Investigating the Transportation Impacts of Interior Health Authority's Building Relocation: Survey Design, Data Collection, and Preliminary Analysis

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Abstract

Interior Health Authority (IHA) will be co-locating ten programs to a new office location in downtown Kelowna, BC by October 2016. As a result, approximately 900+ staff members will be commuting to the downtown core every day. This number of attracted daily trips will increase traffic congestion and parking pressure at peak periods at the new site, which is already suffering from parking constraints. Moreover, the projected number of parking stalls available for employees is not sufficient to meet the anticipated parking demand. The economic, social, and environmental impacts associated with increasing parking capacity makes finding alternative strategies more desirable. This research adopts a threefold approach to study the travel patterns and mode choices of IHA employees before designing a Transportation Demand Management (TDM) plan to alleviate traffic congestion, parking pressure, and Greenhouse Gas (GHG) emissions at the new office location. First, a reveled/stated preference survey was designed and conducted to collect information on the travel behaviour of IHA staff. Second, analytical tools were developed to identify the determinants of mode choice of IHA staff. Third, an implementation strategy was recommended to maximize transportation mode shift and reduce the number of parking stalls required. Implementation strategies included: carpooling programs, incentivizing the use transit or non-motorized modes, and educating IHA employees on the carbon footprint associated with their choices.

Introduction

The City of Kelowna is situated in the Southern Interior of British Columbia (BC), Canada. The city is considered the largest municipality in the Okanagan Valley with a population of 123,500 in 2015 (City_of_Kelowna 2015). The city's economy runs on an active tourist industry, tree fruit industry, forestry, and the manufacturing of light industrial products. The City of Kelowna is a classic example of the low-density sprawling development which hiders the attractiveness of sustainable transportation options and promotes automobile use. Figure 1 below displays the location of Kelowna within BC.

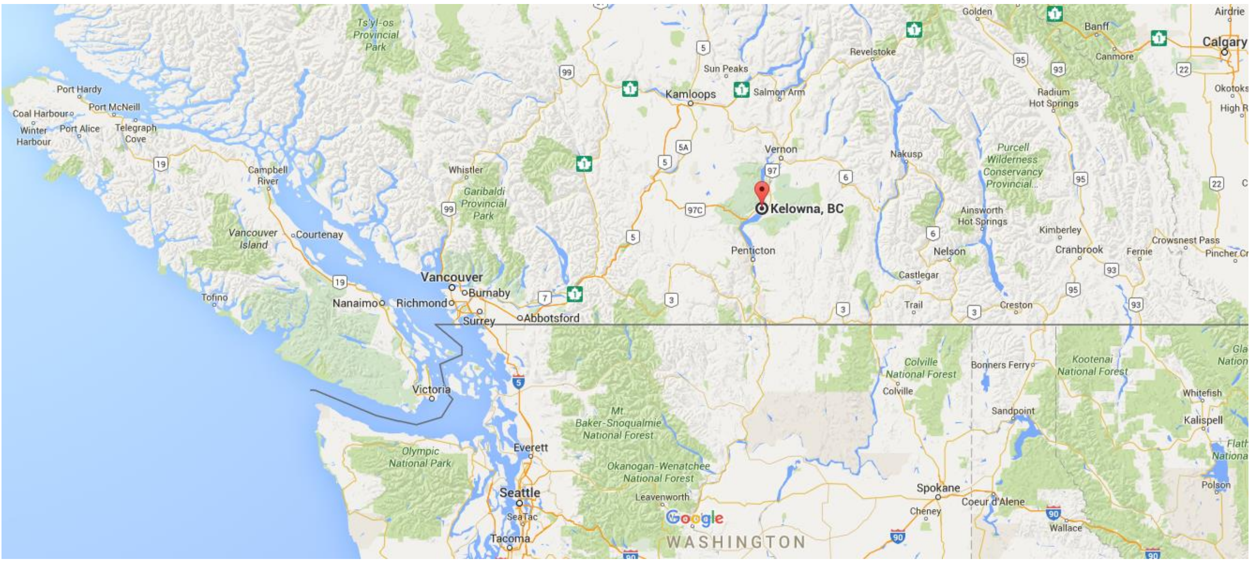

Figure 1: Map of BC Highlighting Kelowna

For three years in a row since 2014, traffic congestion has been cited to be the major issue the city is facing. Further, with the increasing rates of population and suburban growth, the community is expected to recognize a greater level of congestion in the upcoming years, raising concerns about citizens' health and quality of life (City_of_Kelowna 2015).

The common response to traffic congestion in North America in the past has been to increase the capacity of the transportation system by adding traffic lanes, parking stalls, etc. Besides being extremely expensive, this solution only masks the issue rather than providing a cure and ultimately attracts more drivers to the roads, which worsen the problem. As such, Transportation Demand Management (TDM) is becoming more popular as an inexpensive way for shaping how, why, when, and where people travel (Meyer 1999; Gärling et al. 2002; Gärling and Schuitema 2007).

Interior Health Authority (IHA) is a leading institution in providing health services to residents in BC's Southern Interior. IHA makes their presence in Kelowna felt with over 29 healthcare services and programs such as clinics, healthcare centers, laboratories, and hospitals. Ten of these programs will be relocated to a single office building in the heart of downtown Kelowna, which results in more than 900 employees moving to the new office building. The rise in daily trips to downtown Kelowna will increase the already strained parking pressure in the downtown core, as the number of employee parking spaces available will not be sufficient to meet this new parking demand.

IHA has a strong tradition of providing leadership on environmental issues and ensuring the environment and energy are considered in all future decisions. Furthermore, as climate change is becoming a major concern, IHA strives to finding ways to minimize greenhouse gas emissions from burning fossil fuels and reduce pressure on the transportation system, thereby increasing community health and welfare (Interior_Health_Authority 2011).

To alleviate the expected traffic congestion and parking pressure in downtown Kelowna due to the new office building, IHA is committed to designing and implementing a TDM plan for its employees affected by the move. The purpose of this research is to develop a TDM plan for IHA. To develop a successful TDM plan, a proper understanding of IHA employees' preferences and travel behavior is imperative. This study made use of the Revealed Preference (RP) and the Stated Preference (SP) methods to collect data and examine IHA employees' preferences and travel behavior. The findings of this investigation are intended to provide IHA with possible TDM policies and strategies to minimize the effect that the office relocation is anticipated to have on Kelowna's downtown traffic, as well as the effect on reallocated staff.

Literature Review

The urban form of cities is shaped by two major elements: transportation and land use. These elements are controlled by social, economic, and political attributes, but the essential character of a city's land use comes down to how it manages its transportation (Newman and Kenworthy 1999). Any sort of sustainable planning without addressing the fundamental transportation issue falls short in the matter. One of the methods to improve and optimize transportation is to develop Transportation Demand Management (TDM) plans.

According to (Meyer 1997), TDM is the application of actions or policies to alleviate traffic congestion by influencing people's mode choice and travel behavior (demand) without altering the capacity of the transportation system (supply). This can be achieved through:

- Offering travellers one or more alternative mobility options that result in higher per vehicle occupancy;
- Providing incentives/disincentives to reduce travel or to push trips to off-peak hours; and/or
- Accomplishing the trip purpose through non-transportation means (e.g. telecommuting, remote work, telework, etc., where travellers work from home rather than commuting to a central place for work).

TDM actions or policies can be implemented in many ways. For example, policies can be city-wide or can target specific sites or travel markets serving different trip purposes. Table 1 shows TDM policies that target work trips classified by area of influence (Meyer 1997).

Table 1: Work Trip TDM Policies

Trip Purpose	Site	Subarea/Corridor	Regional
Work	• Carpool • Vanpool • Mass Transit (Public/Private) • Alternative Work Hours • Telecommuting • Parking Policies	• Subarea Rideshare • High Occupancy Vehicles (HOV) Lanes • Parking Policies • Transit Subsidies • Subarea Telecommute	• Area-Wide Rideshare • Transit Service • HOV Lanes • Area-Wide Pricing • Trip Reduction Ordinances

An earlier study that evaluated the effectiveness of transportation control measures found that the three most effective measures were related to pricing, mandatory employer trip reduction programs, and land use planning (Cambridge Systematics 1992). One such strategy noted that offering childcare services near or at the work site is an example of positive land use planning. Furthermore, if applying high travel costs to driving is not desired, the use of subsidies can also be effective. Such subsidies could include reduced fare transit and/or incentives for carpooling.

As highlighted above, many TDM policies can be implemented to influence passengers' mode choices and travel behavior. However, for the selected policy to be successful, it is imperative to study passengers' preferences and travel behavior.

Revealed Preference (RP) and Stated Preference (SP) surveys are two widely used approaches in transportation research to collect data on passengers' preferences and develop mode choice/shift models that reflect commuters' behavior in different circumstances.

RP-based mode choice models intend to describe and forecast travel behavior based on factual information (e.g. travel time it takes someone to get to work) and current choices (e.g. mode of travel someone takes to get to work) obtained from survey respondents. The RP data is favorable in many circumstances but still carries some drawbacks. Firstly, RP data is limited to analyzing the effects of existing attributes on current mode choices, being of little use in evaluating policies that deal with non-existing attributes and/or unknown modes of travel. Secondly, RP data provides limited variation of attributes within the sample which makes it hard to uncover the role of these attributes in mode choice (Eneme 2013).

SP data, on the other hand, depends on presenting a number of hypothetical scenarios to respondents who are asked to make choices amongst a set of options. A main feature of SP surveys is to make respondents think and choose answers to different non-existing alternatives (Louviere and Woodworth 1983). This provides the researcher with greater control and flexibility as they have defined the conditions that are being evaluated using designated statistical techniques. As such, SP-based mode choice models can help deriving the relative importance of the design attributes beyond the limit provided by RP-based models (Louviere and Hensher 1983). However, a major disadvantage of SP surveys is that respondents' choices may not necessarily be the actual choices they would make in real-life situations (Eneme 2013).

SP scenarios are typically defined by a number of different attributes (e.g. travel time, travel cost, etc.). These attributes in turn are described by pre-specified attribute levels (e.g. travel time increase 10%, travel cost decrease by 20%, etc.) that are drawn from some underlying experimental design. The experimental design aims at shuffling attribute levels to produce different scenarios while being able to determine the independent influence of each attribute on the observed outcome (e.g. mode choice). A good experiment contains adequate attributes along with enough variation in the attribute levels to create meaningful behavioural responses (Hensher 1994). Moreover, the number of scenarios a respondent will be facing is generally dictated by the experimental design. Therefore, choosing an appropriate experimental design technique plays a major role in SP studies.

Numerous approaches to experimental design exist and can be classified into: Full Factorial Designs and Fractional Factorial Designs. Full factorial designs consider all possible combinations within a set of attributes levels, and accordingly all possible effects (i.e. main and interaction effects) can be estimated (Sanko 2001). Table 2 shows an example of the full factorial design including three alternatives (A, B, and C), one attribute, and two attribute levels. The total number of different scenarios in this case is: (2) × (2) × (2)= $2^{3 \times 1}$= 8.

Table 2: Full Factorial Design Example

Scenario	A	B	C
1	-1	-1	-1
2	-1	-1	1
3	-1	1	-1
4	-1	1	1
5	1	-1	-1
6	1	-1	1
7	1	1	-1
8	1	1	1

Full factorial designs are the most conservative form of experimental designs in which all possible attribute level combinations are examined. However, full factorial designs can be impractical if a large number of alternatives, attributes, and attribute levels exist. In such cases, fractional factorial designs (e.g. orthogonal design, efficient designs, Bayesian efficient, etc.) are useful. Fractional factorial designs select a subset of full factorial designs in a structured manner such that the best data is produced from the experiment. Orthogonal designs are the most popular type of fractional factorial designs, yet they have limitations. One major limitation of orthogonal designs is there violation to the utility balance property which means that they cannot avoid unrealistic scenarios where a certain alternative is clearly more preferred over the others (i.e. not providing much information) (Huber and Zwerina 1996). Although other fractional factorial designs are available, orthogonal designs remain entrenched within the literature and continue to be the mainstream (Rose and Bliemer 2014).

Orthogonal designs aim at minimizing the correlation between attribute levels in each scenario and ensure that all parameters are independently estimable (i.e. uncorrelated). Orthogonal designs also satisfy the attribute level balance property (i.e. each attribute level appears the same number of times for each attribute). In other words, the sum of the inner product of any two columns is zero, as shown in Table 3.

Table 3: Orthogonal Design of Three Alternatives, One Attribute and Two Attribute Levels Each

Scenario	A	B	C	AB	AC	BC	Correlation Matrix			
								A	**B**	**C**
1	-1	-1	-1	1	1	1				
2	-1	1	1	-1	-1	1	**A**	1	0	0
3	1	-1	1	-1	1	-1	**B**	0	1	0
4	1	1	-1	1	-1	-1	**C**	0	0	1
			Sum	0	0	0				

Table 4 is an example of a non-orthogonal design, as the inner product of any two columns is a non-zero value.

Table 4: Non-orthogonal Design of Three Alternatives, One Attribute and Two Attribute Levels Each

Scenario	A	B	C	AB	AC	BC	Correlation Matrix			
								A	**B**	**C**
1	-1	1	-1	-1	1	-1				
2	-1	-1	1	1	-1	-1	**A**	1	0	0
3	1	-1	1	-1	1	-1	**B**	0	1	-1
4	1	1	-1	1	-1	-1	**C**	0	-1	1
			Sum	0	0	-4				

As shown in the above examples, the number of scenarios has reduced from eight to four using an orthogonal design.

Survey Design

This study employed a web-based survey for data collection. A link to access the questionnaire was sent out to each member of the target population (N= 1,522 IHA employees affected by the relocation) via email through their employer. Given that there was no need to neither print out the questionnaire nor to manually enter data, the online survey offered cost and time savings as well as tailor-made interviews for each participant based on her/his earlier responses in the questionnaire (Cobanoglu et al. 2001; Kwak and Radler 2002; Kaplowitz et al. 2004).

The survey was divided into an introduction and three consecutive sections. The introduction presented an overview of the study, described the various sections of the questionnaire, and sought consent for participation. Section A gathered RP information regarding daily commuting work trips and current travel options. In particular, this section asked questions about home and work locations, time to leave home, time to leave work, and primary means of commuting as one of the following options: vehicle driver, vehicle passenger, carpool, public transit, bicycle, or walk. After identifying the primary mode of travel, additional mode-specific information was collected. For example, vehicle drivers were asked about their travel time, travel cost, parking cost, etc. whereas transit users were asked additional questions about their waiting time, number of transfers they make, etc. Further, the survey gathered information on passengers' perceptions about the public transit service and active transport network in Kelowna, as well as the frequency of using these modes in the last year. Finally, the last part of Section A collected information on secondary means of commuting (in case of unavailability of the primary option) and the barriers to use it as a primary option. This information provided a clearer idea about the hierarchies within the choice set of each employee.

Section B set up a SP experiment where each respondent faced a number of hypothetical scenarios and asked to make a choice amongst various alternatives for their work commute. Five alternatives and eight attributes (three levels each) were used to design the SP experiment, as shown in Table 5.

Table 5: Attribute and Attribute Levels

Attribute	**Car**		**Public Transit**	**Active Transportation**	
	Drive Alone	**Shared Ride**		**Bicycle**	**Walk**
Travel Cost/Fare ($/One-way Trip)	**Current**	-50%	**Current ($2.50)**	---	---
	+50%	**Current**	+10%	---	---
	+100%	+50%	+20%	---	---
Parking Cost ($/One-Way Trip)	$90	-50%	---	---	---
	+50%	$90	---	---	---
	+100%	+50%	---	---	---
Transit Access Time (min/One-Way Trip)	---	---	**Current** +10%	---	---
	---	---	**Current** +20%	---	---
	---	---	**Current** +30%	---	---
Transit Waiting Time (min/One-Way Trip)	---	---	**Current** +10%	---	---
	---	---	**Current** +20%	---	---
	---	---	**Current** +30%	---	---
Door-to-door Travel Time (min/One-Way Trip)	**Current**	-50%	-50%	**Current**	**Current**
	+50%	**Current**	**Current**	**Current**	**Current**
	+100%	+50%	+50%	**Current**	**Current**
Number of Transfers (0, 1 , 2 or more)	---	---	0	---	---
	---	---	1	---	---
	---	---	2 or more	---	---
Park-and-Ride Availability (Yes-Free, Yes-Not Free, No)	---	---	Yes (Free)	---	---
			Yes (Not Free)		
	---	---	No	---	---
Pathways/Bike lanes Availability (No, Some, Most)	---	---	---	No travel on bike lanes	No travel on pathways
	---	---	---	Some (<50%) travel on bike lanes	Some (<50%) travel on pathways
	---	---	---	Most (>50%) travel on bike lanes	Most (>50%) travel on pathways

The attributes used in this survey are thought to be what most of passengers consider while selecting their desired mode of travel to work. In addition, these attributes are also the ones that most of the TDM plans alter to influence passengers' choices. Attribute levels, on the other hand, were customized for each respondent based on her/his earlier responses in Section A. For example, as shown in Table 5, passengers' "current" travel time that was already given in Section A is manipulated by 50% increase and 100% increase to make up three levels.

Shuffling attribute levels within the experiment plays a major role in determining the independent contribution of each attribute to the final choice (Rose and Bliemer 2009; Cooper et al. 2011). As such, the allocation of attribute levels to the different scenarios is crucial to SP experimental designs. This study adopted the orthogonal design to develop the SP experiment. Ngene 1.0.2 was used to generate the design.

Given five alternatives and eight attributes of three levels each, the orthogonal design produced a total of 54 scenarios. The generated scenarios ensured uncorrelated attribute levels and maintained attribute level balance. Although, this number of scenarios is much lower than that of a full factorial design ($3^{8 \times 5}$), it was still unfeasible to let a single respondent face all 54 different sets of choice situations.

Therefore, an orthogonal design with blocking was sought. Orthogonal design with blocking is a method that splits the orthogonal array into smaller subsets (blocks). This way, each respondent will be shown a lesser number of scenarios. However, each block is not orthogonal on its own, but the combination of all blocks will maintain orthogonality. As such, the orthogonal design was blocked into 9 blocks of 6 scenarios each (multiples of 54) to satisfy the degrees of freedom and attribute level balance within each block. This way, each respondent will face a random block of 6 choice scenarios instead of 54. Nine different identical surveys were completed, each containing one different SP block. Then, a separate web-link was created for each survey (i.e. a total of 9 links were created) before being sent out to respondents (each respondent received a single web-link) via email at random.

In this study, only respondents who selected vehicle driver or vehicle passenger/carpooling as their main mode of transportation were asked to answer the SP. Vehicle drivers and vehicle passengers/carpoolers were only asked to provide their travel time by their chosen mode (i.e. by car). In the same time, travel times by other modes needed to be presented in the SP experiment. As such, a time matrix was developed to convert travel time by car to travel time by transit, cycle, and walk.

To develop this matrix, a list of the home locations of IHA employees affected by the relocation to the new office was used. By analyzing home locations, it was found that home locations were spread out between addresses in downtown Kelowna (where the new office will be located) and as far away as Vernon, BC (about 50 km north of Kelowna).

It is expected that TDM plans resulting from this study will not affect employees living that far. For example, anyone coming from Vernon would never consider biking or walking as the distance is too far. Transit service from Vernon to Kelowna is also tough as it requires two transfers (UBCO connector to 97 Express). To produce realistic travel time estimates and to avoid skewing biking and walking times for anyone living in Kelowna, it was important to specify a threshold for active commuting as an inclusion criterion for developing the time matrix. The 2013 Okanagan Travel Survey was used for this task. The 2013 Okanagan Travel Survey is the most recent household-based trip diary that was conducted in fall 2013 and covered a sample of residents of the Central Okanagan and the City of Vernon. Data from the 2013 Okanagan Travel Survey was analyzed and the trip length distribution by mode was calculated, as shown in Figure 2.

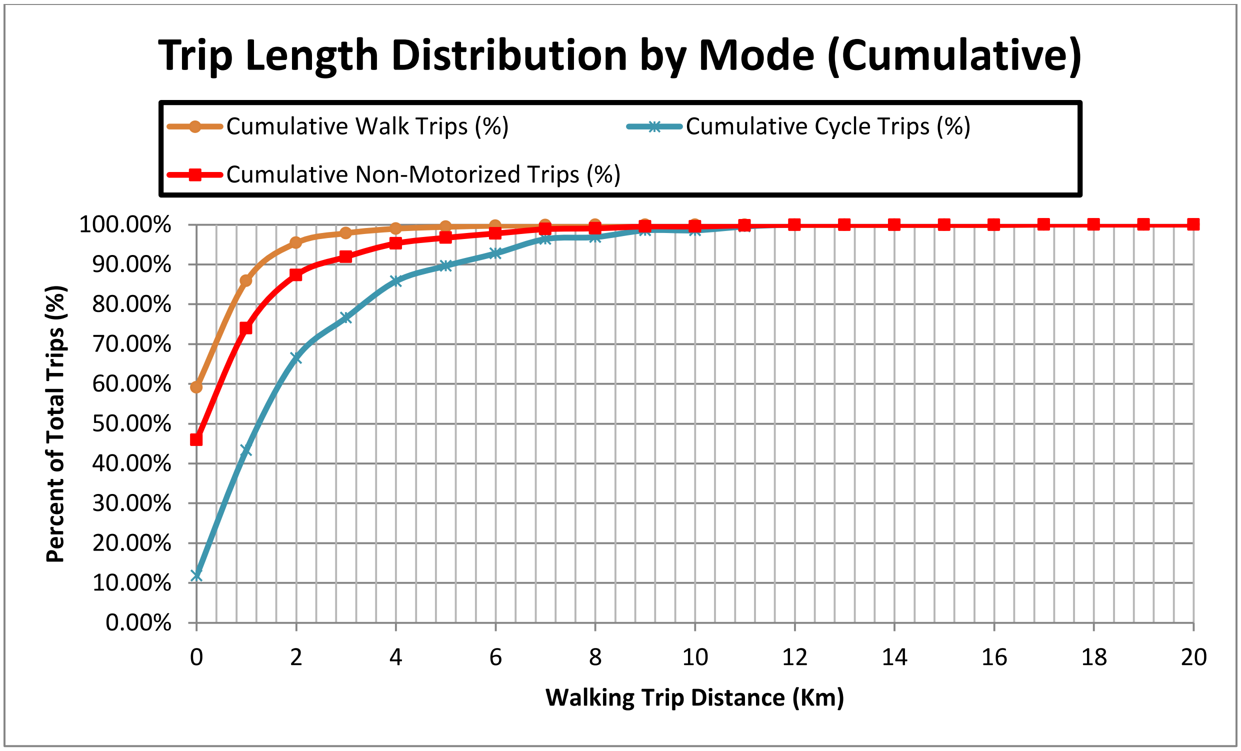

Figure 2: Cumulative Trip Length Distribution by Mode

According to Figure 2, about 95% of all cycling and walking trips were for short trips of up to 4 km in length. As such, all trips of more than 4 km in length were eliminated from time matrix calculation (i.e. employees that have their home location within 4 km from their work location were kept). Home postal codes of employees were then entered into Google Maps where the travel times from home to the current work locations were estimated by all modes (i.e. car, transit, cycle, and walk). Travel times were then averaged for each mode and used to create the time matrix, as shown in Table 6.

Table 6: Final Average Kelowna Travel Time Matrix

Scenario	To Mode				
	Mode	**Car**	**Transit**	**Bike**	**Walk**
From Mode	**Car**	*1	*3.32	*1.57	*4.79
	Transit		*1	*0.50	*1.52
	Bike			*1	*3.07
	Walk				*1

So, to get a realistic estimate of travel time for each mode based on respondent travel time by car entered in Section A of the questionnaire, this matrix was used (i.e. if they are a car user, their time is multiplied by each attribute in the car row to approximate their other commute travel times).

During the survey design stage, three different pilot surveys were tested by UBCO researchers and IHA staff. The pilot surveys were conducted among a random sample of IHA staff. After addressing their comments and concerns, the final survey was designed, as seen in Appendix B. The final survey was sent out on January 18th, 2016. Below is a summary of the surveys important dates and deadlines.

Table 7: Pilot Survey and Final Survey Launch Dates

Date	Action
November 10th, 2015	1st Pilot sent out
November 28th, 2015	2nd Pilot sent out
January 5th, 2016	3rd Pilot sent out
January 18th, 2016	Final Survey sent out, 9:30 am
February 3rd, 2016	Final Survey finished, 5:00 pm

Each time the survey was piloted, a similar or slightly different group of IHA were involved, leading to different changes after each run. Mostly formatting and page layout was required, as well as adding and removing certain questions. At the end of each pilot, there was a general feedback section asking the respondents their general thoughts, as well as what should be removed and added.

Sample Design

The developed survey is intended to collect data on passengers' preferences and mode choices. Ideally, data would be gathered from every IHA staff member moving to the new office location; however, this is not a feasible option. To be able to make reliable inferences about the population (i.e. deducing passengers' preferences and travel behaviour from the sample and generalize to the population), it is imperative to determine a representative sample size (Franklin et al. 2003).

This study used the Simple Random Sampling (SRS) method, where each member of the sample has an equal probability of being chosen only once, to maintain an unbiased representation of the population.

For sample size determination, a maximum population variability of P = 0.5 was considered with a margin of error e = 0.05% at a 95% confidence level. To put this into perspective there is a 5% chance of obtaining a sample size that produces an estimate outside the standard deviation range. The confidence level is associated with a z score which is a constant needed for the sample size calculation, a 95% confidence level is associated with a z score of 1.96. The design effect, also known as DEFF, is an attribute that is multiplied by the sample size to account for sampling error. A DEFF of 1 was considered for the calculations since it is a simple random sample design (Richardson et al. 1995). The steps below demonstrate the sample size calculation given a total population of 1,000 staff members moving to the new office (the higher limit is being used to be more conservative). According to the calculations, the study needs at least 280 survey respondents to obtain accurate representation of the population.

1. Calculate the initial sample size, n_1:

[1] $$n_1 = \frac{z^2 P(1-P)}{e^2}$$

Calculate the initial sample size, n_1:					
z	=	1.96			
P	=	0.5	n_1	=	384.16
e	=	0.05			

2. Adjust the sample size to account for the size of the population, n_2:

[2] $$n_2 = n_1 \frac{N}{N + n_1}$$

Adjust the sample size to account for the size of the population, n_2:		
N = Total Population	=	1,000
n_2	=	277.54

3. Adjust the sample size for the effect of the sample design, n_3:

[3] $$n_3 = DEFF \times n_2$$

Adjust the sample size for the effect of the sample design		
DEFF	=	1
n_3	=	277.54

Data Analysis

This section portrays the Revealed Preference (RP) characteristics of the sampled respondents obtained through the final survey launched from January 18th, 2016 to February 3rd, 2016. The purpose of this survey was to gather the current work-trip travel behavior of all 900+ IHA employees. Based on the counts from the survey, there were a total of 668 respondents, who gave their consent before proceeding with the survey. However, in total, there were 464 complete records (204 incomplete records) received initially, giving a response rate of 46.40%, which is above the normal survey response rate of 20%. Based on the calculated sample size, only 280 completes were needed to properly represent the study population. Table 8 depicts the overall statistics of the collected sample. Summary of the sample statistics and demographic description are explained in Table 9.

Table 8: Sample Descriptive Statistics

Response Rate			
Total Population Size:	1,000	Completes:	464
Total Survey Response	668	Incompletes:	202
Survey Response Rate:	66.80%	Completes Response Rate:	46.40%

Table 9: Sample Demographic Statistics

Sample Descriptive Statistics			
Variable	**Value**	**Sample Size**	**Percentage**
Gender	Female	346	74.57%
	Male	103	22.20%
Age Group Range	18-24	4	0.58%
	25-34	84	12.28%
	35-44	125	18.27%
	35-44	125	18.27%
	45-54	151	22.08%
	55-64	95	13.89%
	55-64	95	13.89%
	65+	5	0.73%
Number of People in the Household	1	65	15.59%
	2	173	41.49%
	3	78	18.71%
	4	101	24.22%
Have Driver License	Yes	459	99.00%
	No	5	1.00%
No. of Vehicles	0	4	1.00%
	1	105	31.07%
	2	155	45.86%
	3	42	12.43%
	4 or more	36	10.65%
Job Type	Non-clinical	343	73.92%
	Clinical	121	26.08%
Contract Type	Full-Time	394	84.91%
	Part-Time	70	15.09%
Income Range (Canadian Dollar)	Do not wish to disclose	99	21.48%
	$20,001 - $40,000	34	7.38%
	$40,001 - $70,000	91	19.74%
	$70,001 - $100,000	87	18.87%
	$100,001 - $150,000	97	21.04%
	$150,001 - $250,000	47	10.20%
	Over $250,000	6	1.30%

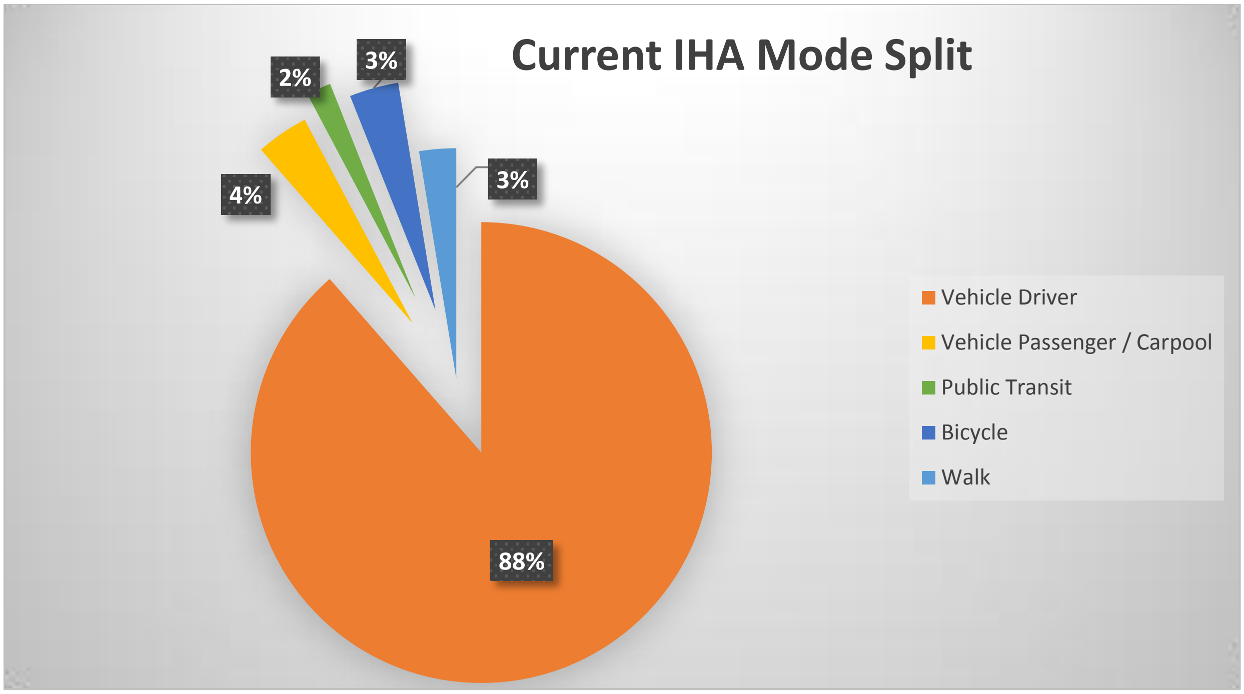

Figure 3: Current IHA Staff Mode Split

The current mode split of IHA staff is shown in Figure 3. It can be seen that 88% of IHA employees moving to the new Community Health and Services Centre (CHSC) drive to/from work (92% vehicle driver and passenger combined). This percentage is above the vehicle driver mode split in Kelowna which is 66.4% (82% vehicle driver and passenger combined) according to the 2013 Okanagan Travel Survey.

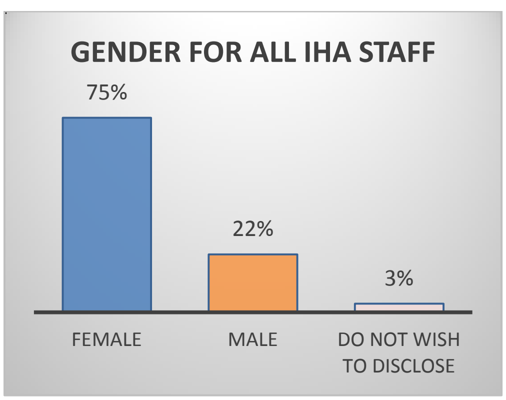

Figure 4: Male and Female Distribution of IHA Employees

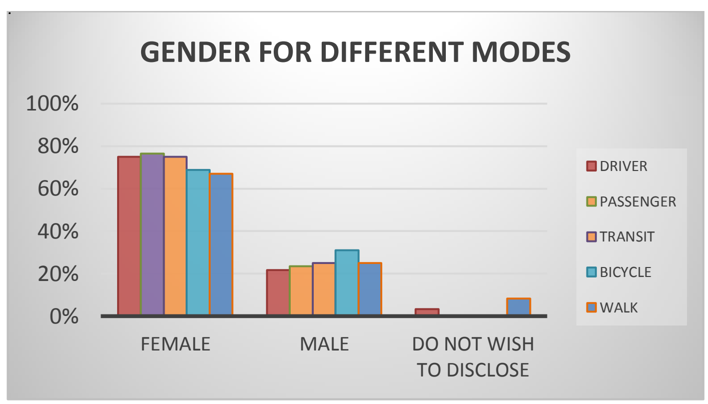

Figure 5: Male and Female Distribution of IHA Employees

About 75% of the employees are females, as shown in Figure 4. Over 74% of IHA staff are non-clinical, and approximately 80% of them have a full-time contract with IHA. According to Figure 5, males tend to have more desire to walk and cycle, whereas females have higher tendency to be vehicle driver or vehicle passenger.

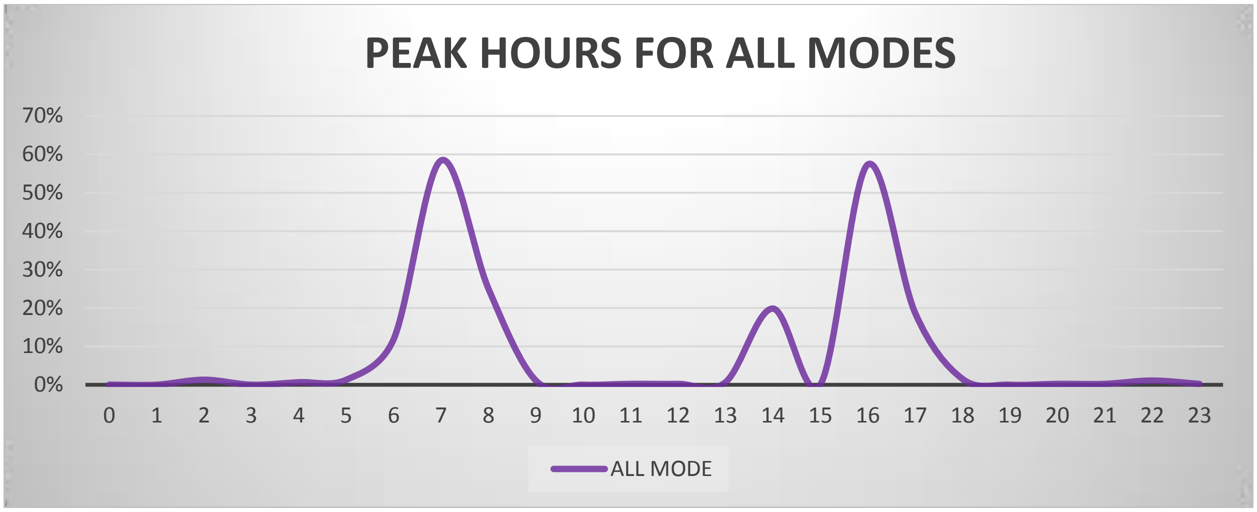

Figure 6: Leave Home to Work

As shown in Figure 6, most of IHA employees leave their home to work at around 7:00 am and leave work around 4:00 pm. These departure times are in line with the peak times for morning and afternoon trips in Kelowna (8:00 am and 4:00 pm), as reported in the 2013 Okanagan Travel Survey. It is also interesting to see another afternoon peak occurring around 2:00 pm, which is one hour before the higher frequency transit service starts at 3:00 pm. Accordingly, IHA employees leaving work at 2:00 pm might not consider public transit as an option given its lower service frequency at that time.

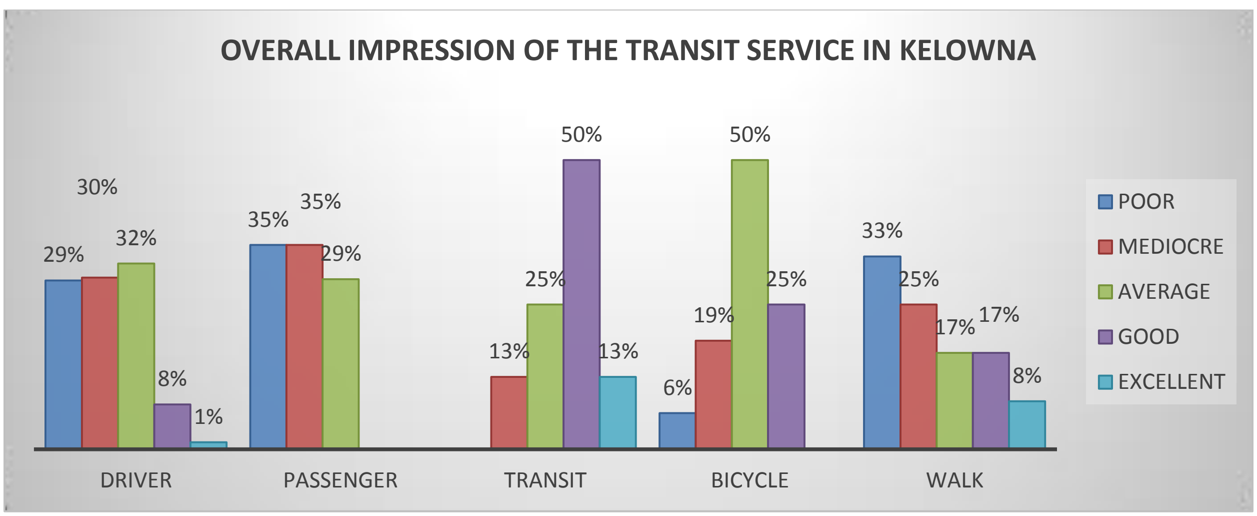

Figure 7: Overall Impression of the Transit Service in Kelowna

Figure 7 demonstrates IHA employees' overall impression of the transit service in Kelowna. It seems that transit users have a good perception of the service provided to them. Motorists, on the other hand, are less impressed with public transit in Kelowna (about 60% of vehicle drivers rated transit lower than average). Enhancing transit level of service and probably maintaining a higher frequency starting 2:00 pm could potentially improve the perception of vehicle drivers and eventually increase their mode shift to transit.

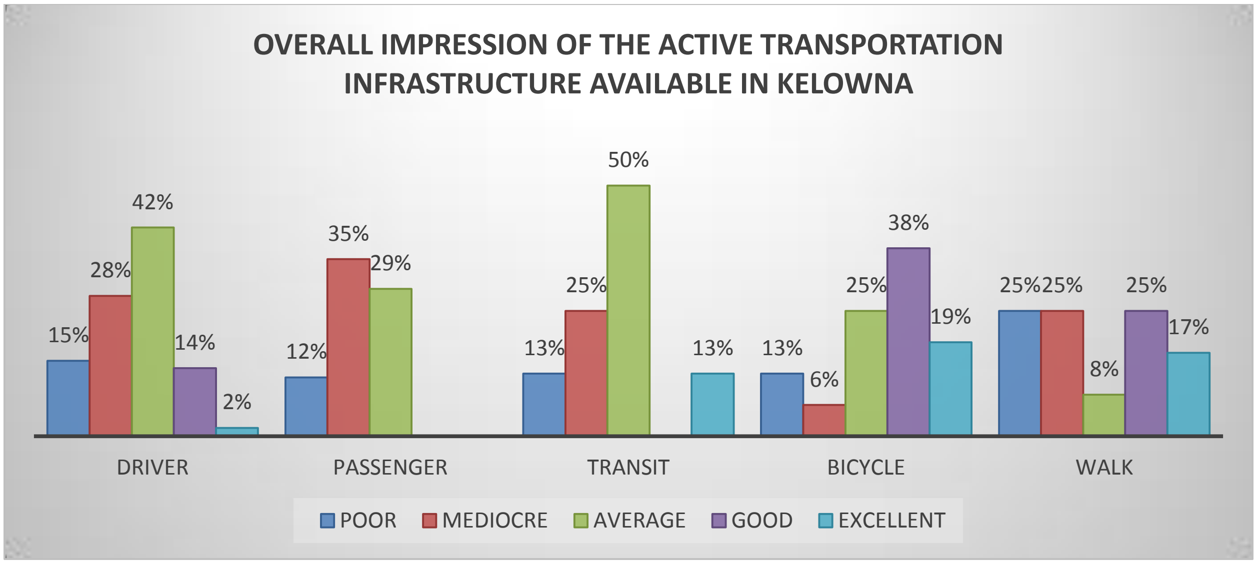

Figure 8: Overall Impression of the Active Transportation Infrastructure in Kelowna

It seems that cyclists have a good impression of Kelowna's active transportation infrastructure, as shown in Figure 8. However, about 45% of vehicle drivers feel that the active transportation infrastructure in Kelowna is below average. To embark on the way to sustainability, the City of Kelowna needs to provide more accessibility in term of sidewalks and bike lanes throughout the city. This could provide more incentive for vehicle drivers to use active transportation in the future.

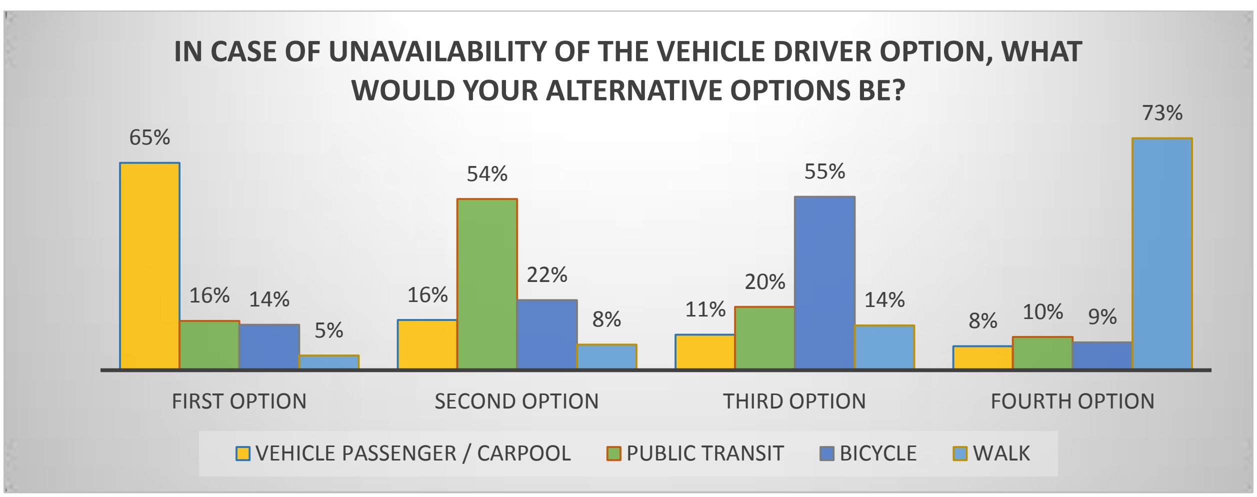

Figure 9: Alternative Travel Options in case of Unavailability of the Vehicle Driver Option

Figure 9 shows that in case of unavailability of the vehicle driver option, drivers prefer to be car passenger, transit user, cyclists, and walker as their first, second, third, and fourth option, respectively. Despite the existence of various sustainable travel options, IHA staff who drive still prefer to use a vehicle (i.e. vehicle passenger) as their second option. This finding highlights the superiority of the automobile as a mode of travel in Kelowna. The following figures present more insights into the driving force behind the superiority of the automobile and the barriers to switch to sustainable transportation options.

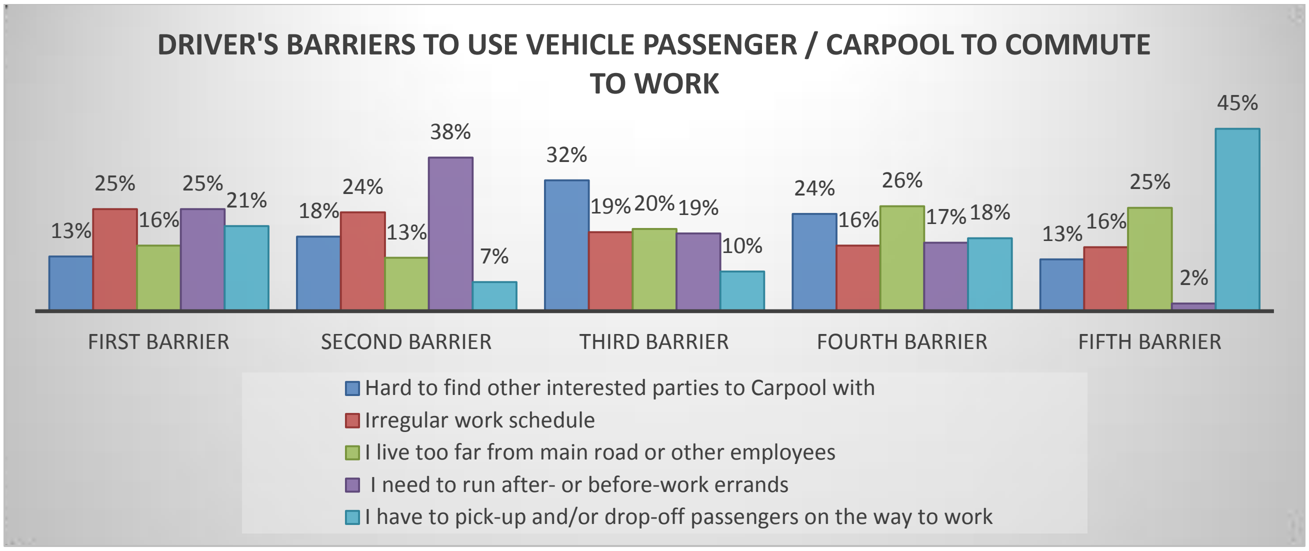

Figure 2: Driver's Barriers to Use Vehicle Passenger/ Carpool to Commute to Work

Most of IHA staff who drive indicated that their main barriers to carpool are running before/after-work errands and having irregular work schedules, as shown in Figure 10. The figure also shows that picking-up and/or dropping-off passengers are the least concerns to drivers when it comes to switching to carpooling. To overcome these barriers, shifting running errands to between-work and providing alternative work hours are recommended as two TDM policies. These policies can also be supplemented by ensuring a travel option for running between-work errands, and offering preferential parking spaces for carpoolers and subsidizing their travel/parking costs. By providing a break during the workday for running errands, employees will have more flexibility to carpool to/from work as running errands before/after work will no longer be a barrier. Moreover, shifting the activity of running errands from the morning and the afternoon peak periods will reduce the traffic and parking pressures on Kelowna's transportation network. As a supplementary travel option for running between-work errands, IHA could incentivize its employees to utilize the Okanagan (OGO) Car Share Co-op service, located a short walk away from the new building, to run errands during the workday. In addition, ensuring regular work schedules will help employees plan their trips with other interested carpoolers. If an irregular work schedule is unavoidable, at least make sure that clusters of potential carpoolers are identified based on their home locations before assigning them the same "irregular" schedule so that they can plan their trips to/from work. A more detailed study is suggested for future work to design custom-made trip itineraries for clusters of potential carpoolers based on shortest routes from their home locations to the new office.

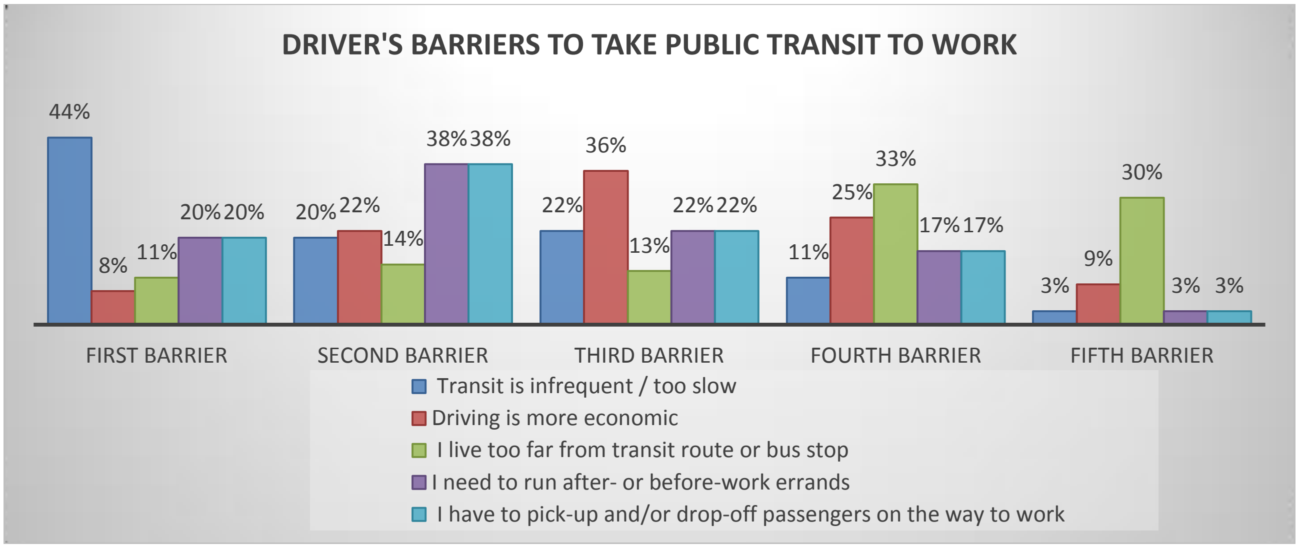

Figure 3: Driver's Barriers to Take Public Transit to Work

Based on Figure 11 most of IHA staff who drive indicated that their first barrier to switch to public transit is transit itself being infrequent/too slow, and not about driving being more economic for example. In addition, it seems that walking distance to/from the transit service is not an issue for IHA employees. In fact, these findings support an earlier recommendation about enhancing transit level of service (e.g. increasing frequency, reducing waiting time, etc.) to improve vehicle drivers' perception of public transit and eventually increase mode shift, see Figure 7. For example, starting higher frequency transit at 2:00 pm could attract some of the drivers leaving work at that time. Alternatively, IHA could consider providing private means of mass transportation to for its employees leaving work at 2:00 pm. Figure 11 also shows that the need to run before/after-work errands is identified as the second barrier to use transit. To overcome this barrier, shifting running errands to between-work is recommended as a TDM policy. This policy can also be supplemented by ensuring a travel option for running between-work errands and subsidizing transit users' travel cost. By providing a break during the workday for running errands, employees will have more flexibility to take transit to/from work. Moreover, shifting running errands from the morning and the afternoon peak periods will reduce the traffic and parking pressures on Kelowna's transportation network. As previously mentioned, IHA could incentivize its employees to utilize the Okanagan (OGO) Car Share Co-op service, located a short walk away from the new building, to run between-work errands.

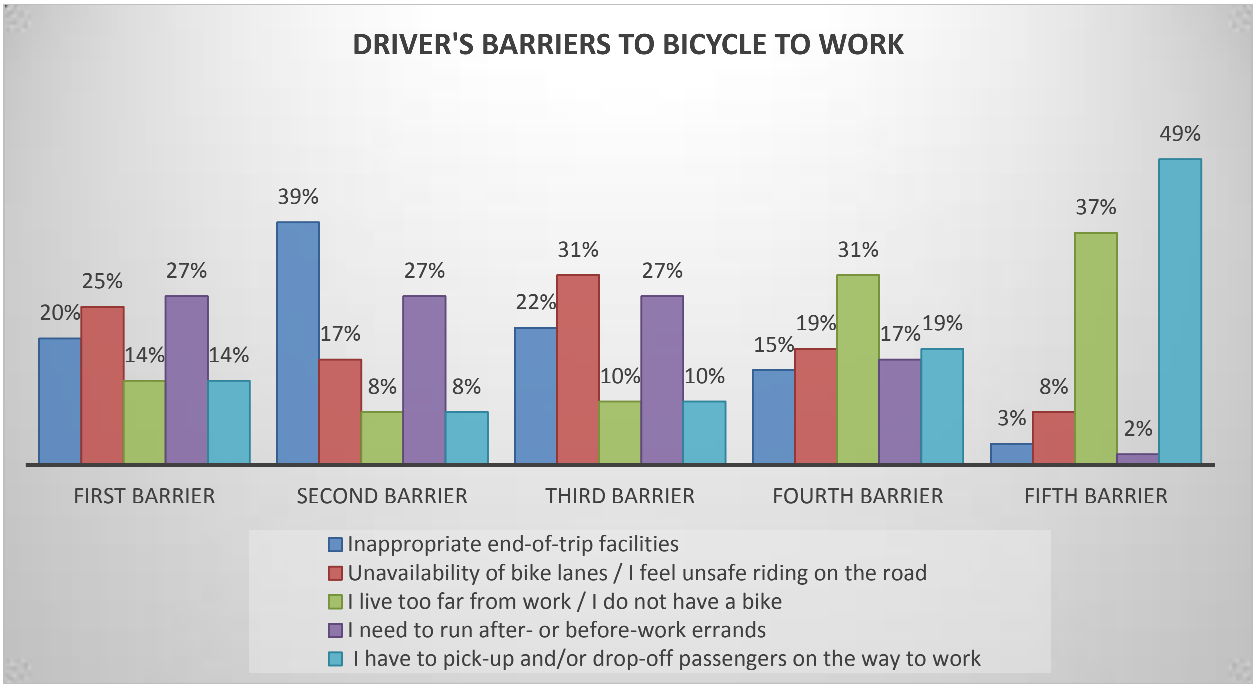

Figure 4: Driver's Barriers to Bicycle to Work

Even though cycling is considered a sustainable and healthy mode of travel, IHA staff members who drive believe that this mode is impractical due to their need to run before/after-work errands and the unavailability of bike lanes/safety concerns associated with riding a bicycle on the road, as shown in Figure 12. In fact, the latter barrier (i.e. unavailability of bike lanes/safety concerns) supports an earlier recommendation about the need to improve bike lanes throughout the city to incentivize vehicle drivers to switch to cycling, see Figure 8. Furthermore, the need for running errands before/after work could be tackled by shifting this activity to between-work as recommended earlier. This policy can also be supplemented by incentivizing employees to utilize the Okanagan (OGO) Car Share Co-op service to run between-work errands. Inappropriate end-of-trip facilities is also indicated as a main barrier for motorists to switch to cycling. As such, it is recommended that IHA provide appropriate end-of-trip facilities (e.g. showers, bike lockers, etc.) to help vehicle drivers embark on the path to sustainability. Interestingly, it seems that travel distance to work is not an issue.

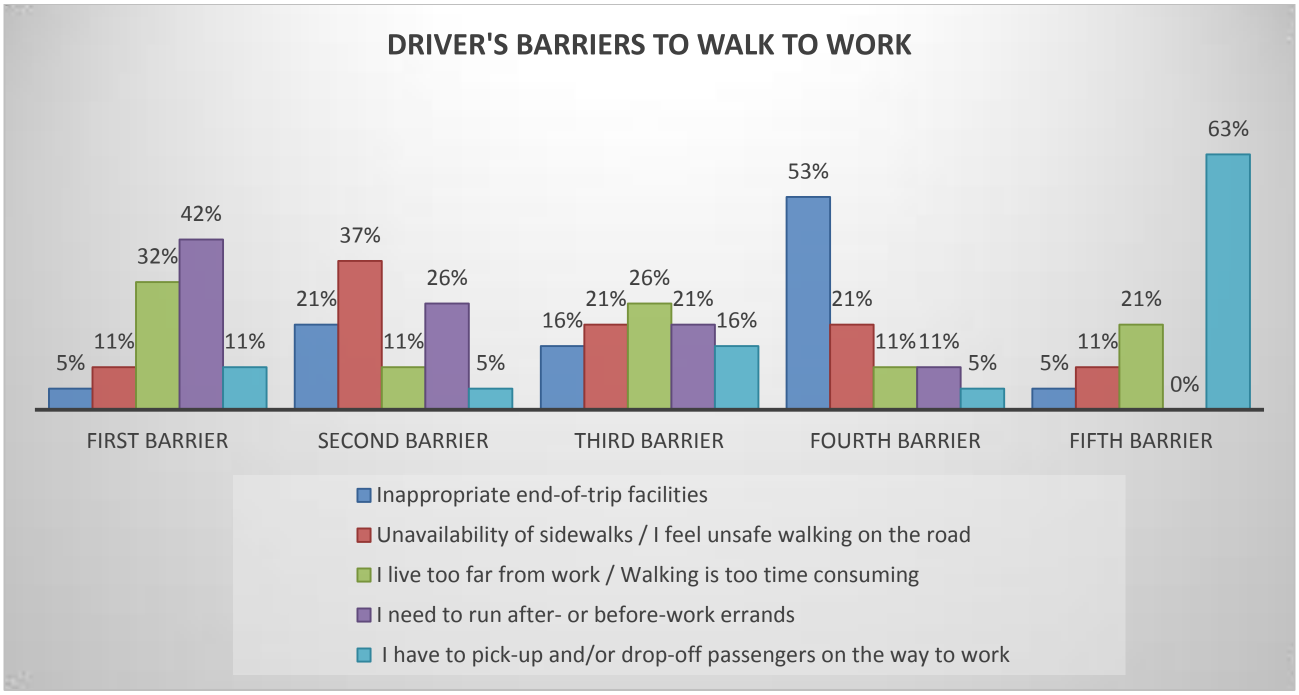

Figure 13: Driver's Barriers to Walk to Work

Walking is the primary mode of transportation for short trips especially when there are not a lot of belongings to carry during the trip. For IHA employees who drive to work, walking was identified as the last option in the case of unavailability of the vehicle driver option, as shown earlier in Figure 9. According to Figure 13, the main barrier for motorists to switch to walk is the need to run before/after-work errands. One TDM policy to overcome this barrier is to shift running errands to between-work as recommended earlier. This policy can also be supplemented by incentivizing employees to utilize the Okanagan (OGO) Car Share Co-op service to run between-work errands. Moreover, unavailability of sidewalks and feeling unsafe walking on the road are identified as the second concern. This finding supports an earlier recommendation about the need to improve sidewalks throughout the city to incentivize vehicle drivers to switch to walking, see Figure 8. Travel distance appears to be a barrier for employees living too far from the new office.

Transportation Demand Management (TDM) Plan

Before TDM strategies are fully explained it should be noted that the most influential step IHA took to encourage sustainable transportation was relocating ten offices across the city to one in the downtown core. As accessibility to sustainable modes of transport is fundamental in encouraging commuters to switch, this new building location offers that. First, the location is just minutes away from Queensway Transit Exchange, Kelowna’s transit hub. Second, the building is also a short walk away from designated parking spots of the Okanagan (OGO) Car Share Co-op service. Finally, the new active transportation corridors the city has developed and plans to expand is another important factor. The map below displays the close proximity of Queensway Transit Exchange and OGO Car Share.

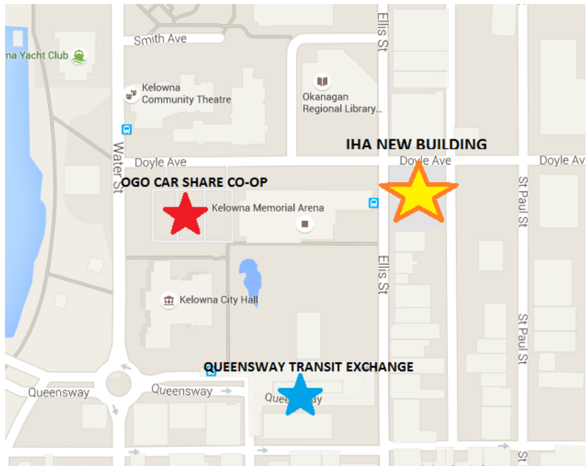

Figure 14: IHA New Building Relative to OGO Car Share Co-op and Queensway Transit Exchange

The analysis of the collected data provided significant insights into the preferences of IHA employees. Using such data, a customized TDM plan was designed for IHA, influencing the attributes affecting high (low) levels of car (sustainable transportation) use. The list below summarizes possible implementation strategies:

- Offer preferential parking spaces for carpoolers and subsidize their parking cost;
- Encourage carpooling among staff via different methods (e.g. postal code matching, etc.);
- Increase the frequency of transit services and implementing more direct transit routes could potentially improve the overall impression of the transit service and increase mode shift to transit;
- Offer incentives for taking transit and subsidize its cost;
- Provide more accessibility in term of sidewalks and bike lanes throughout the city could provide more incentive to use active transportation;
- Improve end-of-trip facilities and creating more bike lanes can help drivers to embark on the path to sustainability;
- Work schedule adjustments;
- Utilize the nearby car share for running errands; and
- Education and promotion campaigns to promote and increase awareness about available sustainable options (e.g. carpooling, public transit, carsharing, etc.).

Conclusions

Interior Health Authority (IHA) will be reallocating ten of its programs to a single office building in the heart of downtown Kelowna. This will result in more than 900 employees moving to the new office building. To alleviate the expected traffic congestion and parking pressure in downtown Kelowna due to the new office building, this research developed a TDM plan for IHA employees affected by the move. This study made use of the Revealed Preference (RP) and the Stated Preference (SP) methods to collect data and examine IHA employees' preferences and travel behavior. Factual data on daily commuting to work and current travel options was gathered along with socioeconomic and demographic characteristics of employees. In the stated preference section, a number of hypothetical scenarios were presented to each respondent where he/she was asked to select one or more alternatives from amongst a finite set of options described by pre-specified factor levels drawn from some underlying experimental design. However, this paper only reported on RP data, while SP dataset is kept for future work.

The findings of this research provided IHA with possible TDM policies and strategies to alleviate parking pressures and minimize the effect that the office relocation is anticipated to have on Kelowna's downtown traffic, as well as the effect on reallocated staff. Implementation strategies included: carpooling programs, incentivizing the use transit or non-motorized modes, and educating IHA employees on the carbon footprint associated with their choices.

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