How effectively are the public transport needs of existing and future residents of the ICE being met? How can the public transport system be changed to better meet demand?

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Executive Summary

- Transport in the Inner-City East (ICE) has been identified by the ICE Revitalisation Working Group as an issue when needs improvement.

- The research question developed was “How effectively are the public transport needs of existing and future residents of the ICE being met? How can the public transport system be changed to better meet demand?”

- GIS, surveys, and interviews with Environment Canterbury and Christchurch City Council were used to answer the research question.

- The research resulted in potential solutions regarding better care of bus shelters and lower bus fares, and increased frequency of the 60 Line. An overhaul of the fare system, such as the adoption of distance based prices, could aid lower fares. Bus accessibility, through a network analysis and surveys. was deemed to be suitable.

- The biggest shortcomings was time limitations, this limited survey results, for future projects more time is key to guarantee larger respondent numbers.

Introduction

An effective public transport (PT) system is a critical aspect of a suburbs development. The benefits of PT can include environmental sustainability, prevention of congestion, helping to build the economy by transporting people to work and importantly, access for all (Stjernborg & Mattison, 2016). Access for all is essential as PT offers a method of transport for those who cannot drive, for instance, older people or people with disabilities.

The Inner-City East (ICE) seen in *Fig. 1* is an area which very heavily relies on PT due to the demographics of the suburb; only 6.9% of people living in the ICE have access to a motor vehicle, as compared to wider Christchurch which has a vehicle ownership rate of 16.9% (Stats NZ, 2013). The ICE has a large proportion of the elderly and people with disabilities. Therefore, the distance to bus stops could discourage these groups from using the service. The ICE is a relatively low-income area with the median income being $25,300 (Stats NZ, 2013), meaning that the price of the service is could also disincentive use of PT. New housing developments in the area are built with little to no parking which disincentives car-ownership. This puts an even heavier reliance on the PT system. Therefore, looking to the future it is important to ensure that the needs of the residents are met.

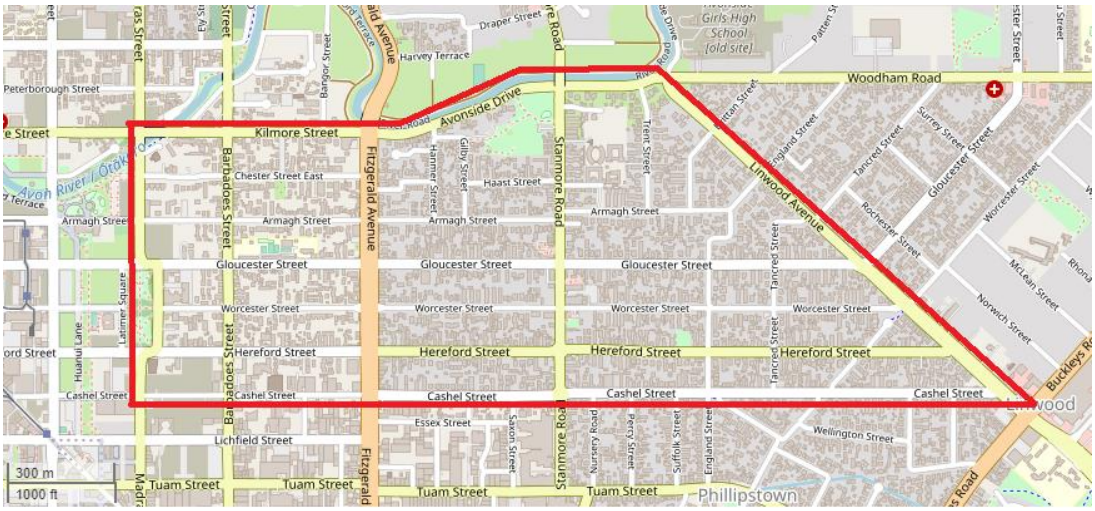


Figure 1: Map of the ICE Outlined in Red (OpenStreetMap Contributors, 2019)

Three different parties make decisions surrounding Christchurch's PT systems; Christchurch City Council (CCC), Environment Canterbury (ECan), and the New Zealand Transport Agency (NZTA). ECan decides the routes, the councils handle the bus stops and shelters, while NZTA help with general funding and planning of routes. Currently, Christchurch has three different types of bus lines, including the high-frequency core network, city connectors and cross-town links (ECan, 2018). The core network operates primarily on arterial roads in an attempt to transport people from one destination to another quickly. The city connectors and cross-town links include all other buses in Christchurch (ECan, 2018). These buses connect the suburbs to the city, maximising coverage at the expense of travel time. This study aims to identify issues and develop solutions to better meet the needs of people in residential areas such as in the ICE.

Review of Relevant Literature

Stahl (2008) address the prioritisation of accessibility and safety measures involving older people, focussing on public transport and footpath maintenance. The research was done using postal questionnaires and observations aimed at the over-65 age group. This paper noted that issues such as pathway accessibility were issues common with elderly and people with disabilities which helped shape questions in the surveys. Stahl (2008) is relevant as the study method it utilises could be utilised for this research, namely postal questionnaires and observations at community lunches. Papa, Carpentieri and Guida (2018) also assess the accessibility of the elderly, again concluding that there needs to be a certain level of prioritisation for this group as they make up part of the 'transport disadvantaged'.

Mavoa, Witten, McCreanor and O'Sullivan (2012) investigate public transport issues, particularly the access to both bus stops and end destinations. Accessibility was analyzed by using a Public Transport and Walking Accessibility Index (PTWAI) and inputting this into a GIS program. Their analysis found that only 5% of Auckland's urban population have adequate levels of service. Their study is relevant as this study could implement a similar type of GIS analysis to investigate the distances to bus stops in the ICE.

Wright (2010) investigates the links between the frequency of public transport use and the socioeconomic status of the area in Christchurch. This research is significant as it found there is a link between the number of daily trips and the deprivation of an area; the higher the deprivation, the higher the number of daily trips. Wright (2010) is particularly relevant to this research as the study area of the ICE has a lower average income than Christchurch as a whole (StatsNZ, 2013).

Mukherjee (2019) evaluates the shortcomings of the public transport system in Christchurch and what the public feel would make the system more useful and usable. This study was conducted by interviewing both policy makers and public transport operators, the general public were given a questionnaire about their main mode of transport along with any issues that prohibit them from using public transport. The survey found that those who do not use the busses often stated that the routes not suiting them or the system being unreliable as the reason for this. This is relevant as interviewing people from ECan and CCC could be a focus of this research.

Influence of Wider Literature and Interests of Community Partner on the Research Questions

Our research questions are; 'How effectively are the public transport needs of existing and future residents of the ICE being met?' and 'How can the public transport system be changed to better meet demand?' These questions relate to a study by Guzman and Oviedo (2018) as they look at the public transport system in Bogota, Colombia and how the government introduced pro-poor subsidies. This was done by issuing smart cards to those who met the criteria and would discount the cost of the trip. This relates to our research as Bogota and the ICE are comparable in terms of income as they both have very similar average incomes meaning that subsidies for the poor could be something that can be looked at in Christchurch.

There were multiple sources which were assessed to analyse the efficiency of implementing a demand responsive transport (DRT) system. The first of these sources was the study by Alonso-González, Liu, Cats, Van Oort, and Hoogendoorn (2018) which addresses the DRT system in the Netherlands. This was implemented in order to increase mobility and provide a more flexible alternative to other modes of transport. It was found that as a whole, it increased the mobility of users along with significantly decreasing the travel time. Ryley, Stanley, Enoch, Zanni, and Quddus

(2014) also found that DRT can be a suitable alternative for PT. However, both studies refer to issues such as funding and subsidies as prohibiting factors to implement a DRT system.

Another study which related to the research question was by Stenzel et al. (2016) who assessed the accessibility of medical care facilities, focussing specifically on the elderly. Stenzel et al. (2016) is relevant to our research due to the closure of doctor's clinics and pharmacies in the ICE following the earthquake series. Stenzel et al. (2016) was conducted by using GIS programmes to show how some areas have little to no connection to medical services by public transport, which is something that could be addressed in this study. Higgs, Zahnow, Corcoran, Langford and Fry (2017) also found similar results where accessibility to medical services from low socioeconomic areas by PT is lacking and could be improved upon.

Methods

Surveys

In order to answer the research question, surveys were developed to measure the usage of public transport in the ICE and how satisfied patrons were with access to various services. Both qualitative and quantitative data was gathered. All surveys were created and hosted on Qualtrics Survey Software. Each survey gathered age, whether the respondent lives in the ICE area, and frequency of bus usage, as well as a space for any potential comments.

The study comprised of three surveys. Survey one was distributed at bus stops in the ICE. It included questions inquiring what service the respondent was accessing by bus, for example, shopping, medical services, or work. Secondly, it was inquired how often the subject used the bus system in a week. Finally, the respondents were asked for any issues they had surrounding both the quality of the bus stop and buses themselves. Several bus stops were targeted, with groups going out in two to four hour shifts between 7 am and 6 pm. *Fig. 2* shows what bus stops were used for surveys. All three bus routes servicing the area was covered; Orange, Yellow, and 60. Survey one was designed to be quickly completed to give people enough time to comfortably complete the survey and catch their bus.

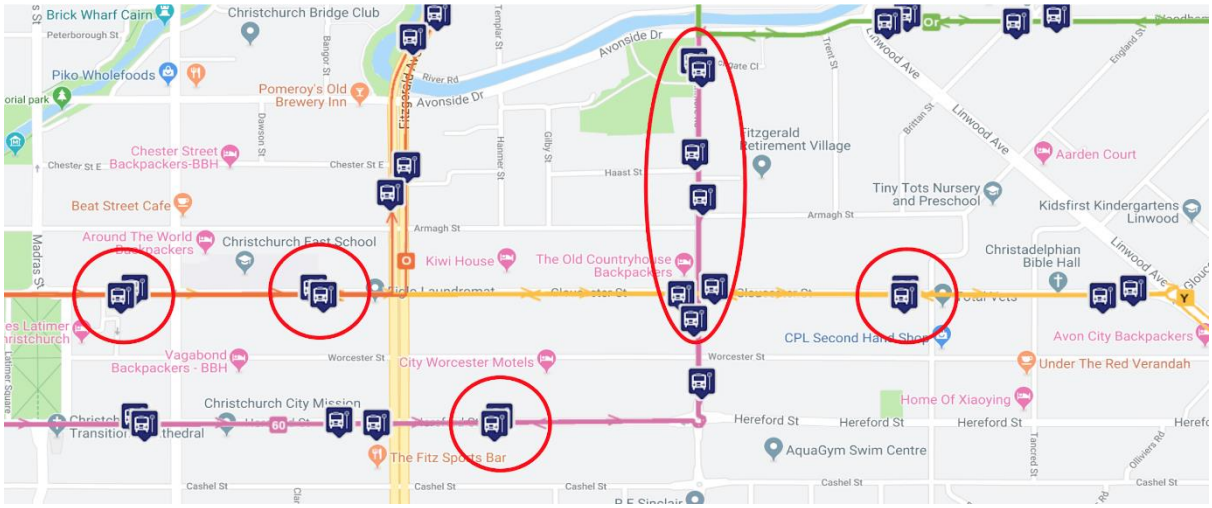


Figure 2: Map of Bus Stops where Surveying was completed

Survey two was conducted at various community gatherings such as the gold coin lunch hosted by Te Whare Roimata, and the Tiny Shops on Stanmore Road. This survey was slightly longer and aimed to

spark conversation and build a more casual, conversational atmosphere than survey one. The aim was to build rapport and create a space where people felt comfortable and had enough time to discuss their feelings and opinions of the PT system. This survey inquired the subject's age group and potential issues they may have with the current bus system. The survey continues by questioning how satisfied respondents were with access to key services, from 'extremely satisfied' to 'extremely dissatisfied'.

Finally, survey three was distributed via flyer into approximately 2000 homes in the ICE. This survey contained a link to 'netresultz.co.nz' which, when typed into a browser, redirected to the online survey (F*ig. 3).* This final survey outlined potential solutions elucidated from previous survey data - including lowering fares, more frequent buses, and better bus shelter quality. Respondents were asked to rank their support or opposition of the potential solutions for the ICE area using a matrix table, from 'strongly support' to 'strongly oppose'.

Figure 3: The Flyer Distributed in ICE

Interviews

In order to complement public opinion, professional opinion was sought from ECan and Christchurch City Council's (CCC) transport sectors. The first interviewee was Darren Fidler of the CCC, the Strategic Transport Advisor. The second was Len Fleete of ECan, a Senior Strategy Advisor for Public Transport. The interviews were designed to gain an understanding of the logistical methods behind PT functioning, upkeep, and changes.

Geographic Information System Analysis

ArcMap's network analysis function was utilised to create a service area for all bus stops that service the ICE area. A shapefile containing all of Christchurch's bus stops was imported and cleaned to remove unnecessary stops. A secondary shapefile of Christchurch roads was imported, and bus stops were 'clipped' to the transport network. Polygons were created at 200m intervals up to 1000m on the transport network surrounding the bus stops. The final output was put into an image processing script to find the proportion of the area that was within each interval.

Results

Part One: Surveys 1 and 2

Access to Bus Stops

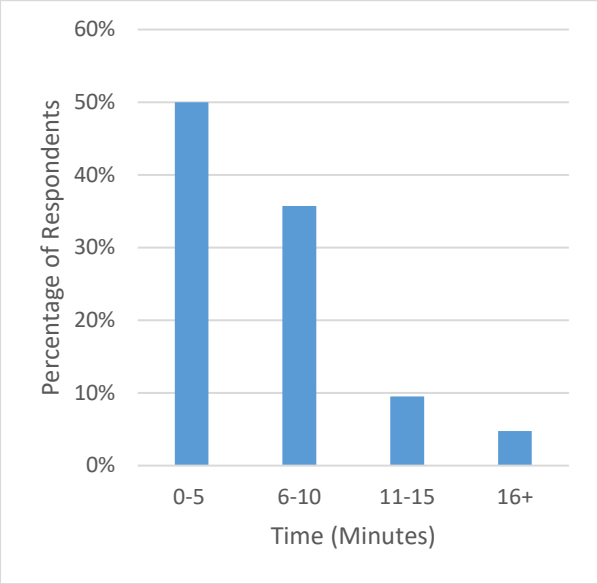


Figure 4: Time Taken For Bus Users to Walk to Their Bus Stop (Survey 1)

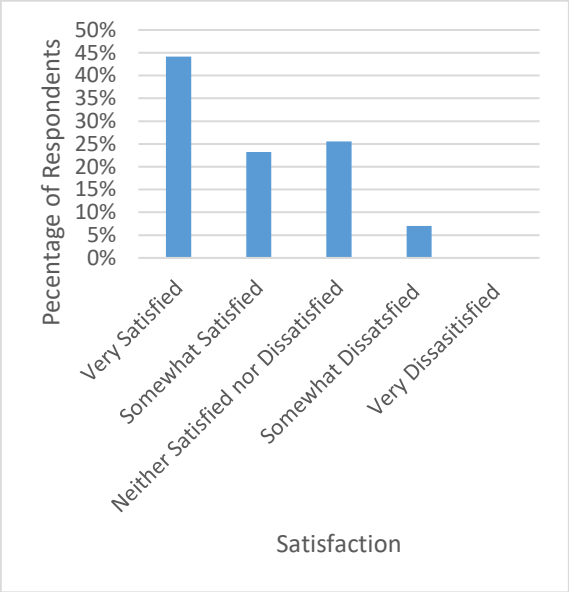


Figure 5: Level of Satisfaction of Bus Users with their Walk Time to their Bus Stop (Survey 1)

Table 1: Two-Way table of Time Taken to Walk to Bus Stop and Satisfaction with Walk Time to Bus Stop (Survey 1)

	Satisfaction					
Time Taken (minutes)	**Very Satisfied**	**Somewhat Satisfied**	**Neither Satisfied nor Dissatisfied**	**Somewhat Dissatisfied**	**Very Dissatisfied**	***Total***
0-5	31%	7%	7%	2%	0%	48%
6-10	12%	12%	10%	5%	0%	38%
11-15	2%	2%	5%	0%	0%	10%
16+	0%	0%	2%	2%	0%	5%
Total	45%	21%	24%	10%	0%	100%

Figure 6: Service Areas of Bus Stops within and Surrounding the ICE

Fig. 4 displays the time it took respondents to walk to their bus stop by their measure. The most common time category was 0-5 minutes, at 48%, lowering to 36% taking between 6 and 10 minutes. Only 15% of respondents took longer than 10 minutes. *Fig. 5* displays the level of satisfaction respondents had with their walk-time. 67% of respondents were satisfied with their walk-time, compared to 7% being dissatisfied. The remaining 26% were neither satisfied nor dissatisfied. Table 1 displaying walk-time and satisfaction. A chi-squared test was conducted at $\alpha=0.01$ to investigate whether there was a relationship between walk-time and satisfaction. The test returned a p-value of $0.21 > 0.01 = \alpha$. Therefore, the null hypothesis cannot be rejected, concluding that satisfaction is not related to walking time.

Access to Services

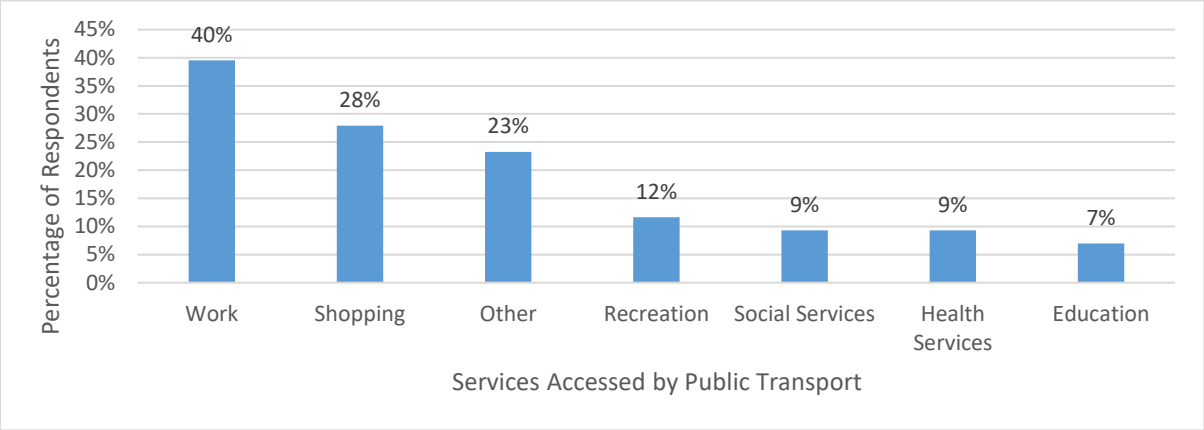


Figure 7: The Destination of Bus Users (Survey 1)

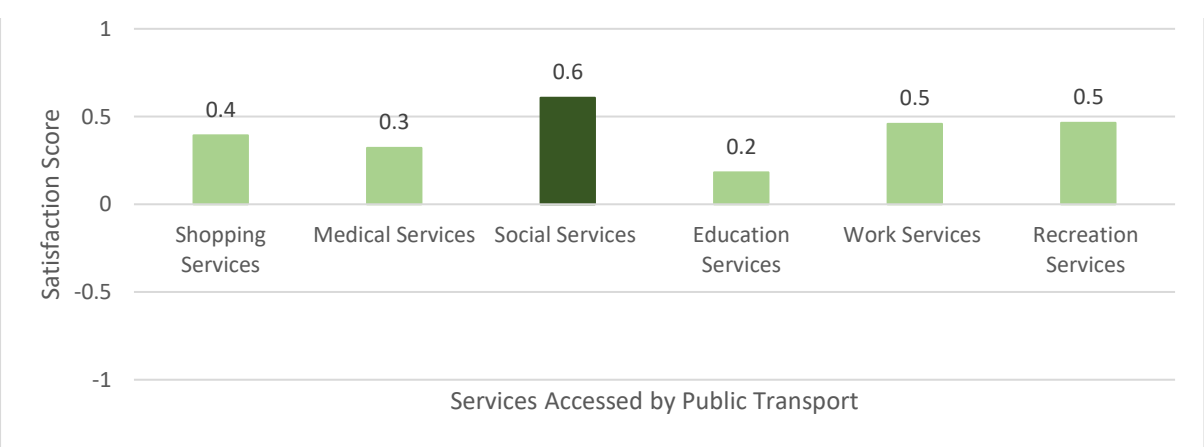


Figure 8: Satisfaction Scores of Accessibility to Key Services (Survey 2). 1 Indicates extreme satisfaction, -1 indicates extreme dissatisfaction.

Fig. 7 shows that 40% of people using the bus service were travelling to work. 28% were travelling to shopping facilities. The remaining were travelling to recreational activities, social services, health centres, education or other. Note that the total is over 100% as respondents could be heading to more than one destination. *Fig. 8* displays satisfaction levels for the level of access that bus services provide to key destination categories. It shows that generally, bus-users are satisfied with their access overall. Social services are most accessible services, with education being the least accessible. However, *Fig. 7* shows education being the least demanded facilities to access.

Bus Stop Conditions

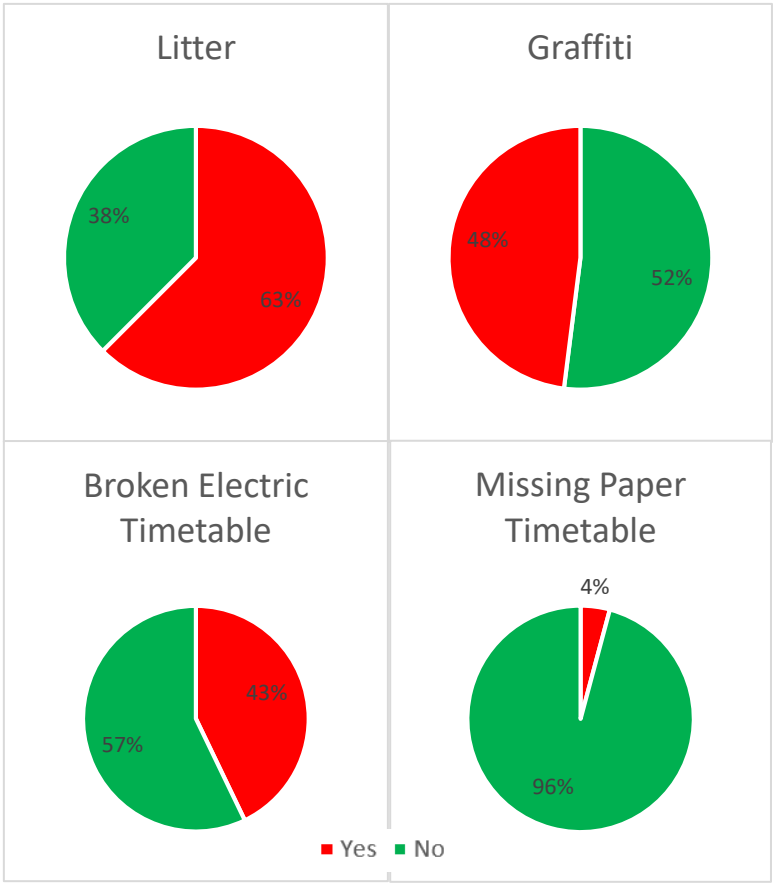


Figure 9: Conditions of Bus Stops in the ICE

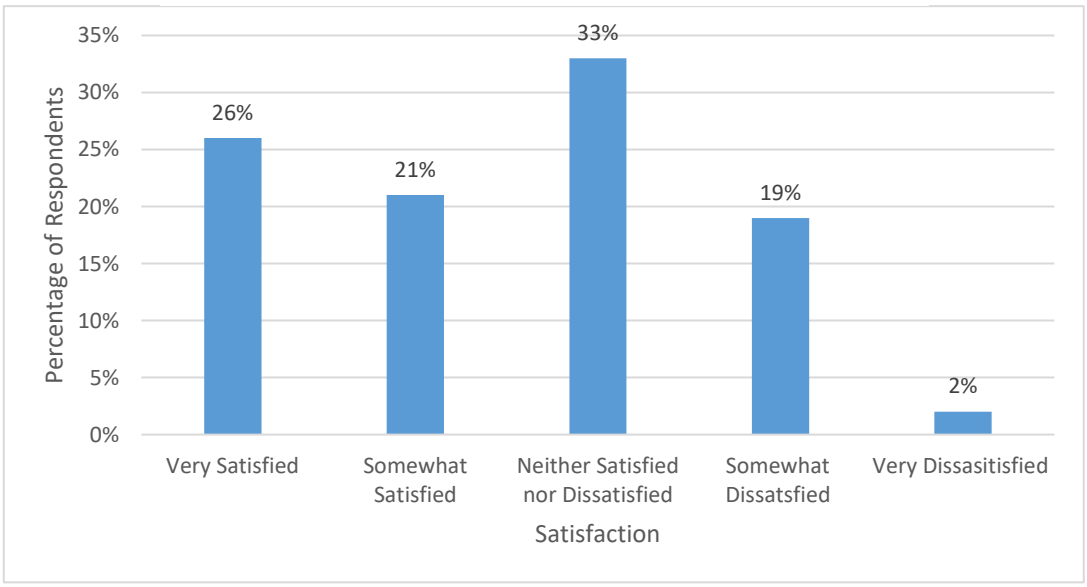


Figure 10: Level of Satisfaction of Bus Users with the condition of their bus stop (Survey 1)

Fig. 10 displays how satisfied respondents were with the conditions of their bus stop. 47% of respondents were satisfied, 21% were dissatisfied, and 33% were neither satisfied nor dissatisfied.

Bus Scheduling/Frequency

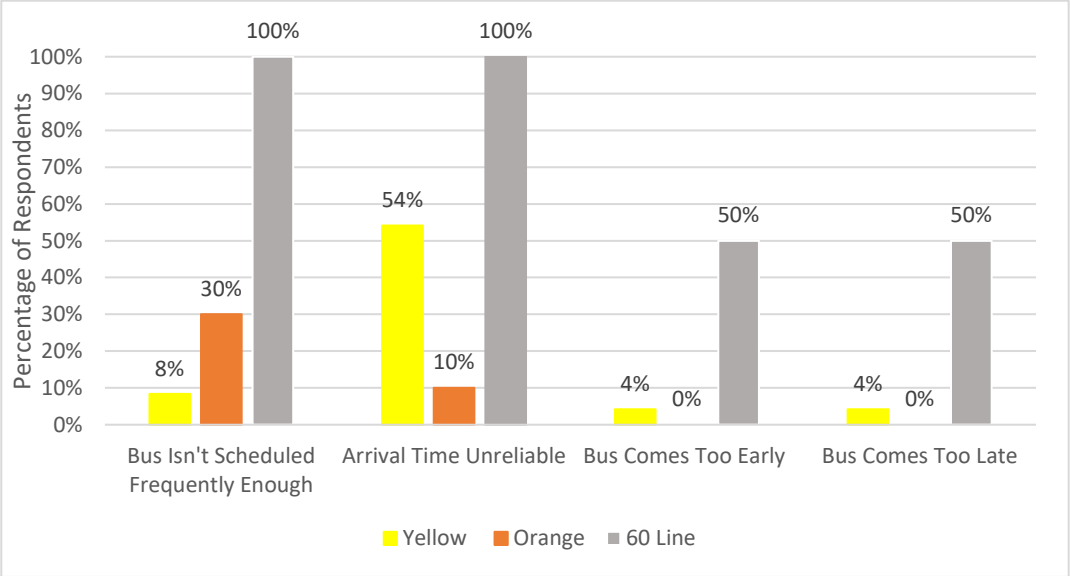
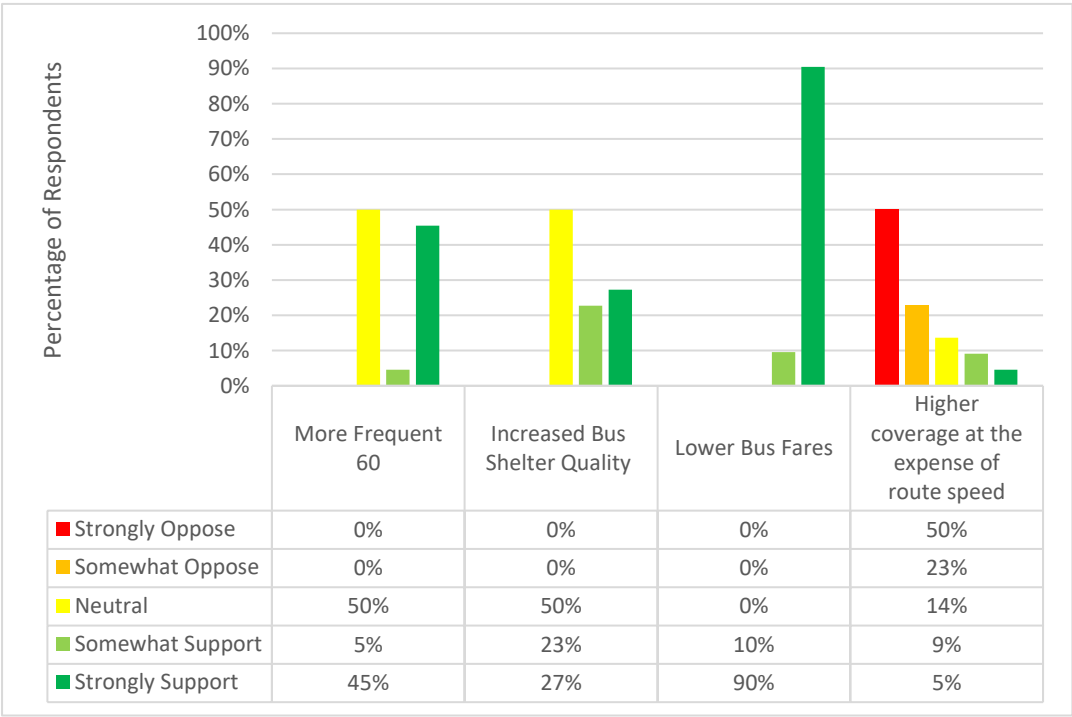


Figure 11: Opinion of bus reliability

Fig. 11 displays how respondents feel about their bus reliability for the bus they were catching. It is clear that the 60 Line is seen as the most unreliable bus, with 100% of respondents claiming the bus is not scheduled enough and has an unreliable arrival time, a proportion significantly above that of the Yellow and Orange lines. The Orange Line is seen as the most reliable bus, with only 10% of respondents claiming the bus is unreliable, and no respondents claiming it comes too early or late.

Part Two: Survey Three



	More Frequent 60	Increased Bus Shelter Quality	Lower Bus Fares	Higher coverage at the expense of route speed
Strongly Oppose	0%	0%	0%	50%
Somewhat Oppose	0%	0%	0%	23%
Neutral	50%	50%	0%	14%
Somewhat Support	5%	23%	10%	9%
Strongly Support	45%	27%	90%	5%

Figure 12: Responses to suggestions made to improve the public transport service

Fig. 12 shows responses when asked to rate potential public transport solutions drafted in response to surveys one and two. Out of the four solutions, lower bus fares was the most supported solution, strongly supported by 90% of respondents, and somewhat supported by 10% of respondents. More frequent 60 route and increased bus shelter quality were both supported by 50% of respondents, with 50% indifferent. The higher coverage solution was opposed by 73% of respondents.

Part Three: Other Comments

Respondents were allowed room to make additional comments at the end of all surveys. Out of 79 total responses overall, 25 additional comments were given and categorised as follows.

Table 2: Extra comments regarding bus service satisfaction

Comment	Quantity
The bus stop conditions need improvement	5
The bus is too slow, unreliable or infrequent	5
The bus drivers are rude	4
The bus service is good	4
The bus service is too expensive	4
The bus conditions need improvement	2
Other	1

Part Four: Interviews

The results of the conducted interviews with members of the CCC and ECan gave a detailed outlook of the public transport system and how it runs in Christchurch. This began to give a perspective on the importance of fare recovery to make up for subsidised transport. The patronage versus coverage issue was also explained; there has to be a line between access for no-one and convenience for everyone and vice versa. Issues surrounding both footpath and bus stop quality were both addressed and are being looked at, to increase accessibility for the transport disadvantaged.

Discussion

Public Transport Issues and Solutions

Access to Bus Stops

This study found that the needs of ICE residents to access a bus stop in a reasonable amount of time is being met above satisfactorily. Environment Canterbury (2018) stated their goals for Christchurch is that most people should be within 10 minutes walking time of a bus stop. This study found that nearly all ICE residents live within 400m of a bus stop. At an average walking speed of 1.24m/s (Schimpl et al., 2011), most residents should be able to access a bus stop within 5.4 minutes. Elderly, with an assumed average speed of 1.21m/s (Schimpl et al., 2011), should be able to access a bus stop within 5.5 minutes. This study found that 15% of respondents claimed their walk-time was above 11 minutes. This could be due to misreported self-measured walking time. Studies have found that there is often conflict between self-reported and objectively measured time spent engaged in activity (Dyrstad, Hansen, Holme, & Anderssen, 2015; Lagersted-Olsen et al, 2014). Therefore, self-measured walking time may be unreliable. Further research may involve tracking the time it takes users to walk to their stops.

Increased distribution of bus stops would lower average walking time to bus stops. However, it would likely also add to unnecessary bus stopping, increased waiting time and bus unreliability lowering the performance of the bus stop system overall (Huang & Liu, 2014). Given that the majority of ICE residents are satisfied with their walk time, but dissatisfied with the reliability of the bus systems, this study does not recommend the addition of extra bus stops within the ICE. Further research may include extensive GIS analysis using population density data to identify the ideal bus stop positions.

Access to Services

A key concern of this research was how well the Christchurch public transport system met demand; was it getting people where they wanted to go? This study found that satisfaction levels with access to key services were high. Access to shopping, medical, work and recreation services were somewhat satisfactory; access to social services were very satisfactory. However, this data is limited by the lack of response of two transport-disadvantaged groups; elderly and youth. For ethical reasons, surveying bus-users under 17 was logistically challenging. Attempts were made to contact a school in the area with no response. This is problematic as youth utilise public transport the most of any age group in New Zealand; between 8-10% (Ministry of Transport, 2015). Elderly - age 75+ - use public transport at a lower rate of 4% (Ministry of Transport, 2015). However, those who do use public transport are heavily reliant on public transport for access to health, welfare and shopping services (Environment Canterbury, 2018). This study attempted to consider the elderly demographics use and opinion of public transport, however, attempts to contact two retirement homes in the area were not replied to.

Further research may consider a focus solely on the elderly and youth. Such a study could examine the effectiveness of public transport alongside alternative transport options such as ECan's 'Total Mobility' transport scheme.

Bus Stop Conditions

This study has identified bus stop conditions as an issue requiring attention. In this regard, litter, graffiti and broken electric timetables were recognised. In comparison to other satisfaction measures conducted by this study, satisfaction with bus stops conditions was low. Further, 50% of respondents supported increasing bus stop quality. The majority of survey answers regarding bus stop conditions came from the highest quality bus stops in the area, often containing shelters, benches and electronic timetables. Therefore, it is likely that further surveying at lesser quality bus stops would yield results showing lower satisfaction with bus stop conditions.

Environment Canterbury (2018) identified providing accurate real-time customer information at high-usage stops as a policy concern as '*accurate, accessible, timely and easily understood information is critical to the public transport experience, and therefore the success of the system*' (Environment Canterbury, 2018, p.50). In line with these values, this study recommends that ECan works with the Christchurch City Council in order to repair and maintain the 43% of broken electronic timetables in the ICE in a timely manner.

Graffiti has been identified as an issue of bus stop quality in the ICE. LaGrange, Ferraro & Supancic (1992) found that the presence of graffiti increases the perceived risk of fear for safety. Safety concerns are likely to hinder the usage of public transport, therefore lowering patronage and the effectiveness of public transport. Consequently, it is recommended that the Christchurch City Council increases their efforts to combat graffiti in the area. This could be through the existing

graffiti program 'Off the Wall' or through increased efforts working with the nearby probation centre in Waltham.

Bus Scheduling, Frequency and Reliability

This study has identified two areas of frequency and reliability requiring improvement; the frequency of the 60 route, and the reliability of the 60 and Yellow Route, particularly the 60. A significant 100% of respondents catching the 60 reported dissatisfaction with both frequency and reliability. Studies have shown that inconsistent bus travel times have a more significant negative impact than long travel times (Carrion & Levinson, 2012). Policy 2.1 of Environment Canterbury's Regional Public Transport Plan claims that they will provide *'high standards of service reliability and punctuality'* as this is '*the most important aspect of providing an attractive system that meets the need of the customer'* (Environment Canterbury, 2018, p.49). To align with these values and meet the needs of ICE residents, the reliability issues of the 60 and Yellow services should be addressed and repaired. This could be done by measuring the actual transit time of these lines and modifying the timetables to reflect this.

Further improvements to bus schedules in the ICE could involve increasing the frequency of the 60 line. This study has identified this particular issue as one of which ICE residents strongly need. Currently, the 60 runs every 30 minutes for most of the day, increasing to every 10 or 15 minutes during peak morning and afternoon times. Residents of the ICE want the 60 to run more often, a sentiment shared by an interviewed Strategy Advisor Land Transport at ECan. Further, Environment Canterbury (2018) have identified the 60 as one they will increase to a 15-minute, all day timetable. However, no timeline for this change has been given before 2028. This study recommends this change be made as soon as possible.

Bus Fares

Fig. 12 ICE residents very strongly support lower bus fares. ECan's fare model theoretically operates on a zone-based structure. *Fig. 13* displays the zone borders. Christchurch City is within Zone 1 with nearby satellite towns such as Kaiapoi and Rolleston in Zone 2. Travelling between zones is more expensive than within them. Due to the distance between zones, it is best to understand Christchurch's fare structure as a flat fee

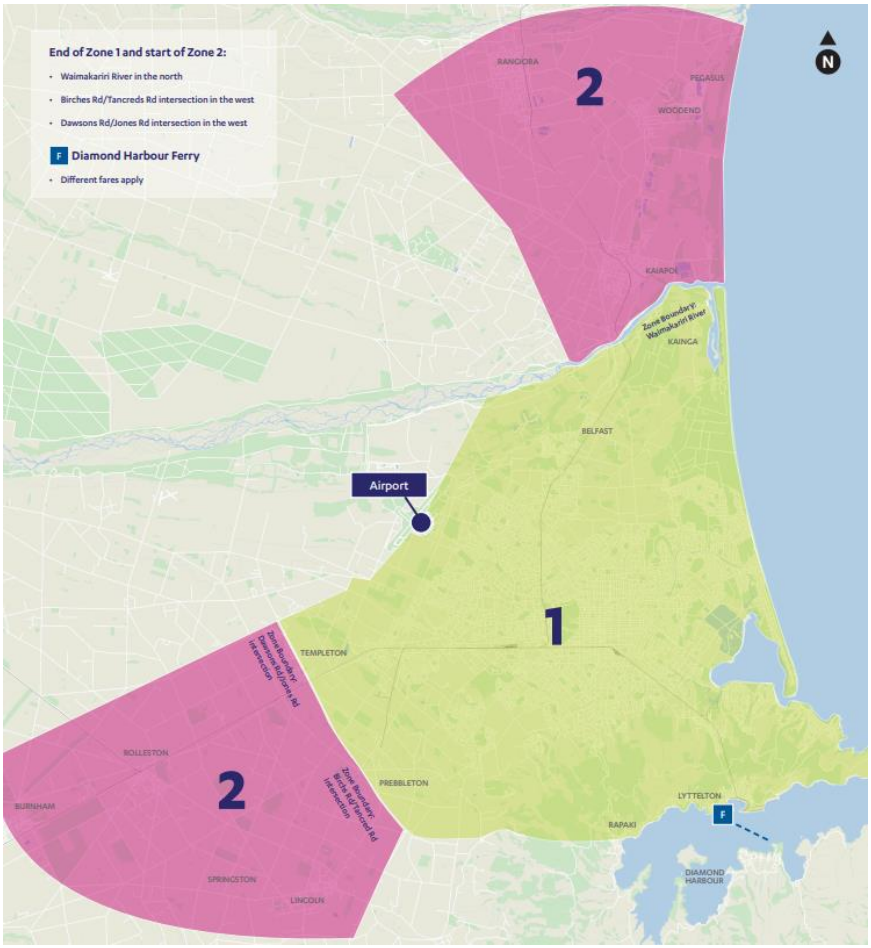


Figure 13: Greater Christchurch Bus Zones (Metro, 2019)

structure, as there is a set fee to travel on the bus within Christchurch. For an ICE resident, a 4km return trip into the City Centre costs the same as a 27km return trip to Prebbleton. Flat fare systems have been criticised as unfair as they incentivise long journeys at the expense of short trip users (Brown, 2018; Bandegani & Akbarzadeh, 2016). Therefore, this study recommends ECan conduct a feasibility study on transitioning to a graduated distance-based system. Such a system would charge users based on each unit of length travelled. Additional equipment would need to be installed in busses to allow users to scan on and off, however, with the impending rehaul of the Christchurch bus fleet the initial cost of these machines could be outweighed by more equitable fares. Alternative solutions may include the implementation of a proper zonal system, or procuring increased funds from central or local government to lower the fares overall.

Limitations

This research has encountered some limitations which have ultimately impacted the quality of our research. The first limitation involved health and safety measures taken to prevent risk of harm to the researchers. One such measure took place on a Saturday afternoon, where surveying was taking place at a bus stop. An encounter with an intoxicated man from the area resulted in the group members removing themselves from the situation twice, and finally abandoning the surveying for the day. This limited the quality of our study by lowering the number of potential responses collected, particularly for that time and day of the week. Ultimately, this may have further impacted research as it was decided that no surveying would occur after 6 pm for safety reasons.

A further limitation was the short time frame for research. Due to the nature of data collection, it was challenging to capture representative data in the allocated period. In order to gather representative data, surveying time had to be spent at low-traffic bus stops with few respondents. This resulted in more representative data, but fewer respondents

Another limitation was the inability to survey users under 18 years of age without parental consent. This created a gap in the results and should be considered when drawing conclusions from the data and to make recommendations.

A further limitation that was encountered was the inability to use recent data from the 2018 Census. Without specific data on suburbs and a delayed released, group members used data 2013 Census which obviously would hold information on very a different Christchurch.

Future Research

This study has created the bedrock of data, opinions, usage, locations and ideas about how the residents of the ICE see public transport. Talking with members of both Regional and City council, and with users of the system in the community, has always been seen as a critical step in understanding ideas, improvements, satisfaction and dissatisfactions within the system, and should not be neglected when future research is taking place. Due to the broad nature of this research, and the amount of factors requiring considering limited the depth of which each factor could be investigated. Future research could focus on specific factors, such as bus fare reform.

An issue not covered specifically by this research but of concern are the attitudes of some bus drivers towards the users in the ICE. Whether it’s being rude, agitated or not pulling in far enough to the curb, many residents claimed in conversation with the researchers that bus driver attitude was poor. Future research could consider the extent of this issue.

Another important aspect for future research is understanding the views of future residents in the area. This is crucial as it helps to see if the system has been reviewed or if similar issues still exist within the system, for instance, distances to bus stops, travel times to services and quality of the bus service and shelters. Comparing the data from this research to a project in five years-time might show very different results, and therefore future research should be encouraged to collect data more current to the project.

Conclusions

This study has investigated five areas of potential issues regarding PT not meeting user demand in the ICE, namely bus stop conditions, bus scheduling and reliability, bus fares, access to bus stops and access to key services. Social surveying, interviewing and GIS analysis was conducted to investigate these issues. Analysing this data, three recommendations have been made to better meet the demands of current and future residents, whilst remaining realistic. Firstly, ECan and CCC should work with community partners to repair electric timetables, clean graffiti and litter, and upkeep bus stops. Secondly, the 60-line should be increased to a 15-minute timetable, and its unreliability issues should be addressed. Lastly, ECan should investigate alternative fare charging methods to increase financial equity and incentivise short bus trips over car use. Future studies may view our research as a stepping stone to further expand upon the improvement of the PT system within the ICE and Christchurch.

Acknowledgements

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