for vulnerable populations.

Based on this review (see more details in Wambura and Wong, 2024), we recommend that transit evacuation plans be made available to the public to enhance both public accountability and community

preparedness. Plans may include essential information on pick-up locations, evacuation routes, and evacuation support for people with disabilities. Transit evacuation planning should further consider the diverse needs of underserved groups. For instance, while carless residents and low-income households would require regular transit services, people with disabilities and older adults may require paratransit services, accessibility features, or medical equipment to evacuate safely. Moreover, recent immigrants to Canada with limited English proficiency may benefit from a translation of evacuation information whereas those who are deaf, or blind may require accommodations such as sign language interpreters, and oral, written, or picture-based communication formats. Finally, transit agencies and emergency management offices may consider working directly with non-governmental organizations (NGOs) and community-based organizations (CBOs) representing underserved populations to effectively reach these groups and involve them in the evacuation planning process (Wambura and Wong, 2024).

Figure 16 – Evacuation buses in areas with a mandatory evacuation order in the Bronx, U.S.A. (Source: Metropolitan Transportation Authority / Flickr)

5.2) Descriptive Statistics

The survey asked several questions about people's risk perceptions, sources of information, and urban evacuation choices and intentions. First, participants indicated the type of hazards that would most likely impact their residence. About 36% stated that it was very likely or somewhat likely that a disaster (of any type) would impact their residence in the next five years. Regarding the kind of hazard, the results uncovered that two hazards related to winter season were the most cited as very likely and somewhat likely: extreme cold temperatures (80.8%) and blizzards (76.5%). These hazards were followed by two threats related to spring and summer seasons: heat waves (67.3%) and extreme smoke (53.9%). Regarding their previous experience with hazards, almost half of them have been affected by at least one type of hazard before.

When asked how they might learn about an emergency or mandatory evacuation order (Figure 17), the most selected option was text messages (76.2%). This communication method was followed by Alberta Emergency Alerts (66.4%), television (51.5%) or radio (49.1%) announcements, and social media (42.6%). A moderate percentage of individuals indicated that they would receive information from someone (neighbour, friend, or extended family) (28.6%), and 22.4% would be informed by checking Internet websites (news or other sites). However, less than 20% would learn about an emergency or mandatory evacuation by checking city or state emergency management or government pages.

Figure 17 - How do you believe you will hear about an emergency or a mandatory evacuation order? (Select all that apply, n=950)

Regarding their preparedness for an evacuation (Figure 18), only 4.7% indicated that they were very prepared, while a large number of participants were not prepared (20.3%) or only a little prepared (26.1%). This indicates that a significant portion of the Edmonton population lacks preparedness to conduct an evacuation of their household.

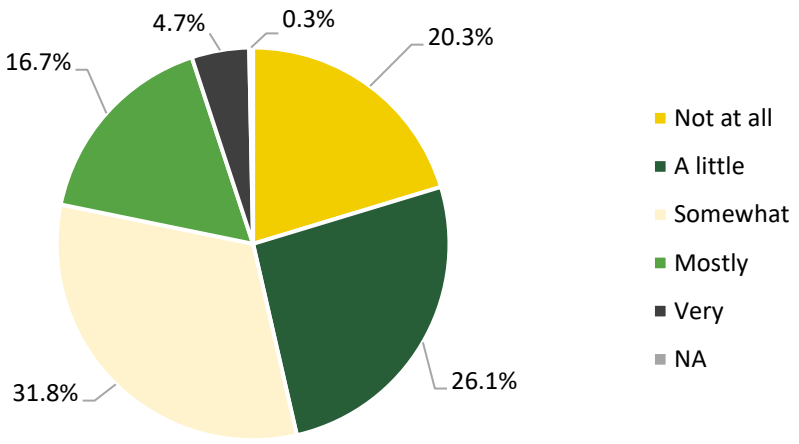

Figure 18 – To what extent do you feel prepared for an evacuation? (n=950)

Respondents also indicated if they would evacuate if a hazard had begun within a few kilometres of their residence (Figure 19). A significant portion would evacuate immediately (32.4%). Another 26.4% would evacuate after receiving a voluntary order and 14.5% would evacuate after receiving a mandatory evacuation order. Respondents may have a relatively high level of risk perception and consider a voluntary evacuation order sufficient evidence of a high level of risk to their household. Moreover, 19.5% would evacuate after gathering their family and 3.6% would evacuate after they see their neighbours evacuate. Importantly, just 1.9% of respondents would defend against the hazard and then evacuate and only 1.6% would not leave at all. This decision-making pattern toward evacuation is encouraging, especially as other hazards have exhibited much lower evacuation compliance rates, even when mandatory evacuation orders are widely distributed. For those who specified that they would not evacuate (1.6%), the main reasons that led to their decisions were: 1) they believed that the hazard would not be threatening to them, 2) they wanted to protect their property from the hazard, and 3) they did not know where to go.

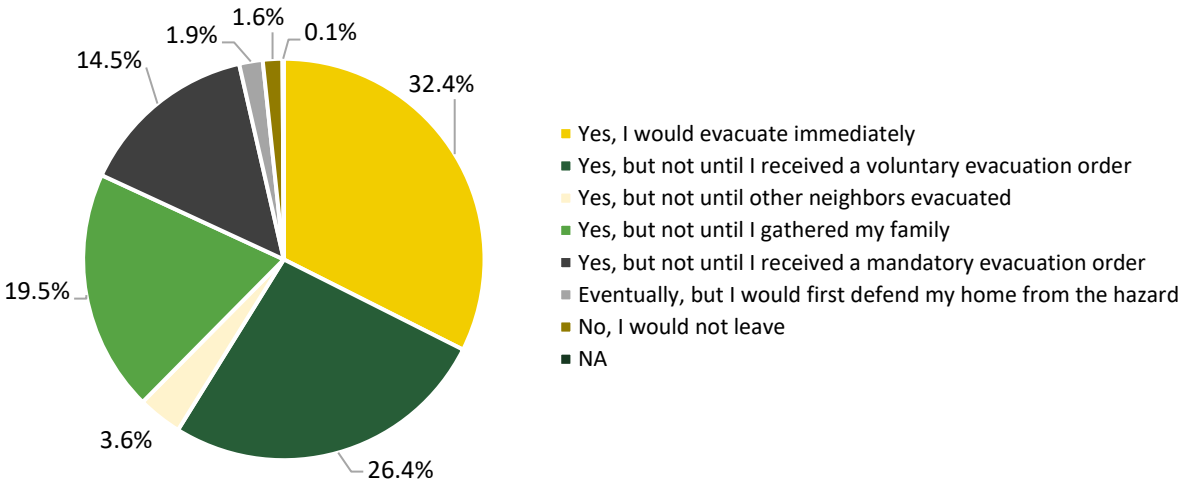

Figure 19 – "Consider a situation where a hazard has begun within a few kilometres of your residence." Would you evacuate from your residence? (n=950)

The length of time it takes for evacuees to leave their residence is often considered milling time, preparedness time, or departure time. Most individuals would take 30 minutes or less to prepare to leave their residence after receiving a notification to evacuate (Figure 20), with about 18.1% leaving within 15 minutes and 41.4% between 15 and 30 minutes. Additionally, 24.5% will leave in 30 minutes to 1 hour, 11.5% in 1 to 2 hours, and less than 5% in more than 2 hours. Results indicate a relatively rapid movement of people between 15 minutes and 1 hour which is a typical benchmark across hazards. However, additional assistance, resources, or communication may be necessary for people who will take longer than 1 hour to leave.

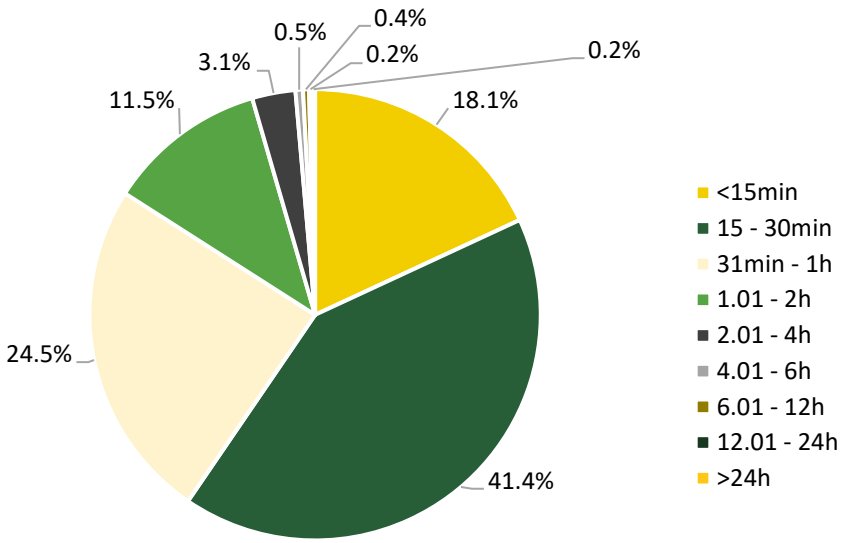

Figure 20 – After receiving a notification to evacuate, approximately how long will it take to prepare to leave your residence (minutes)? (n = 934)

Regarding vehicle trips that they intend to take before their evacuation trip (Figure 21), 45.3% would take one trip, 27.6% two trips, 10% three trips, and 9% four trips or more. An additional 8.1% would take no trip. This trip-making pattern is consistent with car ownership as more than 90% would use a personal vehicle to evacuate. As noted in Figure 22, public transit and active modes combined had almost the same representation as shared mobility (e.g., carpool, ridesource, carshare, etc.). Most respondents also indicated that would use a smartphone or GPS-based navigational tools during an evacuation and would follow most of the directions suggested. Moreover, most do not have a preference over road types during their evacuation (Figure 23). About 21% indicated that the majority of their evacuation trip will involve local roads, 17.9% will use mostly major/arterial roads, and 18.7% will use highways. Less than 2% will mostly use rural roads.

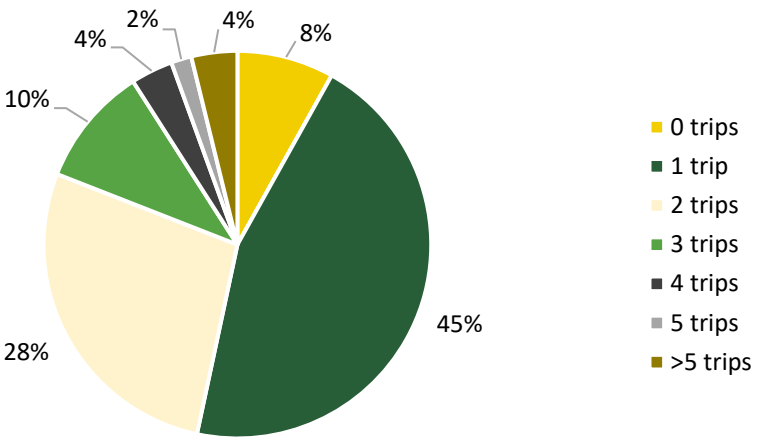

Figure 21 - How many vehicle trips do you intend to take before your evacuation trip? (n = 939)

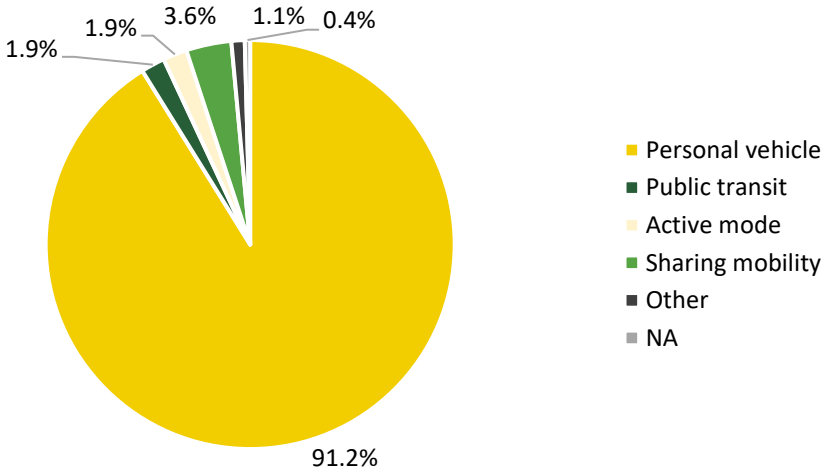

Figure 22 - What primary mode of transportation would you use to evacuate? (n = 950)

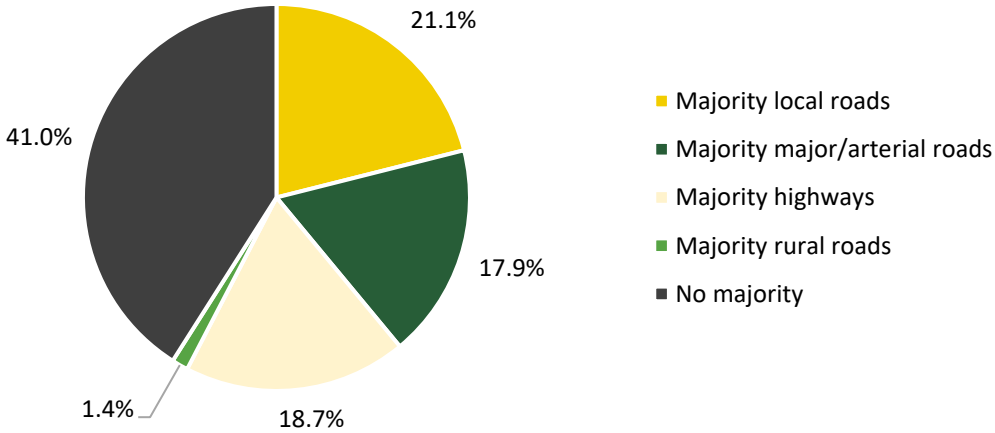

Figure 23 - Route choice during an evacuation (n=949)

When asked about the type of shelter at the final destination of their evacuation (Figure 24), the majority of evacuees indicated that they would shelter in a family member's residence or a friends' residence (60.7%). About 15% would shelter in public shelter or community centres, and 15.5% would shelter at hotel, motel or Airbnb. Focusing on destination location, 46.8% of respondents would evacuate to the City of Edmonton and another 13.7% would evacuate to other places in the Edmonton Metropolitan Area. Outside of the region, 11.3% would evacuate to locations across Alberta, 4.2% to other provinces, and 24% outside Canada (Table 17).

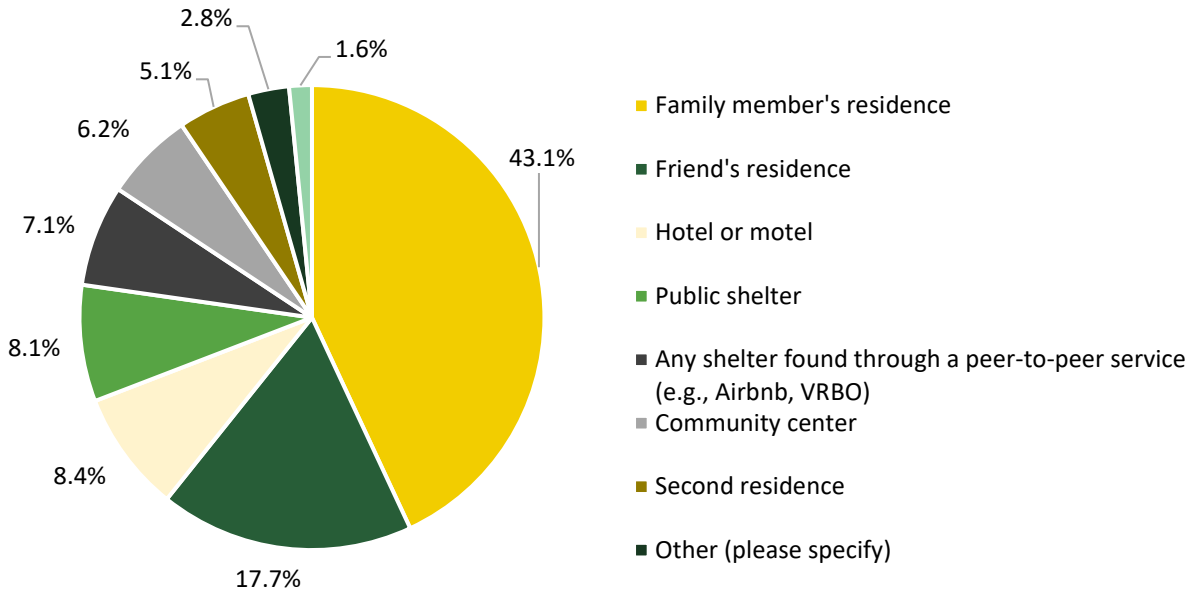

Figure 24 - Shelter type at final destination of the evacuation (n=950)

Table 17 - Final destination location

Final destination location	
City of Edmonton	46.8%
Edmonton Metropolitan Area, excluding the city	13.7%
Alberta, other locations	11.3%
Other provinces in Canada	4.2%
Outside Canada	24.0%

5.3) Behavioural Modeling

This section presents a series of multinomial logit models developed to determine variables that influence key evacuation choices within an urban evacuation context of Edmonton, Canada. As an important limitation, these evacuation choices are hazard agnostic. Future work will need to specifically identify the type of hazard for respondents, since different hazards can lead to different choices. Table 18 shows the model for exploring evacuation decision, Table 19 for shelter type, Table 20 for mode choice, Table 21 for route choice, and Table 22 for preparation time.

Figure 25 – Edmonton traffic at night | Dustin Bowdige / Unsplash

5.3.1) Evacuation Decision

We first developed a multinomial model for evacuation choice. We combined 'would eventually evacuate but first defend' and 'would not leave' as the best representation of evacuation unwillingness (i.e., stay/defend). This was used as the base case. The research findings on evacuation decision (Table 18) indicate that individuals who have evacuated in the past are more likely to leave immediately or following a voluntary evacuation order. Households owning two or more cars are more inclined to evacuate after receiving a voluntary evacuation order. Households with more than two members are more likely to evacuate immediately or after gathering their family members. Additionally, young adults are more willing to evacuate immediately or after their neighbours have evacuated, while women are more likely to evacuate after gathering their family. Carless individuals are less likely to evacuate after receiving a voluntary evacuation order. Those employed full-time or part-time are less likely to evacuate after receiving a mandatory evacuation compared to all other choices. Individuals who plan to shelter at a friend's or family member's residence are more inclined to evacuate after receiving a voluntary evacuation

order. Moreover, those who intend to take 1 or no vehicle trips before their evacuation trip are more likely to evacuate immediately.

Table 18 – Evacuation decision modeling results

Multinomial Logit Model
Choice 1: Yes, I would evacuate immediately
Choice 2: Yes, but not until I received a voluntary evacuation order
Choice 3: Yes, but not until other neighbours evacuated
Choice 4: Yes, but not until I gathered my family
Choice 5: Yes, but not until I received a mandatory evacuation order
Choice 6: I would eventually evacuate, or I would not evacuate (**Base**)

	Yes, I would evacuate immediately			**Yes, but not until I received a voluntary evacuation order**			**Yes, but not until other neighbours evacuated**			**Yes, but not until I gathered my family**			**Yes, but not until I received a mandatory evacuation order**		
Variable	*Estm. Coef.*	*p-value*		*Estm. Coef.*	*p-value*		*Estm. Coef.*	*p-value*		*Estm. Coef.*	*p-value*		*Estm. Coef.*	*p-value*	
Constant	1.28	0.000	**	1.58	0.000	**	-0.50	0.155		1.16	0.000	**	1.85	0.000	**
Household characteristics															
Household has more than two individuals	0.42	0.009	**							0.57	0.03	**			
Household has 2 or more cars				0.38	0.014	*									
Individual characteristics															
Carless individual				-0.83	0.041	*									
Young adults (<35 years)	0.39	0.007	**				0.93	0.013	*						
Women										0.37	0.30	*			
Individual is employed full-time or part-time													-0.56	0.007	**
Evacuation experience and decisions															
Previous evacuee	0.98	0.000	**	0.40	0.037	*									
Intend to take 1 or no vehicle trip before their evacuation trip	0.35	0.017	*												
Shelter at family member's residence or friend's residence				0.32	0.045	*									
Number of observations	949														
ρ2 (fit)	0.16														
ρ2 (adjusted fit)	0.15														
Final Log-Likelihood	-1425.438														

* 95% significance **99% significance

5.3.2) Shelter Type Choice

Next, we developed a model that focused on shelter type across four choices, largely grouped into a family/friends, hotel/motel, public shelter, and second resource. Family/friends was the base choice. In Table 19, the modeling identified that previous evacuees and homeowners are more likely to stay in hotels, motels, Airbnbs, or other secondary resources (e.g., second residence, vehicle) rather than with family/friends or at a public shelter. Those who will take less than 10 min to prepare to evacuate are more likely to stay in secondary resources, and less likely to stay in a hotel, motel, or Airbnb in comparison to the other options. Those who intend to take one or no vehicle trips before their evacuation trip are also more likely to stay in a hotel, motel, or Airbnb. In addition, visible minorities and carless individuals are more likely to stay in public or government shelters. Individuals with disabilities are less likely to shelter in a hotel, motel, or Airbnb, while lower-income households are the opposite. Finally, those who trust most people are less likely to shelter in a hotel, motel, or Airbnb compared to all other options.

Table 19 - Shelter type modeling results

Multinomial Logit Model
Choice 1: Family or friends house (**base**)[1]
Choice 2: Hotel/Motel/Airbnb
Choice 3: Public or Government shelter[2]
Choice 4: Second resource (Portable vehicle, second house)[3]

	Hotel/Motel/Airbnb			**Public or Government shelter**			**Second resource (Portable vehicle, second house)**		
Variable	*Estm. Coef.*	*p-value*		*Estm. Coef.*	*p-value*		*Estm. Coef.*	*p-value*	
Constant	-2.00	0.000	**	-1.59	0.000	**	-3.07	0.000	**
Household characteristics									
Household lower-income (< $50,000 CAD)	0.41	0.049	*						
Individual characteristics									
Disability	-0.56	0.028	*						
Homeowner	0.38	0.025	*				0.45	0.008	**
Visible minority				0.52	0.006	**			
Carless				0.86	0.013	*			
Evacuation experience and decisions									
Previous evacuee	0.73	0.000	**				0.96	0.000	**
Take less than 10 min to prepare to leave residence	-0.75	0.027	*				0.78	0.005	**
Intend to take 1 or no vehicle trip before evacuation trip	0.53	0.006	**						
Trust and compassion									
Neighbours are generally/almost always trustworthy	0.50	0.013	*						
It is possible to trust most people	-0.83	0.000	**						
Number of observations	938								
ρ2 (fit)	0.276								
ρ2 (adjusted fit)	0.264								
Final Log-Likelihood	-941.49								

* 95% significance **99% significance

1 includes accommodation with members of my religious community
2 includes work, university, tent/camping, public place, military shelter, international airport, mall, church building
3 includes cottage and vehicle

5.3.3) Mode Choice

Unlike the previous models, mode choice had fewer significant variables overall, indicating the importance of availability. With public transit as the base choice, the mode choice model (Table 20) revealed that those who have evacuated in the past are more likely to take public transit and shared mobility than to use personal vehicles or active modes to evacuate. Those who will take less than 10 minutes to prepare to evacuate are more likely to use active modes or shared mobility to evacuate in comparison to public transit and personal vehicles. Individuals who own their residences and those who are employed full-time or part-time are more likely to use personal vehicles to evacuate than other modes. Additionally, carless individuals are less likely to use personal vehicles compared to other modes.

Table 20 - Mode choice modeling results

Multinomial Logit Model
Choice 1: Personal vehicle
Choice 2: Active mode
Choice 3: Public transit (**base**)
Choice 4: Sharing mobility

	Personal vehicle			**Active mode**			**Sharing mobility**		
Variable	*Estm. Coef.*	*p-value*		*Estm. Coef.*	*p-value*		*Estm. Coef.*	*p-value*	
Constant	3.78	0.000	**	0.24	0.561		0.28	0.392	
Individual characteristics									
Homeowner	0.67	0.005	**						
Employed full-time or part-time	1.03	0.001	**						
Carless	-3.80	0.000	**						
Evacuation experience and decisions									
Previous evacuee	-1.26	0.000	**	-1.626	0.016	*			
Take less than 10 min to prepare to leave residence				1.105	0.035	*	1.304	0.002	**
Number of observations	936								
ρ2 (fit)	0.813								
ρ2 (adjusted fit)	0.805								
Final Log-Likelihood	-242.06								

* 95% significance **99% significance

5.3.4) Evacuation Route Choice

For choosing a route for evacuation (Table 21), households with more than two individuals are less likely to have a strong preference for a particular type of road. Households with more than three cars are less likely to use rural roads for the majority of the journey, but more likely to use a variety of roads (all compared to arterial/major roads and highways). Young adults are more likely to use multiple road types or use mostly highways than the other options of roads in their evacuation trips. Additionally, individuals with a disability are more likely to choose a specific road type. Carless individuals and those who will take less than 10 minutes are less likely to use highways during their evacuation trip. Individuals who had evacuated previously are more likely to use mostly local roads or multiple road types. It should be noted

that the fit for this model is somewhat low, indicating that attributes of the route and circumstance may impact route choice more than sociodemographic characteristics.

Table 21 - Route choice modeling results

Multinomial Logit Model

Choice 1: Majority local roads
Choice 2: Majority arterial roads (**base**)
Choice 3: Majority highways
Choice 4: Majority rural roads
Choice 5: No majority

Variable	Majority local roads			Majority highways			Majority rural roads			No majority		
	Estm. Coef.	*p-value*		*Estm. Coef.*	*p-value*		*Estm. Coef*	*p-value*		*Estm. Coef.*	*p-value*	
Constant	0.05	0.648		-0.04	0.755		-2.55	0.000	**	0.07	0.660	
Household characteristics												
Household has more than two individuals										0.33	0.028	*
Household has more than 3 cars							-8.83	0.000	**	0.81	0.039	*
Individual characteristics												
Young adults (<35 years)				0.48	0.009	**				0.54	0.000	**
Individual with a disability										-0.35	0.038	*
Carless				-1.32	0.030	*						
Evacuation experience and decisions												
Previous evacuee	0.50	0.018	*							1.18	0.000	**
Take less than 10 min to prepare to leave residence				-0.64	0.015	*						
Number of observations	949											
ρ2 (fit)	0.18											
ρ2 (adjusted fit)	0.171											
Final Log-Likelihood	-1252.92											

* 95% significance **99% significance

Majority indicates that an individual has allocated 50% or more in that type of road in the question that asked, "What approximate percentage of your route are on the following road types during an evacuation?"

5.3.5) Preparation Time

Departure timing (or preparation time in our case) focuses on the time it would take for the individual to evacuate after deciding to evacuate (Table 22). The base case for this is a fast preparation time of 0-20 minutes (denoted as quickly in this section). Looking at the results, previous evacuees are more likely to prepare quickly in comparison to all other categories. Similarly, those who intend to take one or no vehicle trip before their evacuation trip are more likely to evacuate under one hour. Individuals who would transport strangers before evacuating with their family are more likely to prepare quickly compared to 41 minutes or more. Individuals who would use public transit to evacuate are more likely to take 41 to 60 minutes to prepare to evacuate. Those who would use shared mobility to evacuate are more likely to

evacuate quickly or within 41-60 minutes. Low-income individuals are more likely to take 21 to 40 preparing, while women are more likely to take 41 to 60 minutes to prepare to evacuate. Additionally, individuals who own their residences are more likely to evacuate quickly compared to slow preparation (more than one hour). Moreover, households that have more than two members are more likely to take 21 to 40 minutes to evacuate.

Table 22 - Preparation time to evacuate modeling results

Multinomial Logit Model

Choice 1: 0-20 minutes (**base**)
Choice 2: 21-40 minutes
Choice 3: 41-60 minutes
Choice 4: more than 60 minutes

	21-40 minutes			**41-60 minutes**			**More than 60 minutes**		
Variable	*Estm. Coef.*	*p-value*		*Estm. Coef.*	*p-value*		*Estm. Coef.*	*p-value*	
Constant	-0.50	0.001	**	-0.47	0.001	**	0.25	0.148	
Household characteristics									
Household has more than two individuals	0.34	0.034	*						
Individual characteristics									
Homeowners							-0.41	0.008	**
Woman				0.33	0.045	*			
Low-income (< 50,000CAD)	0.39	0.035	*						
Mode choice									
Mode choice to evacuate: sharing mobility	-0.95	0.057					-2.07	0.047	*
Mode choice to evacuate: public transit				1.46	0.003	**			
Evacuation experience and decisions									
Previous evacuees	-0.44	0.017	*	-0.55	0.007	**	-0.78	0.001	**
Intend to take 1 or no vehicle trip before their evacuation trip							-0.87	0.000	**
Individual would transport strangers before they and their household evacuate				-0.46	0.032	*	-0.76	0.005	**
Number of observations	934								
ρ2 (fit)	0.069								
ρ2 (adjusted fit)	0.056								
Final Log-Likelihood	-1205.76								

* 95% significance **99% significance

5.4) Focus Groups

To obtain an understanding of general evacuation behaviour during emergencies beyond the survey, we talked to focus group participants about their plans for an evacuation. First, we asked participants (n=52) whether they would choose to evacuate given a mandatory or voluntary evacuation order. Many of the

participants (82%) reported that they would evacuate, whereas 18% stated that their decision would depend on factors such as the type and severity of a disaster, availability of transportation services, and the presence of medical and physical assistance while evacuating. Notably, many of those who expressed uncertainty about evacuating were from the people with disabilities focus group. While many participants said that they would evacuate, only 38% of all participants indicated that they were ready for an emergency evacuation (see Figure 26). The rest of the participants expressed uncertainty about where to seek information, what actions to take, and where to go during an emergency scenario. A majority of the participants who expressed a lack of emergency preparedness were from the recent immigrants' focus group.

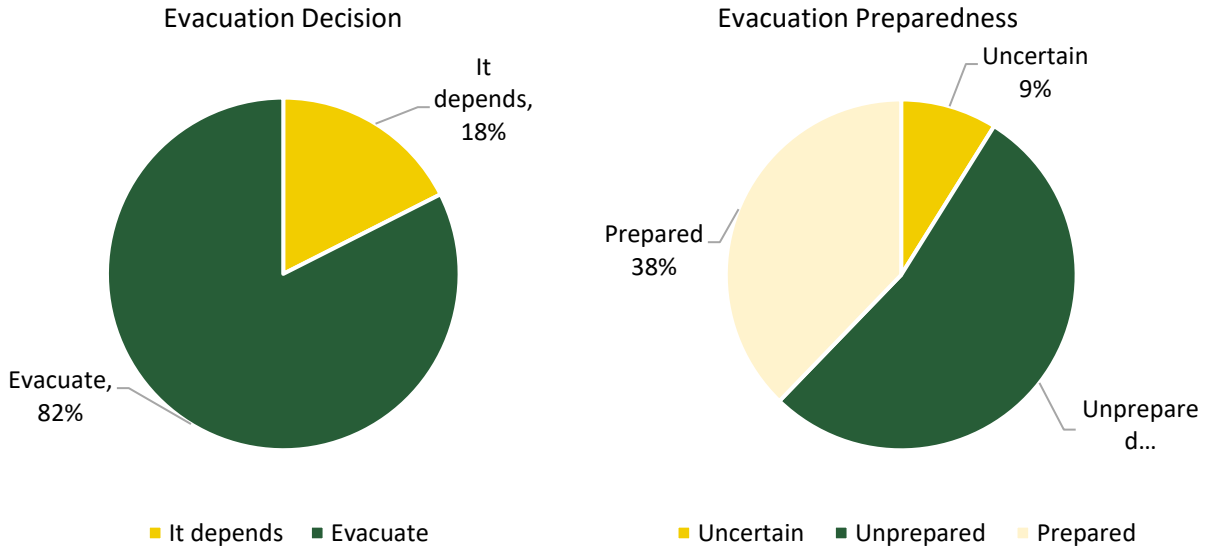

Figure 2626 - a) Evacuation decisions and b) Evacuation preparedness among focus group participants (n=52 participants)

We further asked the participants to consider where they expected to hear evacuation information from. This would enable evacuation planners to understand residents' preferred sources of information during an emergency. Table 23 shows a distribution of codes related to each information source. We found that participants primarily looked to the government for evacuation information, with many from the racial and ethnic minorities' group stating that they would refer directly to the City of Edmonton's website to verify information on disasters, transportation options, and shelter locations. When asked how much time participants would need to prepare for an evacuation once an order had been issued, their responses varied. Figure 27 provides a summary of these results.

Table 23 - Distribution of codes related to sources of evacuation information

Parent Code: Evacuation Communication (n = 173 coded segments)		
Code	**Code Frequency**	**Percentage**
Government Sources	29	16.76%
Information Sharing: General	25	14.45%
Social Media	22	12.72%

Evacuation Orders/Alerts	21	12.14%
Google/Online	16	9.25%
TV/Radio	14	8.09%
News	11	6.36%
Public Notice Boards/Announcements	8	4.62%
SMS	7	4.05%
Neighbours	7	4.05%
Emergency Numbers (911/211)	4	2.31%
Accessible Information	4	2.31%
Family/Friends	3	1.73%
Context-dependent	2	1.16%

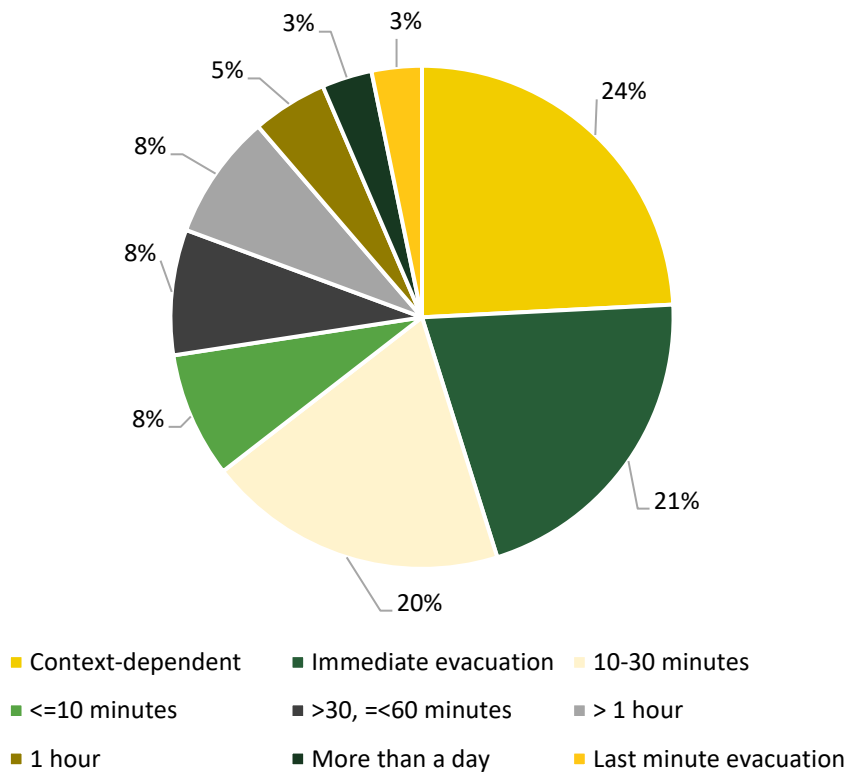

Figure 27 - Distribution of codes related to expected evacuation preparation time (n=62 coded segments)

Notably, we observed that among the 62 coded segments related to evacuation preparation time, 24% pointed to context-dependent responses. Participants stated the amount of time they would take to prepare would primarily depend on the nature of the disaster. For example, while they may have more time to prepare for a flood warning, the same may not be the case for a wildfire alert. Some participants, however, remarked that they would evacuate immediately after receiving an evacuation order (21% coded segments). Many of these were from the low-income households group. The rest of the discussions on evacuation time ranged from 10 minutes after an evacuation order to a last-minute evacuation

attempt. These results may aid emergency officers in determining the optimal time to issue evacuation alerts and ensure sufficient preparation time among community members.

We then asked participants what mode of transportation they would use to evacuate during a disaster. We present these results in Figure 28 below. We found that 32% of the participants would drive whereas 24% indicated a preference for public transportation and 19% expressed a preference for walking. The rest of the participants preferred other modes such as taxi, biking, and carpooling. With regard to public transportation specifically, participants identified concerns with irregular bus and train schedules during disasters as well as overcrowding due to insufficient capacity. Moreover, the older adults and people with disabilities groups expressed a need for the provision of accessible features as well as physical and medical assistance in transit during evacuations. Participants pointed to mobility challenges, including being immunocompromised, which can make evacuations difficult. Finally, the low-income households and women focus groups identified public transportation costs as a potential barrier to evacuating. They, therefore, called for fare-free transit policies during emergencies to support those from low-income families.

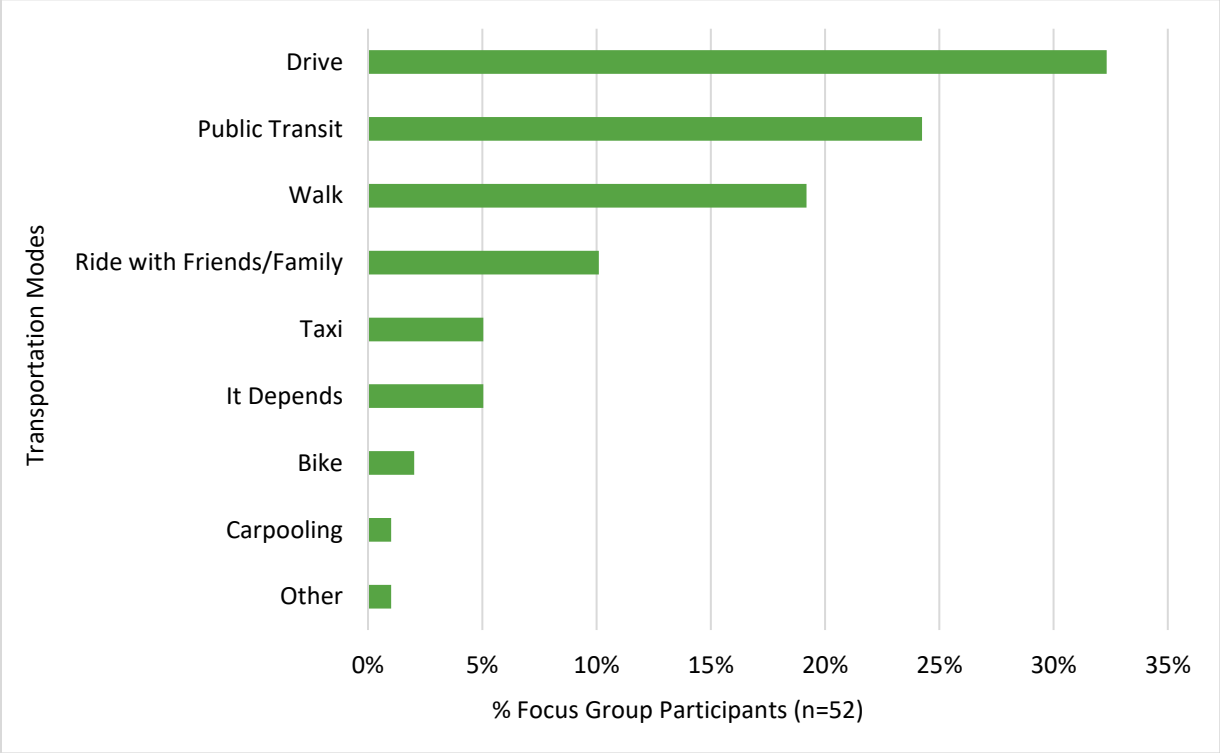

Figure 28 - Preferred transportation modes during emergency evacuations (n=52)

We observed that the highest number of coded segments related to driving were among the racial and ethnic minorities and women focus groups (Table 24). These groups indicated a preference for driving during an evacuation citing reasons such as flexibility, comfort, speed, and ease in transporting children and luggage. Racial and ethnic minorities had the highest number of coded segments related to public transit. The group discussed the importance of having reliable transit services during an emergency, particularly for those who have no alternative forms of transportation. Walking was discussed as a potential mode of transportation during an evacuation by households with children, recent immigrants,

and carless residents. These groups discussed affordability as a barrier to using transit during evacuations. They further pointed to walking as a reliable form of transportation during congestion scenarios when evacuating.

Table 24 - Distribution of codes related to evacuation transportation modes (N = 99 coded segments)

	Drive	Public Transit	Walk	Bike	Carpooling	Taxi	Friends/Family	It Depends	Other
Older Adults	1	2	0	2	0	1	5	1	0
Children in Household	3	4	5	0	0	0	0	1	0
Recent Immigrants	4	1	5	0	0	0	1	1	0
Carless Residents	0	2	5	0	0	0	0	0	0
Lower-Income Households	2	1	2	0	0	3	1	0	0
Racial and Ethnic Minorities	9	8	0	0	0	0	0	2	0
Individuals with Disabilities	4	4	0	0	0	0	0	3	0
Women	9	2	2	0	1	1	0	0	1

Figure 29 shows a breakdown of public transit themes that were identified during our focus group discussions. We observed that reliability and accessibility were most frequently cited across all the focus groups, each accounting for 23% of the total coded segments. Reliability was a prevalent theme among low-income households who depended on transit for daily mobility whereas accessibility was a prevalent theme among people with disabilities and older adults who further expressed a need for physical and medical assistance on transit during evacuations. Affordability was a key theme among women and low-income households who called for fare-free transit for eligible low-income evacuees during emergencies. Social cohesion was a surprising theme from the focus group discussions, comprising 13% of the total coded segments around transit themes. Participants, particularly from the older adults group, discussed the importance of evacuating with other people in transit rather than driving alone to reduce feelings of anxiety during emergencies. Finally, the themes of safety and the ability of transit to evacuate many residents at once were well discussed among the households with children group. The group highlighted the benefits of reducing congestion during evacuations and pointed to safe transit operations as a key tool in achieving this end.

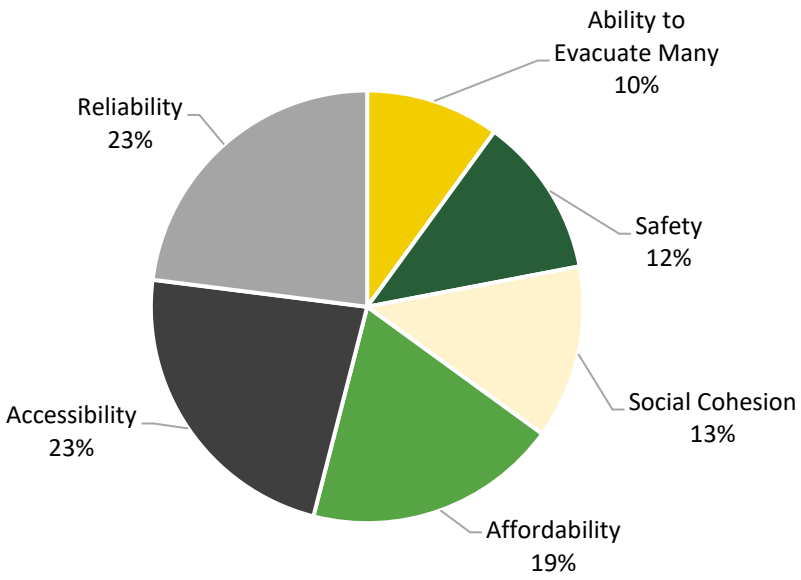

Figure 29 - Public transit themes identified during focus group discussions (n=91 coded segments)

Toward the end of the focus group discussions, we asked participants about their views on disaster/emergency registries (see Figure 30). These registries would collect medical and special accommodation information for individuals who require specialized services or attention during evacuations. Many of the participants (88%) reported that they were comfortable with providing this information to registries to ensure they receive the services they need to safely evacuate. The remaining participants, however, stated that they would only share this information if their data was fully protected.

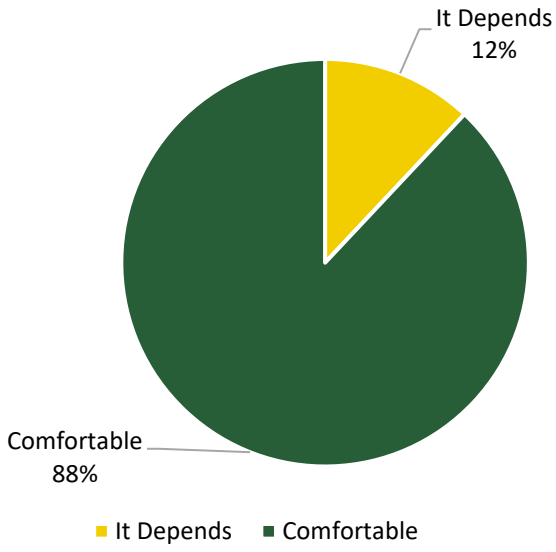

Figure 30 - Comfortability with providing information to emergency registries (n=50 coded segments)

6) Recommendations

Recommendations are provided based on the results of the research. Further details on the development of each recommendation can be found in the supporting literature. The related research also contains more details, especially related to resilience hub design, services, and transportation.

6.1) Criteria for Resilience Hubs

Resilience Hub Design	
Key Recommendations	**Supporting Literature**
• Resilience hubs should be located within the community rather than at far-away places in the city, as individuals prefer to have resilience hubs close to their residences. • Existing locations that can be retrofitted into resilience hubs include recreation centers, community leagues, and libraries. Schools and universities were mentioned by participants to serve as a resilience hub, but educational activities at these facilities may conflict with disaster conditions. • Resilience hubs should be large enough to serve as a temporary shelter during a disaster. • Resilience hub design should incorporate accessibility to facilitate walking for older adults, people with disabilities, and households with children. • Resilience hubs require sufficient infrastructure to meet needs during extreme weather events (e.g., heating, cooling, ventilation, etc.).	(Ciriaco and Wong, 2022, 2023; Ciriaco et al., 2023; Wan and Wong, 2024)
Resilience Hub Services	
Key Recommendations	**Supporting Literature**
• Retrofitted resilience hubs should be able to provide basic services and resources to accommodate community needs (e.g., water, food, electricity, restrooms, etc.) during disasters. • Resilience hubs should provide reliable and clear information to residents during an emergency. • Resilience hub coordinators should have a list of potential volunteers to work during relief efforts, as some residents are willing to help during relief efforts. • For everyday conditions, resilience hubs could include food bank services or meal preparation services to support community needs. • For all conditions, resilience hubs could include basic health services, urgent care, and mental health support. • Resilience hubs require sufficient services to serve as a warming center during extreme cold days, a cooling center during heat waves, and a clean air center during smoke events. • Resilience hub plans should contain information on how and when relief resources will reach the hub.	(Ciriaco and Wong, 2022, 2023; Ciriaco et al., 2023; Wan and Wong, 2024)

6.2) Transportation to/from Resilience Hubs

Transportation to/from Resilience Hubs	
Key Recommendations	**Supporting Literature**
• Resilience hubs should be placed close to residences to accommodate all modes of transportation, as the preferred median distance between residences and resilience hubs ranged between 0.6 km (walking) and 5.2 km (public transit). • Resilience hubs should be centrally located in denser areas and within walking distance of the most likely users of a resilience hub, such as carless, transit-dependent, and low-income populations. • Efficient transit connections for resilience hub users should be a priority in design and location considerations. Resilience hubs should be placed close to bus stops and within walking distance of train stations to enable multimodal and sustainable access. • During emergencies, transit access to resilience hubs could be subsidized or made free for those from low-income households. • Additional transit infrastructure such as heated bus shelters at stops closest to resilience hubs may be considered to increase transit usage and comfort. • Accessibility features for those with disabilities are required when designing resilience hubs. These would include wide sidewalks, ramps, visible crosswalks, and parking spaces for those with an accessible parking permit. • Partnerships could be created with shared mobility companies to ensure availability both during normal conditions and emergencies. • Active transportation infrastructure should be improved around resilience hubs to encourage usage and safety. Strategies may include incorporating speed limits close to resilience hubs in addition to adding sidewalks, bike lanes, and reliable bike parking. • Within auto-centric cities, some parking will be needed to accommodate all resilience hub users, especially individuals with disabilities, older adults, and households with children.	(Ciriaco and Wong, 2022, 2023; Ciriaco et al., 2023; Wan and Wong, 2024)

6.3) Equity Considerations for Resilience Hubs

Older Adults	
Key Recommendations	**Supporting Literature**
• Older adults had a strong preference for urgent care services to be included in resilience hubs. Medical staff should be available at resilience hubs to offer treatments and first-aid services for various health conditions. • Resilience hubs should provide warming centers, cooling centers, and smoke-free zones, particularly for seniors who are an at-risk population. • Resilience hub designs should feature ramps, lifts, and other assistive technologies to accommodate older adults.	(Ciriaco et al., 2023; Wan and Wong, 2024)

• Older adults are highly willing to volunteer during relief efforts. Emergency training should be provided to older adults to adequately prepare them for volunteering opportunities during emergencies.	
People with Disabilities	
Key Recommendations	**Supporting Literature**
• Resilience hub designs should feature ramps, lifts, and other assistive technologies for people with disabilities. • Resilience hub design should ensure accessible and reliable transportation to individuals with disabilities, which may include additional paratransit services.	(Ciriaco et al., 2023; Wan and Wong, 2024)
Low-Income Households	
Key Recommendations	**Supporting Literature**
• Low-income households had the strongest preferences for bike-sharing and bike-parking facilities. Resilience hubs should feature connected bike lanes as well as bike parking facilities. • Jurisdictions could work with shared micromobility service providers to offer e-bikes and e-scooters, which could specifically benefit low-income households to travel to and from resilience hubs.	(Ciriaco et al., 2023)
Visible Minorities	
• Resilience hub should provide information in different languages, especially during a disaster, to accommodate the needs of communities that have a high number of non-English and non-French speakers. This group is highly likely to use a resilience hub to gather information about the disaster.	(Ciriaco et al., 2023)
Women	
Key Recommendations	**Supporting Literature**
• Women had the strongest preferences for car parking services. Resilience hubs may need to include some parking spaces, particularly for women who would prefer to drive to resilience hubs. • Women also had a strong preference for showers and restroom services at resilience hubs. These basic services should be offered and regularly maintained for women and others to use safely and comfortably.	(Ciriaco et al., 2023)
Households with Children	
Key Recommendations	**Supporting Literature**
• Resilience hubs should provide warming centers, cooling centres, and smoke-free zones as these are important for children who are an at-risk population. • Households with children indicated a strong preference for services to reunite families during disasters. Family reunification services should be prioritized during emergencies.	(Ciriaco et al., 2023)
Carless Populations	

Key Recommendations	Supporting Literature
• Among survey respondents, carless populations had the highest preference for transit connections to resilience hubs. Jurisdictions should ensure that those who do not own cars or are unable to drive can access either buses or trains to travel to/from resilience hubs. • To ensure the viability of bicycling and walking, bicycling infrastructure and high-quality sidewalks should be integrated into resilience hub designs.	(Ciriaco et al., 2023; Wan and Wong, 2024)

6.4) Urban Evacuation Operations

Communication	
Key Recommendations	**Supporting Literature**
• Residents should have knowledge of evacuation plans (through a public-facing webpage and resource) or information in advance about existing routes and shelter locations. • Survey respondents indicated a preference to receive evacuation information through text messages, followed by Alberta Emergency Alerts. Province-wide emergency officials should work with the City's emergency agencies to ensure swift communication channels to residents through both alerts and official text messages. • Evacuation orders should be amplified via television, radio stations, and social media outlets (i.e., Facebook, Twitter, Instagram), as these were also key communication channels for research participants. • Evacuation orders should use clear and accessible language to accommodate people with different education levels, learning styles, and disabilities. • Evacuation alerts should include sufficient information on where disasters are taking place, shelter locations for residents, and transportation modes to use. • Transit users were found to be more likely to take a decently long time to prepare for evacuations (41 to 60 minutes. Evacuation communication strategies (such as information on bus routes, bus stops, and emergency kits) could be catered to this demographic to support preparedness. • Most groups were willing to evacuate after receiving a voluntary evacuation order. Mobile alerts and updated government website information should therefore be used to provide voluntary evacuation orders during an emergency.	(Wambura and Wong 2024; Wambura and Wong, 2023); Section 5
Transportation	
Key Recommendations	**Supporting Literature**
• Evacuation plans should include multimodal transportation capabilities. Personal vehicles were a preferred transportation mode choice followed by walking, carpooling, and public transit. Options, especially public transit, should be included in evacuation plans and alerts. • Public transportation should be made affordable, particularly for low-income households. Jurisdictions should consider offering fare-free transit during an evacuation period.	(Wambura and Wong, 2024; Wambura and Wong, 2023); Section 5

• Support should be provided for carless residents to increase preparedness and evacuation compliance, based on concerns and discussion from participants of the focus groups. • Transit schedules during evacuations should be publicly available and regularly updated to ensure efficient transportation for transit-dependent populations within the jurisdiction. • Transportation assistance should be provided for those who need significant support to evacuate. This may include older adults and people with disabilities. Medical staff should also be made available in transit to offer support as needed. • To facilitate evacuation, city planners could also include pickup points in their evacuation plan and add infrastructure (e.g., signs) so that people can easily identify these points. • Partnerships with shared mobility companies could be facilitated to ensure affordable evacuation options. • Those who would take less than 10 minutes to prepare for an evacuation were more likely to use local roads, arterial roads, rural roads, or a mixture of roads for their evacuation trip. As such, more localized roads should be designed to handle high volumes of traffic, especially during the first hour of an evacuation alert.	
Sheltering	
Key Recommendations	**Supporting Literature**
• Previous evacuees and homeowners were found to be more likely to stay in hotels/Airbnb compared to family/friends or a public shelter during an emergency. The city could create partnerships with hotel chains as well as Airbnb to ensure the availability and affordability of sheltering options during an emergency evacuation scenario. • Since visible minorities and carless residents are more likely to rely on government/public shelters, the city should ensure that shelters are available, well-maintained, and easily accessible by transit or active transportation modes. • People with disabilities were less likely to use public shelters or hotels/motels/Airbnb for shelter during emergencies. It is important to ensure that both public and private sheltering options have necessary accessibility features as well as amenities for people with disabilities.	Section 5

6.5) Evacuation Planning Strategies

Inter-agency collaborations	
Key Recommendations	**Supporting Literature**
• The local office of emergency management should create strong partnerships with transit agencies to prepare transit routes, pick-up locations, and transit drivers ahead of a disaster. • Partnerships should be created with schools to secure school buses that can complement public transit and increase evacuation capacity during a disaster.	(Wambura and Wong, 2024; Wambura and Wong, 2023)

• The local office of emergency management should collaborate with ridesourcing companies (e.g., Uber and Lyft) and charter bus services, which can provide shared mobility services and reduce single-occupant vehicles during an evacuation.	
Disaster Registries	
Key Recommendations	**Supporting Literature**
• Jurisdictions should consider establishing disaster registries for residents to voluntarily provide medical information, transportation needs, and any disabilities or mobility challenges before a disaster. • Based on the provided information in registries, the jurisdiction can prepare sufficient shelter or transportation resources for groups with special or additional needs during an evacuation. • Jurisdictions should create accessible means for residents to provide information for the registry (e.g., online, telephone, in-person, etc.). • Disaster registries must ensure that data privacy measures are instituted to enhance confidentiality.	(Wambura and Wong, 2024; Wambura and Wong, 2023)
Community Engagement and Planning	
Key Recommendations	**Supporting Literature**
• Jurisdictions should work with neighbourhoods through community leagues and town hall meetings to understand community-specific needs and create evacuation strategies accordingly. • Jurisdictions should ensure that vulnerable groups such as individuals with disabilities and older adults are present or represented (by NGOs and CBOs) in planning meetings to enable equitable evacuation planning. • With low disaster preparedness levels across residents, jurisdictions should consider offering regular emergency preparedness training workshops to improve evacuation preparedness. • Public and accessible information on how to prepare for an evacuation should further be made available online and through social media outlets to ensure wider reach.	(Wambura and Wong, 2024; Wambura and Wong, 2023)

7) Resilience Hub Placement Tool

The resilience hub placement tool has been designed to assist local officials in ranking and rating different locations to prioritize where to place a resilience hub. For each criterion, a description has been provided along with the research evidence. We suggest a weight, though this can be changed at the discretion of the decision-maker. All weights should add up to 100%. The scoring is completed on a 0-5 scale, with 5 representing an ideal placement. It should be noted that a 5 is considered very hard to achieve and most placement options will fall between 4 and 2. At the suggestion of decision-makers, a minimum score is also included on the far right of the table, as certain elements including accessibility for individuals with disabilities would need to meet minimum laws and regulations. About 2/3 of the weights have been assigned according to transportation resources and criteria and 1/3 of the weights have been assigned to resilience hub resources. This split toward transportation criteria was preferred since the tool is oriented toward spatial placement, not programming or services.

Resilience Hub Transportation Criteria										
Criteria	**Description**	**Research Evidence**	**Suggested Weights****	**5**	**4**	**3**	**2**	**1**	**0**	**Min**
Distance from residence and centrality	Individuals prefer to have resilience hubs closer to their residences. By placing a resilience hub within the community, governments can: 1) provide resources to assist neighbourhoods to be more resilient and prepared to recover from a disaster; 2) benefit underserved communities that rely on community assistance during normal conditions and emergencies; 3) increase accessibility, especially for carless residents, low-income individuals, and older adults; 4) encourage regular usage.	Distance-based survey results indicate a strong preference by residents for highly localized resilience hubs, mostly for those who would walk to a hub. Individuals selected a median distance of 1.7km between their residences and potential resilience hub locations. During focus group discussions, participants emphasized the importance of locating resilience hubs closer to community residences in order to increase walkability and usage during both disasters and normal conditions. This theme was particularly common among people with disabilities, carless residents, and women.	10%	The resilience hub is within a 3 km radius of all target community's residences		The resilience hub is within a 5 km radius of all target community's residences		The resilience hub is farther than a 7 km radius of all target community's residences	NA	1
			2.5%	The resilience hub is located adjacent to the highest density of residences in the target community		The resilience hub is located adjacent to a medium density of residences in the target community		The resilience hub is located adjacent to a very low density of residences in the target community	NA	1
		Both survey respondents and focus group participants revealed a preference to have a resilience hub close to their residences. Results align with existing current literature. Consequently, resilience hubs should be located in places within a more localized community, rather than selective points across a large city.	5%	The facility to be retrofitted is already centrally located within the neighbourhood		The facility to be retrofitted is within the boundaries of the neighbourhood		The facility to be retrofitted is beyond the boundaries of the neighbourhood	NA	1
Public Transit Connections	Public transportation options are essential to ensure sustainable, safe, and reliable travel between hubs and residences, particularly for those who do not have access to personal vehicles.	56.7% of survey respondents indicated that transit connections are a very/mostly important resilience hub feature. Particularly during disaster scenarios, reliable public transit (e.g., bus, rail, microtransit) ensures that underserved groups are able to access resilience hubs for emergency services. From the survey, 27.3% of carless residents and 10.9% of people with disabilities would use public transit to go	2.5%	There is at least one public transit stop (bus stop or train station) next to the resilience hub or within 0.2km of the resilience hub		There is at least one public transit stop (bus stop or train station) within 0.5km of the resilience hub		There is at least one public transit stop (bus stop or train station) within 1km of the resilience hub	No stops exist within 1 km	1
			2.5%	The location selected has a high frequency (15		The location selected has medium frequency		The location selected has low frequency (60	The location has no	1

		to a resilience hub during normal conditions. During an emergency, 16% of carless residents and 6.4% of people with disabilities would use public transit to access resilience hubs. During the focus group discussions, participants spoke of the importance of using public transit to reduce traffic congestion from single-occupant vehicles (making up 9 segments of the identified public transit themes). Representing 12 segments of the identified public transit themes, participants, particularly from the older adults' group, also noted that evacuating with other people on public transit could increase social cohesion and reduce their feelings of anxiety that come with emergencies. Within the survey, 10.9% of people with disabilities indicated that they would use public transit to reach a hub during normal days. During an emergency, 6.4% of individuals with disabilities would use public transit to reach a resilience hub. During the focus group discussions, we found that people with disabilities comprised 20% of those who would use public transit to access resilience hubs during normal conditions. During emergencies, older adults and parents/guardians of young children each comprised 22% of those who would use public transit. Public transit options should therefore ensure accessible features for wheelchair users and those with strollers for their children. Moreover, trained medical staff should cater to the needs of older public transit users who may be medically fragile and require specialized assistance.		min or less) of bus/train services during AM and PM peak hours on weekdays		(30 to 40 min) of bus/train services during AM and PM peak hours on weekdays		min or more) of bus/train services during AM and PM peak hours on weekdays	bus/train services	
			1.25%	The location selected has a high frequency (30 min or less) of bus/train services during midday off-peak hours on weekdays		The location selected has a medium frequency (40 to 50 min) of bus/train services during midday off-peak hours on weekdays		The location selected has a low frequency (60 min or more) of bus/train services during midday off-peak hours on weekdays	The location has no bus/train services	1
			1.25%	The location selected has a high frequency (30 min or less) of bus/train services during evening off-peak hours on weekdays		The location selected has a medium frequency (50 to 60 min) of bus/train services during evening off-peak hours on weekdays		The location selected has a low frequency (60 min or more) of bus/train services during evening off-peak hours on weekdays	The location has no bus/train services	2
			2.5%	The location is served by at least 5 public transit routes within 0.5 km		The location is served by at least 3 public transit routes within 0.5 km		The location is served by 1 public transit route within 0.5 km	The location is served by 0 public transit routes	1
			Note: Frequency of transit service connections may differ in sub-urban neighbourhoods depending on factors such as demand and population density. Fixed or on-demand transit counts for this category.							

Active transportation infrastructure	Connecting active transportation modes to resilience hubs provides multimodal options, particularly for residents without personal vehicles. It also provides safe routes for first/last mile transit connections. Resilient walking and biking infrastructure are also useful during disasters that cause road closures or transit system failures.	Individuals indicated that it is very/mostly important for resilience hubs to be within walking distance from their residences. Walking was the second preferred mode choice to reach a resilience hub during normal conditions and emergencies. Moreover, walking was the first transportation mode choice for carless individuals during normal conditions (38.6%) and emergencies (48.0%). During normal conditions, walking had nearly equal significance to personal vehicles among older adults, with 51.6% selecting personal vehicles and 44.7% choosing walking. Modeling results found that women and long-time residents are more likely to use active modes than public transit to travel to/from a resilience hub during normal conditions. Households that have at least one bicycle are more likely to use active modes than public transit during emergencies. During normal conditions, walking was a popular mode of choice among the women's focus group, emphasizing the importance of community-centred resilience hub placement. During emergencies, walking was primarily favoured among carless residents who cited reasons of affordability and ease of access. 44.7% of older adults and 16.1% of individuals with disabilities would walk to resilience hub during normal conditions. During a disaster, 17.9% of older adults and 11.8% of individuals with disabilities would walk to resilience hubs. Walking to resilience hubs was not a significantly favoured mode of choice among the	2.5%	Pedestrian sidewalks are available to connect active transportation users to resilience hubs		Sidewalks are available but may be fragmented		Sidewalks are available but they are in poor condition	No sidewalks are available	3
			2.5%	The location has crosswalks within or at the end of the block that are safe, well structured, and signed/signalized		The location has crosswalks nearby that are somewhat safe, well structured, and/or signed/signalized		The location has minimal crosswalks nearby or are unsafe, poorly structured, or unsigned/unsignalized	No crosswalks are available	3
			5%	Pedestrian sidewalks and crosswalks connected to resilience hubs are accessible for people with disabilities and/or people with limited mobility (e.g., sufficient sidewalk spaces for those who use wheelchairs, walkers, motorized devices)		Pedestrian sidewalks and crosswalks are only partially accessible for people with disabilities and/or people with limited mobility but could be redesigned to meet their needs		Pedestrian sidewalks and crosswalks are not accessible for people with disabilities and/or people with limited mobility	No crosswalks are available	3

		people with disabilities and older adults focus groups during emergencies. This trend may highlight a need for resilience hub locations with more accessible walking/biking infrastructure to cater to these populations.								
		Among the focus groups, biking was a popular mode of choice among parents/guardians of young children to access resilience hubs during normal conditions. Moreover, during disasters, parents/guardians of young children were the only group that would use bikes to access resilience hubs. Resilience hub locations should therefore be connected to dedicated bike lanes and bike parking facilities to ensure safety and convenience for this demographic.	1.25	The location has bike infrastructure (e.g., bike lanes, cycle tracks, shared pathways) within the block to connect active transportation users to resilience hubs		The location has bike infrastructure (e.g., bike lanes, cycle tracks, shared pathways) to connect active transportation users to resilience hubs but they are fragmented		The location has minimal bike infrastructure (e.g., bike lanes, cycle tracks, shared pathways) to connect active transportation users to resilience hubs.	No bike infrastructure is available	1
			1.25%	The location has sufficient and well-maintained bike parking and bike storage infrastructure		Bike parking and storage infrastructure is available but not well maintained and/or not sufficient for resilience hub users		Bike parking and storage infrastructure is available but not well maintained and/or not sufficient for resilience hub users	No bike parking and storage are available	1

Resilience Hub Placement										
Criteria	**Description**	**Research Evidence**	**Suggested Weights**	**5**	**4**	**3**	**2**	**1**	**0**	**Min**
Type of places to be retrofitted into resilience hubs	Existing locations that already meet some goals and/or provide some basic services that meet the community needs can be retrofitted into resilience hubs by adding other services/resources that will make the community more	Resilience hubs are community-serving facilities developed to support residents, by providing communication coordination, social support services and programs, and resource distribution before, during, or after a disaster (Baja, 2018; Ciriaco & Wong, 2022; Kirwan et al., 2021; Mardis et al., 2021; Sandoval, 2019; Vibrant Hawaii,	10%	The location has the infrastructure and operational capacity that allows for services to run 24/7 during normal days and during emergencies		The location has the infrastructure or operational capacity that can serve the community during normal conditions and give partial support (e.g., business days only)		The location can serve the community only for a few business days during emergencies or during regular days	The location cannot serve the community during any regular hours	3

	resilient and prepared for both, daily needs and disaster scenarios. By selecting an existing, well-known, and well-utilized location for retrofitting, communities can encourage resilience hub usage during a disaster. Rather than building new facilities, retrofits can be effective in reducing overall costs.	2019). Additionally, literature suggests that resilience hubs can have three operational modes (Baja, 2019; Resilience Hub Community Committee, 2020): 1) normal mode; 2) response mode; and 3) recovery mode.				during emergencies or it has infrastructure that can serve the community during emergencies and give partial support during normal days				
		Accessible infrastructure for individuals with disabilities was the most prioritized transportation service for resilience hubs. This service was particularly important for surveyed older adults and people with disabilities, with 82.1% of older adults and 76.7% of people with disabilities indicating it as very/mostly important. During the focus group discussions, the necessity of accessibility features was most discussed by people with disabilities and women compared to other groups. These groups spoke about accessibility designs for people with limited mobility (using wheelchairs, walkers, motorized devices, crutches, and canes) and those with limited vision.	5%	The location is accessible for people with disabilities and older adults, and meets all the guidelines set by the City of Edmonton's Access Design Guide		The location does not meet all of the guidelines set by the Access Design Guide but can be restructured to accommodate accessibility needs		The location is minimally accessible and cannot be retrofitted to add accessibility features.	No accessibility features are available	3
		Individuals are very/somewhat satisfied with having a resilience hub located in community centres, recreation centres, community leagues, libraries, and schools/universities. Moreover, trust and compassion variables had a positive impact on using a resilience hub during disasters, either as a temporary shelter or as a place to gather critical resources. Additionally, individuals who are part of a	5%	The location is well-known and already well-utilized by the community		The location is known but not well-utilized		The location is neither well-known nor utilized by the surrounding community	NA	1

		community organization are more likely to use a resilience hub during normal conditions. Among the focus groups, recreation centres were the most preferred locations to be retrofitted into resilience hubs. These were followed by schools/universities, community leagues, and worship centres.								
		Most individuals indicated that they would use personal vehicles to travel to/from resilience hubs during normal conditions and during an emergency. Among the focus groups, parking spaces were particularly prioritized by parents/guardians of young children, older adults, and low-income households.	2.5%	The location already has existing substantial on-street and off-street parking space		The location has some on-street and off-street parking space		The location has limited on-street and off-street parking space	No on-street or off-street parking	1
Interconnectivity between resilience hubs	Interconnectivity between resilience hubs is important to ensure redundancy and community safety/resilience in cases that the local resilience hub is affected by the hazard and cannot support the users.	Rather than focusing on one resilience hub, Baja (2021) recommends a "network of hubs" approach. A network of connected resilience hubs ensures redundancy and efficiency in service coordination particularly when some sites have higher capacity for particular services compared to others.	1.25%	The selected location has a good transportation network that connects it to other potential resilience hub locations		The selected place has an adequate transportation network that connects it to other potential resilience hub locations		The selected place has a poor transportation network and fails to connect to other potential resilience hub locations	NA	1
Vulnerability of hub location	A resilience hub should be located near the hazardous area but should not be directly adjacent to the hazard such that it could be severely damaged. Adjacency would significantly increase vulnerability of the hub to the hazard.	Given the significant impact hazards can have on communities, de Roode and Martinac (2020) recommend having resilience hubs situated close to but not within high-risk areas in order to strategically serve communities in need. Depending on the types of hazards likely to affect a community, resilience hub project teams should also decide on what risk tolerance the sites can have during emergencies (de Roode and Martinac, 2020).	1.25%	The selected hub location is near the hazardous area		The selected hub location is located close to the hazardous area		The selected hub location is located immediately adjacent to the hazard	NA	3

Community vulnerability to hazards	Communities vulnerable to hazards must be prioritized when planning resilience hubs	When selecting potential resilience hub locations, prioritizing communities that experience greater risk to their homes, jobs, and health, ensures an equitable approach to achieving community resilience. Consequently, resilience hubs can support these communities on steps they can take to respond before, during, and after a hazardous event (USDN, 2018).	2.5%	The community selected is highly impacted by one or more kinds of hazards (e.g., wildfires, heatwaves, smoke events, blizzards, extreme cold, tornadoes)		The community is moderately impacted by one or more hazards (e.g., wildfires, heatwaves, smoke events, blizzards, extreme cold, tornadoes)		The community is minimally impacted by one or more hazards (e.g., wildfires, heatwaves, smoke events, blizzards, extreme cold, tornadoes)	There are no hazards that impact the community	1

Resilience Hub Services/Resources										
Criteria	**Description**	**Research Evidence**	**Suggested Weights**	**5**	**4**	**3**	**2**	**1**	**0**	**Min**
Basic services/necessities	Resilience hubs should offer services and programs that support the community preparedness and response to emergencies, and improve quality of life during normal conditions (Baja, 2022, Breton-Carbonneau and Griffiths, 2020, and Ciriaco and Wong, 2022)	Resilience hubs should offer services and programs that support the community preparedness and response to emergencies, and improve quality of life during normal conditions (Baja, 2022, Breton-Carbonneau and Griffiths, 2020, and Ciriaco and Wong, 2022)	10%	Basic services such as food and water resources, restrooms, and first aid are sufficiently available to resilience hub users during normal conditions and emergency scenarios		Basic services such as food and water resources, showers and restrooms, and first aid are somewhat limited or require improvement in quality		There is a shortage of basic services for resilience hub users and/or services are of poor quality	There are no basic services	1
Services for underserved populations	The impacts of climate change and non-climate-related disasters have been consistently shown to disproportionately affect underserved populations (Benevolenza & DeRigne, 2018; Levy & Patz, 2015; van Wesenbeeck et al., 2016). Low-income households, racial and ethnic minority	The majority of underserved populations are very/somewhat likely to use a resilience hub as a temporary evacuation shelter, as a place to gather critical resources during a disaster, and as a place to gather information about the disaster. Through an Evacuation Preparedness Rating System, Renne & Mayorga (2018) found that only 26% of the evacuation plans from the 50 largest cities of the United States presented	2.5%	There are strong partnerships and collaborations with community-based organizations representing underserved populations during hub programming and design		Some partnerships exist with community-based organizations that represent underserved populations		Minimal partnerships exist with community-based organizations that represent underserved populations	No partnerships exist	3

	groups, people with disabilities, older adults, women, and children are highly vulnerable to both the environmental and health consequences of climate change (Levy & Patz, 2015).	strategies on how to assist underserved and transportation-disadvantaged populations during a disaster. Moreover, a study conducted in New Orleans found that while the city had established pick-up points for transit users, many of these were not strategically located close to those with the greatest need (older adults, low-income households, and people with disabilities) (Bian & Wilmot, 2018).	2.5%	Information services are available in multiple languages in order to accommodate resilience hub users with limited English proficiency*		Information services in other languages are somewhat available or partially accommodate the range of languages used by resilience hub users		Information services in other languages are limited or fail to accommodate the range of languages used by resilience hub users	Information services in other languages are unavailable	1
			2.5%	Underserved populations are sufficiently involved in the planning and design of resilience hubs (e.g., through workshops, information sessions, discussions with community leagues)		Underserved populations are somewhat involved in the planning and design of resilience hubs but their participation is limited		Underserved populations are minimally involved in the planning and/or design of resilience hubs	Underserved populations are not involved	3
Community emergency preparedness and response training	Resilience hubs provide critical communication and information that help educate community members about hazards and prepare them to cope during and respond to future events.	61.7% of participants indicated that community emergency response training is a very/mostly important resilience hub feature. During the focus group discussions, emergency response training services were primarily favoured among low-income households.	2.5%	The resilience hub offers emergency preparedness and/or response training that is effective and tailored to the community's hazard risks		The resilience hub offers preparedness and/or emergency response training that is somewhat effective or is partially tailored to the community's hazard risks		The resilience hub offers minimal preparedness and/or emergency response training/information	There is no training or information at hubs	1
Heating and/or cooling systems	Resilience hubs require heating on extreme cold days and cooling during heat waves to improve quality of life and safe temperatures for users.	81.1% of survey participants indicated that heating systems are very/mostly important resilience hub features. 64.7% indicated that cooling systems are a very/mostly important resilience hub feature. Heating and cooling systems were also regarded as significant among	2.5%	The resilience hub is equipped with heating and cooling systems for extreme weather events. The systems are		Available heating/cooling systems are only adequate or regularly experience malfunctions		Heating/cooling systems are either usually unavailable or unreliable for extreme weather events	No heating or cooling is available	3

		the focus group participants, particularly among the parents/guardians of young children.		regularly maintained						
Emergency Services	Emergency services (e.g., shelters, information desks, medical support, back-up power) are essential for the functioning of resilience hubs during emergency scenarios.	Many respondents noted that offering temporary shelters during emergencies in hubs is a very/mostly important feature (76.4%), with strong prioritization from older adults and women (89.3% and 81.6% respectively). During emergency conditions, 76.9% of the older adult group is very/somewhat likely to use resilience hubs as temporary evacuation shelters. In addition, focus group participants discussed the importance of multiple features for resilience hub shelters including security, child-friendly environments, sufficient spaces, and comfort.	2.5%	The location has sufficient sheltering spaces for emergency scenarios		Location has partial sheltering spaces for emergency scenarios		Location has limited sheltering spaces for emergency scenarios	Sheltering space is unavailable	3
		74.1% of survey respondents indicated that backup/emergency power is a very/mostly important resilience hub feature. Furthermore, back-up and emergency power were selected by most of the underserved groups as important, with responses ranging from 71.0% (low-income households) to 92.9% (older adults). Among the focus groups, back-up power was particularly prioritized by parents/guardians of young children and older adults. Baja (2022) lists power systems as one of the foundational elements of resilience hubs. Various back-up power sources (e.g., solar panels, batteries, back-up generators) can be considered.	2.5%	On-site backup power is available for power outage events		On-site backup power for power outage events is available for some time		On-site backup power for power outage events is available for limited services	Backup power is unavailable	3
		As noted by Ciriaco and Wong (2022), it is important that resilience hubs have family reunification plans to ensure that family members and children are	2.5%	Family reunification support is available during		Some family reunification support is available		Minimal family reunification support is available	No family reunification	1

		connected to each other following an emergency. Additionally, 68.9% of survey participants indicated that support for reuniting families is a very/somewhat important resilience hub feature.		emergency evacuations		but not fully developed			support is available	
		74.6% of survey participants indicated that basic health services are very/mostly important resilience hub features. In addition, 69.8% of survey respondents indicated that urgent care is a very/mostly important resilience hub feature. Many of the older adults (82.1%) indicated that it was important that resilience hubs offer urgent care services. Moreover, some participants from the older adults and people with disabilities focus groups further noted that during an emergency, they would not be able to leave their residence without receiving significant physical and medical assistance from family, friends, or staff. This highlights the need for specialized assistance for people with disabilities and the medically fragile in resilience hubs, particularly during emergencies.	2.5%	Trained medical staff are available to offer medical and physical support to people seeking shelter		Staff are available but only partially meet the needs of the shelter population and/or lack high-quality training		Staff are available but are few compared to the shelter population and/or lack adequate training	No staff are available	3
* In cases where other languages are official (e.g., French), the languages should be added to these criteria.										
** Weights are provided as initial recommendations. Decision-makers can adjust these weights based on community-specific needs and requirements.										

8) Conclusions

This research provides a holistic understanding of resilience hub design and operations, emphasizing transportation needs, placement strategies, and core services for everyday and disaster conditions. In addition, the research presents an analysis of urban evacuation choices that identified the breakdown of behaviour and factors affecting those choices. Our research concludes that accessible, safe, and useful resilience hubs and urban evacuation planning are within reach for Canadian jurisdictions. Importantly, we determined that retrofitted buildings, existing community networks and organizations, and ongoing emergency preparedness efforts can be leveraged and further supported for resilience hub development. To reduce transportation challenges and improve usage, resilience hubs will require a thoughtful location analysis that balances transportation needs, basic services and resources, equity considerations, and funding constraints. We provide a criteria matrix and associated scorecard to assist with this placement.

Focusing on urban evacuation behaviour and operations, we find a broad range of choice-making with a strong willingness to evacuate, high personal vehicle usage, varied communication channels, moderate to long preparation times, some public shelter usage, and high intra-city trip-making. Discrete choice modeling found that different risk perceptions and sociodemographic characteristics affected choice-making, though directionality and significance for variables were often unique to the choice. The results together indicate that operational plans and guidance can be crafted to meet existing needs, while also encouraging safe and efficient behaviours for improved transportation outcomes. Public transit plays a particularly important role, meeting the needs of transit-dependent populations while also connecting resilience hubs and encouraging fewer vehicle kilometres travelled (and associated congestion).

Altogether, this research adds to a growing body of guidance for resilience hubs[4] by assessing transportation needs and strategies while also identifying stated behavioural patterns for urban evacuations. Future work will be needed to further operationalize the research, test different implementation pathways, and build individual capacity in residents for everyday and disaster conditions.

[4] See the Urban Sustainability Directors Network (USDN) for more information: https://www.usdn.org/resilience-hubs.html

9) Appendix

Sample		950
	SOCIODEMOGRAPHIC	
Age	Median	35
	Average	38
	18-25	14.6%
	26-30	15.7%
	31-35	18.7%
	36-40	15.7%
	41-45	11.5%
	46-50	5.6%
	51-55	5.2%
	56-60	4.0%
	61-65	2.0%
	>65	3.9%
	NA	3.0%
Gender identity	Woman	54.4%
	Man	43.3%
	Two or more genders	0.7%
	Other genders (e.g., Non-binary, Transgender, Two-spirit)	0.9%
	I prefer not to answer	0.6%
Indigenous, ethnic, and racial identify	Indigenous	10.9%
	White	54.3%
	Visible minorities	26.5%
	Two or more categories	4.9%
	Other	1.2%
	I prefer not to answer	2.1%
Disability *(n = 890)*	Do not have a disability	70.0%
	Have a disability	26.1%
	Prefer not to answer	3.9%
Household composition	Average number of individuals in the household	3.0
	Percentage of households with at least one child under the age of 18	48.0%
	Percentage of households with at least one adult over the age of 65	17.1%
Employment status	Employed full time	69.4%
	Employed part time	9.6%
	Unemployed looking for work	4.5%
	Unemployed not looking for work	2.2%
	Retired	5.6%
	Student	5.5%
	Disabled	1.8%
	I prefer not to answer	1.5%

Household income in CAD (in 2021) *(n = 818)*	Under $10,000	1.2%
	$10,000 to $19,999	2.1%
	$20,000 to $29,999	6.1%
	$30,000 to $39,999	6.4%
	$40,000 to $49,999	7.0%
	$50,000 to $59,999	9.9%
	$60,000 to $69,999	7.2%
	$70,000 to $79,999	9.9%
	$80,000 to $89,999	7.7%
	$90,000 to $99,999	8.6%
	$100,000 and over	29.1%
	I prefer not to answer	4.9%
Residence ownership	Own the residence	63.9%
	Do not own the residence	30.9%
	Prefer not to answer	1.9%
Residence type	Single-family home	58.2%
	Townhome	13.1%
	Condominium	8.4%
	Apartment (1-10 units)	5.7%
	Apartment (11-50 units)	6.5%
	Apartment (more than 50 units)	5.9%
	Mobile home	0.4%
	Other (please specify)	0.8%
	Prefer not to answer	0.9%
Automobiles	0	4.9%
	1	50.6%
	2	35.8%
	3	5.7%
	More than 3	2.6%
	Prefer not to answer	0.3%

Sample		950
	RESILIENCE HUBS	
Previous knowledge about resilience hubs	Yes	16.1%
	No	77.7%
	Maybe	6.0%
Characteristics that best describes a resilience hub (*top 6 selected*)	Be a community-serving physical spaces	41.6%
	Provide emergency sheltering	62.2%
	Provide longer-term sheltering	21.3%
	Be a central location to access a variety of services	37.8%
	Offer response services during disasters	40.2%
	Provide resource distribution before, during, or after a disaster	36.5%
	Integrate various sustainable transport modes (cycling, walking, public transit)	12.8%
	Increase a city's mobility connectivity	11.8%
	Meet the unique needs of the community	20.7%
	Offer social ties/networks	14.4%
	Build community pride and cohesion	12.2%
	Provide basic health services	27.2%
	Serve as an educational space for community members	13.7%
	Improve communities' climate preparedness and resilience	21.3%
	Improve climate equity for disadvantaged populations	12.1%
	Incorporate sustainability initiatives into its design (solar, rain garden)	10.7%
Places where a resilience hub could be located *(percentages are the sum of very satisfied or somewhat satisfied)*	Community centre	73.4%
	Community league	64.7%
	School	71.6%
	University	67.7%
	Library	65.7%
	Government building	61.1%
	Shopping mall	61.8%
	Stadium	53.6%
	Religious building	52.4%
	Local park	47.4%
	Other	10.4%
Services and resources to be provide by resilience hubs *(percentages are the sum of very important or mostly important)*	Community emergency response training	61.7%
	Back-up/emergency power	74.1%
	Shelter (temporary in disaster)	76.4%
	Support for reuniting families	68.9%
	Information desk	67.6%
	Water	83.3%
	Food bank	78.2%
	Warming	81.1%

	Cooling	64.7%
	Wi-Fi	58.3%
	Restrooms	81.5%
	Showers	69.6%
	Market/grocery	62.0%
	Basic health services	74.6%
	Urgent care	69.8%
	Bike sharing	31.6%
	Bike parking	31.2%
	Within walking distance from residence	52.1%
	Transit connection	56.7%
	Car parking	57.3%
	Parking for electric vehicles	38.3%
	Heated bus stop	42.6%
	Accessible for individuals with disabilities	68.4%
	Computers	44.5%
	ATM	44.2%
	Childcare services (daily)	44.9%
	Elder care services (daily)	49.3%
	Job training programs	38.9%
	Social gathering place	46.1%
	Arts and culture experiences	34.3%
	Community garden	39.8%
	Fitness facilities	38.1%
Individual would choose to use a resilience hub under normal conditions	Very likely	10.9%
	Somewhat likely	30.4%
	Neither likely nor unlikely	24.3%
	Somewhat unlikely	20.9%
	Very unlikely	13.2%
Individual would be comfortable using community's resilience hub as a shelter during an emergency event	Very likely	20.2%
	Somewhat likely	40.5%
	Neither likely nor unlikely	23.6%
	Somewhat unlikely	11.9%
	Very unlikely	3.6%
Individual would use the resilience hub during a disaster as… *(percentages are the sum of very likely or somewhat likely)*	Place to gather information about the disaster	69.8%
	Temporary evacuation shelter	61.2%
	Place to gather critical resources	63.9%
	Place to meet with neighbours	39.6%
Volunteer at resilience hubs *(percentages are the sum of very likely or somewhat likely)*	During relief efforts	60.2%
	During normal days	44.4%
A resilience hub would help… *(percentages are the sum of very likely or somewhat likely)*	Increase social cohesion in my neighbourhood	58.6%
	Meet the needs of neighbours on a daily basis	56.0%
	Community to be more resilient	64.5%

Importance of resilience hub for the community	Very important	25.5%
	Mostly important	27.8%
	Somewhat important	33.2%
	A little important	10.5%
	Not at all important	2.8%
	Prefer not to answer	0.2%

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