# Assessing operation and customer perception characteristics of high frequency local and limited-stop bus service in Vancouver, Canada

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**ABSTRACT**

Public transport agencies implement different strategies aimed at improving transit service operation and to improve satisfaction among its riders. One service strategy employed by transit agencies is the introduction of a limited-stop bus service that runs parallel to a heavily used route to decrease travel times for existing riders and to reduce pressure from the local route. Using bus operations data obtained from automatic vehicle location (AVL) and automatic passenger counter (APC) systems and customer satisfaction data collected in Vancouver, Canada, the present study evaluates levels of satisfaction among users of the local and limited-stop bus service while controlling for the service characteristics these users have experienced in the past seven days. Our results reveal that despite greater variation in on-time performance experienced by users of the limited-stop service, these users were more likely to be satisfied with the transit service compared to users of the regular service. Results of this study demonstrate that the main operational characteristics of a limited-stop service, including in-vehicle time savings and higher route frequency, which is reflected in lower waiting time, are highly valued by its users, while reliability is not an issue along high frequency routes compared to other aspects for users. This study provides transit planners and policy makers with a better understanding of how customers perceive local and limited-stop service, which was attained through the linking of operations and customer satisfaction data.

**Keywords:** Bus service, limited-stop bus service, AVL/APC, customer satisfaction

## INTRODUCTION

The success of a public transport agency largely depends on the number of satisfied passengers using the system and who will continue to use it in the future. Operational improvements, namely reductions in travel time and advances in service reliability, increase the operational efficiency for a public transport provider (*1*), while these improvements may also increase riders' satisfaction (*2; 3*) and result in the growth of patronage (*4; 5*), which is also another measure of success for a public transport provider. One of the most effective strategies to reduce the running time of a bus route, is the implementation of a limited-stop bus service along public transit corridors with high passenger demand.

Limited-stop bus or express service is a special service that only stops at a small number of stops along a bus route where high passenger activity is present (*6*), while usually a parallel route serves all stops along the same corridor. While limited-stop service provides passengers with lower travel times, network design must be carefully considered, to ease passenger transfers (*7*). Spacing of stops along a limited-stop bus service should be several times greater than a local service (*8*) and located at high passenger activity stops and transfer points to maximize the benefits from this kind of service. Whilst there appears to be little in the way of standards for the implementation of a limited-stop bus service, Ercolano (*9)* stated that time savings of a limited-stop route must be at least 5 minutes, in order for users to perceive the operational improvements.

The goal of this study is to predict overall satisfaction levels of users of two concurrent bus routes, a local and limited-stop bus service, while controlling for operational characteristics of the service these users experienced. Using operations data obtained from automatic vehicle location (AVL) and automatic passenger counter (APC) systems and customer satisfaction data collected for the local and limited-stop bus routes in Vancouver, Canada, logistic regression modeling is employed to understand service characteristics influencing overall satisfaction levels of local and limited-stop route users. Results of this article provide further insight on how customers perceive the quality of limited-stop bus service and contribute to the limited evidence in the literature regarding how operational data can be used to better understand how customers perceive transit service.

This study commences with a review of relevant literature on customer satisfaction and operational benefits of limited-stop and local bus service, which is followed by a description of the study context. The next section provides a detailed description of the operations data used in this study and an analysis of on-time performance of both bus routes. Next, we present the satisfaction data used in this study and model results of overall satisfaction levels with bus operations data. Finally, the results are discussed and conclusions from this paper are drawn.

## LITERATURE REVIEW

The implementation of a limited-stop bus service and the various benefits resulting from this operational strategy have been studied from many different approaches. Broadly, the literature can be categorized into studies that evaluated the operational benefits of this new service strategy (*6; 10; 11*), how customers perceived the new service (*12*), as well as studies evaluating best practices for the design of such routes (*13-15*) and others recommending planning approaches for designing the service (*6*).

El-Geneidy and Surprenant-Legault (*16)* observed bus run time savings of a newly implemented limited-stop bus service in Montreal, and found a decrease in the running time of 13% during peak hours. Similarly, running time savings of 10.8% were observed by Diab and El-Geneidy (*10)* while evaluating changes in run time along the same route in Montreal after a combination of operational service strategies. Declines in running time between 10.8 and 13% can lead to substantial savings in operations. Both studies were conducted on an express bus route service which operates parallel to a local bus service. In terms of the local bus service, time savings are also expected on this route because a proportion of the passenger activity of this route will shift to the new limited-stop service (*6*).

Many studies have evaluated the perceptions of customers in parallel with the operational benefits associated with limited-stop bus route service. Conlon et al. (*12)* studied the implementation of a new limited-stop route in Chicago, and found significant increases in satisfaction among the users of the new service. Furthermore, the authors reported that this new service attracted new riders to the route, increased the share of infrequent riders along the route, and drew riders from other bus routes. Following the implementation of a new limited-stop line in Montreal, El-Geneidy and Surprenant-Legault (*16)* surveyed users on their perception of travel time savings, and observed that among users that reported switching to the limited-stop bus service, 72% of riders reported a decrease in their travel time and users actually overestimated their travel time savings. A similar result was observed by Diab and El-Geneidy (*10)*, who quantified users' perceived travel time savings after of a combination of strategies including a limited-stop bus service during three waves in three different years. They found that users still overestimated their travel time savings even after the implementation by several years. Accordingly, passengers have a positive attitude towards service improvements, and generally overestimate travel time savings compared to reality, which was also observed by El-Geneidy et al. (*17)* after determining that users overestimated the time savings associated with an all-door boarding pilot project. Reasons for the overestimation of the benefits associated with a newly implemented service strategy such as limited-stop service remain unclear, and how these perceptions change over time is unknown (*1*).

Archived data collected through AVL and APC systems provide transit agencies with a rich and extensive database that can be analyzed in transit research for planning and operational improvements (*18; 19*). However, the use of operations data in combination with perception variables to understand what influences users' satisfaction levels has been rarely demonstrated in the literature, with the recent exception by van Lierop and El-Geneidy (*20)*. Accordingly, this study aims to expand our knowledge of the link between satisfaction and operations data, by helping us to contextualize the service experienced by local and limited-stop bus route users for a better understanding of satisfaction levels among these users. Also, while previous research was designed to evaluate customers' perceptions of a newly implemented limited-stop service (*10; 11*), the objective of this study is to ascertain the satisfaction levels among limited-stop bus route users by studying a mature service that has been running parallel to a local route in Vancouver for several years at a high level of frequency.

## STUDY CONTEXT

The location of this study is Vancouver, which is the third-largest metropolitan area in Canada; in 2016 the Metro Vancouver area had a population of approximately 2.5 million people. The two bus routes studied, route 99 B-Line and route 9, are operated by Translink, which is the regional transportation authority in the Metro Vancouver area. The two bus routes serve a major east-west arterial in Vancouver, Broadway, which provides connections to and from several of Vancouver's busiest hubs. Furthermore, these routes connect to the rapid transit lines in Vancouver as displayed in Figure 1.

The main operational differences between these routes are that route 99 is a limited-stop service, the route exclusively operates low-floor articulated buses, and the alignments of the two routes differ slightly at the eastern and western ends. The western terminus of route 99 is located at the University of British Columbia (UBC), whereas route 9 ends around 4 km prior to UBC, whilst it provides occasional service to the university (between September and April). From the eastern side, route 9 commences around 3 km at Boundary Loop, then it is joined by the 99 at Commercial Drive to run in parallel along Broadway street till it intersects with Alma street in the west where route 9 usually ends. The alignments of both routes are displayed in Figure 1. The 99 B-Line has an average one-way route length of 13.9 km, and on average the travel time is 40 minutes. Route 99 has average daily boardings of 55,000 passengers, making it the busiest bus route in the Translink bus network (*21*). During peak hours, customers using the 99 bus service experience a headway of 3.5 minutes or less between buses. The average one-way length of route 9 is 10.4 km, and has an average trip duration of 63 minutes. During peak hours, the headway of route 9 decreases to 5 minutes. In 2015, the average weekday daily boardings on route 9 was 22,950 riders, making route 9 the fourth busy route in the network.

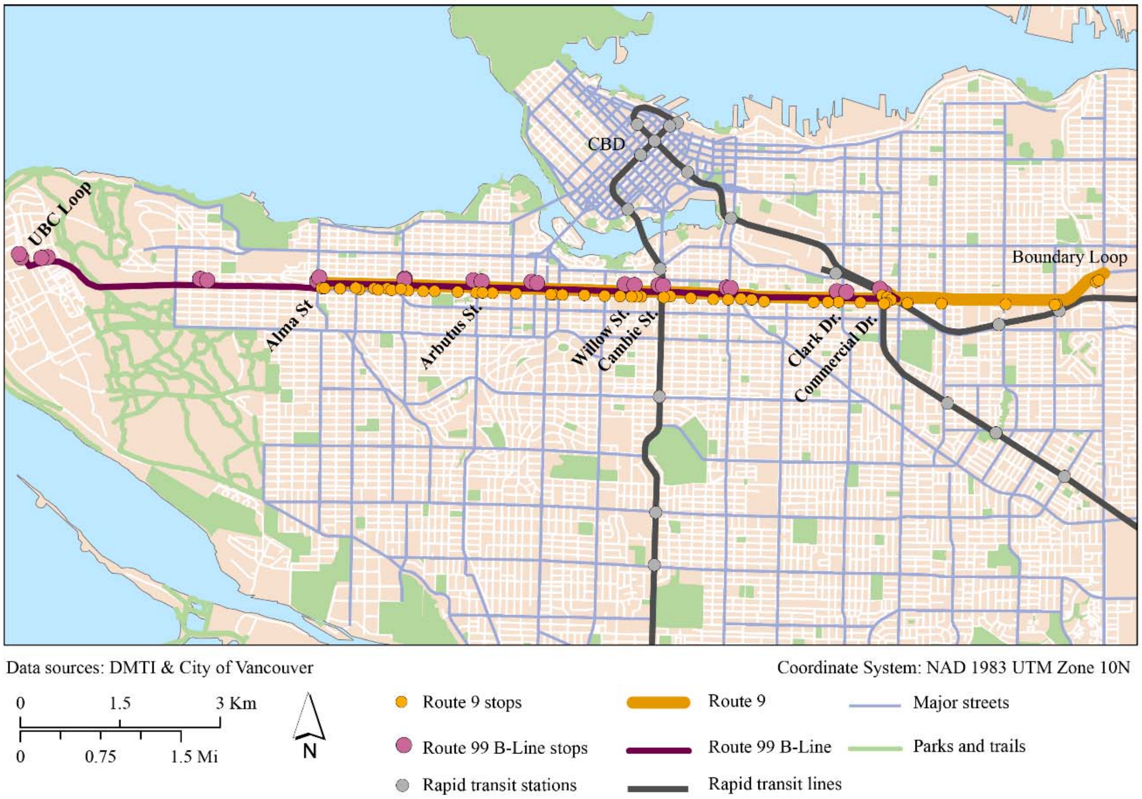


**FIGURE 1 Context map for routes 99 B-Line and 9 in Vancouver, Canada.**

Two sources of data were obtained from Translink, the first was AVL/APC operations data for both routes, and the second was customer satisfaction survey data. In our analysis we use only data collected between January 1, 2011 and December 31, 2013 from both sources. Focusing first solely on the operations data, we evaluated the on-time performance of routes 99 and 9. This is followed by an analysis of customer perceptions of service quality of both routes, using Translink's customer satisfaction surveys, while considering the actual service these customers experienced.

## ANALYSIS OF OPERATIONS

The AVL/APC was provided at the stop-level and it included scheduled and actual trip start time, stop arrival and departure times, whether or not the wheelchair ramp or bicycle rack was used, the number of boardings and alightings (averaged across all doors), and the passenger load at arrival and departure.

Since time savings associated with limited-stop service are evident in the literature, in this study we focus on the on-time performance of this operational strategy. For our on-time performance model, the dependent variable was the average schedule adherence of stop departure times across each trip. Schedule adherence was calculated as the absolute difference between the scheduled stop departure time and actual departure time to capture average on-time performance across the trip.

The key independent variable in this model is route 99, a dummy variable that will distinguish between a trip on route 99 and route 9. This variable will capture any differences in average on-time performance between the local and limited-stop service, where a positive value will indicate that the limited-stop service (route 99) incurs more delays along the route.

Other variables we collected and tested in our model include the average and standard deviation of the load, passenger activity (the sum of alightings and boardings along each trip), the proportion of stops where a user either used the bicycle rack or the wheelchair ramp, and a measure of crowding. The measure of crowding used in this study was the proportion of stops along a trip that had a leave load that exceeded the standing capacity of the bus; over 85 people on route 99 and over 55 people on route 9. Additional characteristics were controlled for in our model, including whether the trip occurred during a peak hour (5 – 9:30AM, 3-6:30PM), and the direction of the trip. Table 2 presents summary statistics for variables used in our final on-time performance model.

**TABLE 1 Descriptive Statistics of Variables Used in On-time Performance Model**

| Variable Name | Description | Mean | SD |
|---|---|---|---|
| **On-time performance** | Average deviation from scheduled stop departure time (s). | 139.47 | 100.43 |
| **route 99** | Dummy variable equal to 1 if the trip occurred on route 99. | 0.43 | 0.50 |
| **Eastbound trip** | A dummy variable equal to 1 if the stop occurs on an eastbound trip. | 0.48 | 0.50 |
| **Passenger Activity** | The average number of passenger boardings and alightings at all doors at stops during a trip. | 181.56 | 101.49 |
| **Peak hour trip** | Dummy variable equal to 1 if the trip occurred during a peak hour (5 – 9:30AM, 3-6:30PM). | 0.48 | 0.50 |
| **Average leave load** | The average number of passengers on a bus at the departure of a stop along a trip. | 22.91 | 16.21 |
| **Percent of crowded stops** | Proportion of stops along a trip that departed a stop exceeding the capacity of the bus. | 0.02 | 0.09 |
| **Percent of crowded stops squared** | The square of the proportion of stops along a trip that departed a stop exceeding the capacity of the bus. | 87.80 | 480.25 |
| **Wheelchair ramp use** | A dummy variable equal to 1 if the wheelchair ramp was activated during a trip. | 0.18 | 0.38 |

Linear regression was used to model on-time performance of each trip, with a series of independent variables that were found to capture the variation in stop-level on-time performance. We removed trips that occurred on the weekend and holidays, and incomplete trips as well as trips that occurred between December 24 and December 31 of each year, as a result of irregularity of travel patterns during this week. A total of 95,197 trips were included in our final model, 53,876 trips from route 9 and 41,321 trips from route 99. The variables in our final model explain approximately 13 percent of variation in on-time performance. Table 2 presents the estimates and 95% confidence intervals for the on-time performance model.

**TABLE 2 On-time performance model**

| | Estimate | t-value | 95% Confidence interval | |
|---|---|---|---|---|
| **Constant** | 85.56*** | 107.27 | 84.00 | 87.13 |
| **Route 99** | 44.27*** | 50.08 | 42.54 | 46.00 |
| **Eastbound trip** | 3.35*** | 5.49 | 2.16 | 4.55 |
| **Passenger activity** | 0.25*** | 42.39 | 0.24 | 0.27 |
| **Peak hour trip** | -8.57*** | -13.77 | -9.79 | -7.35 |
| **Average leave load** | -0.54*** | -10.78 | -0.63 | -0.44 |
| **Percent of crowded stops** | 0.42*** | 4.28 | 0.23 | 0.62 |
| **Percent of crowded stops squared** | -0.01*** | -6.06 | -0.01 | -0.01 |
| **Wheelchair ramp use** | 17.63*** | 21.62 | 16.04 | 19.23 |
| ***=p<0.01, **=P<0.05, *=p<0.1 | | | Adjusted $R^2$: 0.13 | |

The dummy variable differentiating the two routes was statistically significant and positive in this model, indicating that a trip on route 99 on average is 44 seconds more delayed than a trip on route 9, while holding all other variables at their mean. This finding indicates that when compared to route 9, the local stop service, the limited-stop service offered by route 99 has a positive and statistically significant effect on the probability of being late. Eastbound trips were on average 3.4 seconds more delayed than westbound trips, while keeping all other variables constant. The passenger activity variable indicates that each passenger alighting or boarding adds 0.25 seconds to the average delay along trips, while controlling for all other variables. Similar to Surprenant-Legault and El-Geneidy (*11)*, higher levels of passenger activity result in delays in on-time performance. We tested the square term of passenger activity in this model, which accounts for the fact that each passenger boarding and alighting takes less time than the previous, however it was not a statistically significant predictor of on-time performance in our model. As expected, trips where the wheelchair ramp was activated were delayed on average by 18 seconds, while keeping all other variables at their mean.

The percentage of stops along a trip that were crowded had a positive and statistically significant effect on the seconds delayed at each stop. An increased percentage of crowded stops along a trip was associated with an additional delay of 0.4 seconds, while holding all other variables constant. However, the square term of crowding included in our model indicates that there is a diminishing impact of crowding on the on-time performance. Trips during peak hours are more punctual than off-peak hour trips, which was expected as previous research observed faster dwell times during peak hour trips (*19; 22*), which is mostly likely a result of a greater proportion of regular riders and more directional traffic.

## ANALYSIS OF CUSTOMER SATISFACTION

As of 2015, Routes 99 and 9 were ranked the first and fourth busiest bus routes, respectively, in the Translink network. There are key operational differences between these routes, namely route 99 only serves select stops, which makes it faster and has significantly higher daily average boardings than route 9 (namely 55,000 compared to 22,950 on route 9). Accordingly, we wanted to evaluate differences in satisfaction among respondents whose most recent trip was on either one of these two routes, while controlling for the performance of these two routes using the AVL/APC data used above.

The customer satisfaction surveys are conducted quarterly, and are collected with the purpose of evaluating how existing customers (specifically participants who reported taking a trip in the past 30 days) perceive the quality of service provided by Translink. Surveys are conducted by telephone, and are voluntary, which can result in non-response bias. The survey begins broadly by asking customers to rate their overall experience with the transit system in the Greater Vancouver Region within the past seven days. Then, the survey asks respondents to name the mode(s) and route number they have used during their last or second to last trip and follows that with questions about their perception of service quality during that trip. The survey questions cover a range of service characteristics, including their perception of crowding, trip duration, and the on-time performance of their most recent trip. At the end of the survey, participants are asked a series of questions related to their socio-demographic and household characteristics and their usage of transit.

For the purpose of our study, we selected respondents who reported using the bus on their last trip, but removed users who reported using more than one bus or mode, to avoid any bias that may impact their perception of the service on route 9 or 99. We focused on questions related to the customers' perception of the performance of these two routes, for example the level of crowding and how one would rate the trip for providing punctual service. Table 3 presents summary statistics of the differences in socio-demographics between the limited-stop (route 99) and local (route 9) riders, and mean levels of satisfaction related to service performance variables. A *t*-test was used to compare perceptions of service characteristics and differences in socio-demographic characteristics and usage levels of riders on route 99 and 9 and the results are shown in Table 3.

What we were mainly interested in understanding was the overall satisfaction with the users' most recent trip on route 9 or 99, as a function of operational characteristics, personal characteristics, and the context of that individuals' trip. Accordingly, we linked satisfaction survey data collected between January 1, 2011 and December 31, 2013 with the AVL/APC operations data collected at the same time period. The key information available for us to match the trip of an individual to the operations data were the date of the interview, the time of day and day of week of that individual's trip (which occurred in the past seven days), and the route that they used. Unfortunately, the exact date of the trip, direction of the trip and its origin and destination were not collected in the survey, which imposes a limitation on the kind of study that can be conducted with this data. Accordingly, we linked each survey entry date with operations data of trips over the past week that occurred during the same time period (e.g. weekday morning peak). This provided us with average values of operations variables we anticipated would impact an individual's overall satisfaction levels, such as on-time performance, crowding, passenger activity and leave load. Linking the data sources was done to better understand the service these users actually experienced.

**TABLE 3 Summary Statistics of Survey Variables Comparing route 9 and 99 Users**

| | Route 99 | Route 9 | |
|---|---|---|---|
| **Personal Variables** | | | |
| Age 16-34 | 25% | 14% | *** |
| Age 35-54 | 40% | 41% | |
| Age 55 plus | 35% | 45% | ** |
| Household Income level | | | |
| Under $25,000 | 12% | 19% | ** |
| $25,000 – 45,000 | 14% | 21% | * |
| $45,000 – 65,000 | 18% | 23% | |
| $65,000 – 85,000 | 18% | 17% | |
| $85,000 and over | 38% | 20% | *** |
| Employed full time | 49% | 45% | |
| Student | 11% | 5% | *** |
| Unemployed | 4% | 6% | |
| **Transit Usage** | | | |
| Irregular riders | 11% | 10% | |
| Customer for over 1 year | 83% | 83% | |
| Compared to 6 months ago, are you now riding transit.. | | | |
| More regularly | 13% | 17% | |
| Less regularly | 11% | 8% | |
| The same | 76% | 75% | |
| Access to a car | 69% | 62% | * |
| Likely to continue to use transit | 94% | 89% | |
| **Satisfaction levels** | | | |
| Overall service provided by the transit system in the Greater Vancouver Region | 7.7 | 8.0 | * |
| Overall service provided by route 9/99 | 7.5 | 7.9 | *** |
| Crowding | 5.3 | 7.3 | *** |
| On-time reliable service | 7.9 | 7.7 | * |
| Trip duration | 8.5 | 8.5 | |
| Frequency of service | 8.1 | 7.6 | *** |

Significantly different sample mean: ***=p<0.01, **=p<0.05, *=p<0.1

As indicated in Table 3, users of route 99 are younger, are more likely to be students and have higher levels of income compared to route 9 users. Regarding their satisfaction levels, differences are observed, however the most noteworthy difference among these riders is their perception of crowding, namely route 99 users are very dissatisfied with crowding levels (mean of 5.3 out of 10), although the route is of high frequency and operates articulated buses.

Our goal is to understand the factors impacting the satisfaction level of users of route 99 or 9. Accordingly, a logit model was employed to predict a satisfied user or not, using the following question as our dependent variable: "Based on your own experience in the past seven days, on a scale of one to ten how would you rate the overall service provided by the transit system in the Greater Vancouver Region?" The selection of this question as our dependent variable, rather than satisfaction with the users' last bus trip will be discussed in the final section. Satisfaction was asked on a scale between 0 and 10, so a binary variable was created, where responses of 8 and above were converted to "satisfied" and below 8 "dissatisfied". These cut offs are based on the internal threshold for which Translink considers customers as satisfied. We modeled overall satisfaction as a function of operations variables we collected over the seven days, including on-time performance and variation in on-time performance, average passenger load, average passenger activity and crowding, and characteristics of that trip, including the route used (99 or 9), and whether the trip occurred during a peak hour. We then expanded our model to include personal characteristics, including age, household car access, and their frequency of transit use.

Two logit regression models were developed using overall satisfaction with transit service in the Greater Vancouver Region as the dependent variable, and the results are presented in Table 4. Model 1 assesses whether the operations variables describing the context of the service during the past seven days, i.e., the conditions experienced by route 99 and 9 users, has an effect on overall satisfaction levels. Model 2 expands on Model 1 by including personal characteristics of the user, namely their age category. Both models have a total sample size of 679, with 194 responses from users of route 9 and 485 responses of users of route 99.

The key policy variable in Model 1 is the route 99 dummy variable, which accounts for whether a respondents' last trip was along this route. This variable showed a positive and statistically significant impact on satisfaction with the service which means that the odds of a route 99 user being satisfied are 4.38 times higher than a route 9 user, while controlling for other variables. This suggests that route 99 users are more likely to be satisfied with service than users of route 9 when experiencing similar operations and levels of passenger activity and loads. As expected, more heavily loaded buses and trips with higher passenger activity decrease the odds of satisfaction among riders. With consistently high occupancy rates along bus routes such as route 99, passengers do not know if they will be able to board the bus if the capacity is full, creating a greater variation in waiting time and travel time for customers (*23*). Furthermore, high occupancy rates on bus routes may change customers' behavior, as risk-averse riders may choose a route with lower occupancy rates (*24*), for assurance that they will be able to board the bus. Variables that were tested in our model but did not reveal statistical significance include average on-time performance and variation in on-time performance, although we found that a trip on route 99 on average is delayed by 44 seconds compared to route 9. The percentage of crowded stops along a trip was also revealed no statistical significance in our model. Crowding has many effects on both the operations of bus service and passengers' well-being (*25; 26*), however the impact of crowding on riders is very complex to analyze particularly in this study predicting satisfaction of users from two bus routes, as a result of the mediating effect of the travel time savings experienced by route 99 users, despite higher crowding levels. Also previous research has shown variance in satisfaction levels with crowding during the peak and off-peak which was mostly related to expectations of riders (*20*). In other words, riders using the 99 route were found to be satisfied with a crowded bus during the peak and not satisfied with the same level of crowdedness along a bus route operating during the off-peak.

**TABLE 4 Predicting Satisfaction with Transit Service**

| | **Model 1: Operations data** | | | **Model 2: Operations data and personal characteristics** | | |
|---|---|---|---|---|---|---|
| Variable | OR | Confidence level | | OR | Confidence level | |
| | | 2.5% | 97.5% | | 2.5% | 97.5% |
| Constant | 645.41*** | 15.83 | 29929.64 | 644.19*** | 15.22 | 30906.58 |
| **Operations Data** | | | | | | |
| Average leave load | 0.91** | 0.83 | 1.00 | 0.92* | 0.84 | 1.01 |
| Variation in leave load | 0.17 | 0.00 | 6.63 | 0.39 | 0.01 | 16.20 |
| Passenger activity | 0.96*** | 0.94 | 0.99 | 0.96*** | 0.93 | 0.99 |
| Passenger activity squared | 1.00*** | 1.00 | 1.00 | 1.00*** | 1.00 | 1.00 |
| **General Trip Information** | | | | | | |
| Peak hour trip | 0.98 | 0.62 | 1.52 | 0.88 | 0.55 | 1.37 |
| route 99 | 4.38*** | 1.46 | 13.52 | 4.36*** | 1.45 | 13.55 |
| **Satisfaction Variables** | | | | | | |
| Age 16 – 34 years | --- | --- | --- | 0.67* | 0.43 | 1.05 |
| Age 35 – 54 years | --- | --- | --- | 0.55*** | 0.37 | 0.80 |
| Age 55 and over | --- | --- | --- | *Reference* | | |
| Goodness-of-fit measures | AIC: 864.35<br>BIC: 895.99<br>N = 679<br>Log likelihood: -420.31 | | | AIC: 858.61<br>BIC: 899.30<br>N = 679<br>Log likelihood: -425.17 | | |

***=p<0.01, **=p<0.05, *=p<0.1

Model 2 expands on our first model by incorporating personal characteristics of the user. We tested different variables including car access, frequency of transit use and income level and found no statistical significance of these variables in our model. Similar operational results are found after controlling for users' age. When compared to individuals aged 55 and over, the odds of users between the ages of 16 and 34 being satisfied are 33% lower. Similarly, the odds of being satisfied for users between the ages of 35 to 54 years is 45% lower than users aged 55 and over. Lower satisfaction levels in younger cohorts have been similarly observed (*20*).

## DISCUSSION AND CONCLUSIONS

The main objective of this article was to assess the impacts of operating local and limited-stop bus service, using both quantitative and qualitative measures. Operational data extracted from AVL/APC systems were employed to provide the performance of the two bus services. The results of the on-time performance model revealed that compared to local bus riders, users of the limited-stop bus experienced an average delay of 44 seconds at each stop. Given the general consensus in the literature regarding the importance of service on-time performance and reliability (*27; 28*) we next evaluated differences in satisfaction levels among local and limited-stop service users, to determine if the observed differences in on-time performance impacted users' overall satisfaction levels. Results of our logit model predicting overall satisfaction with transit service in the Greater Vancouver Region revealed that route 99 users (limited-stop bus route) are 4.4 times more likely to be satisfied compared to route 9 users, when keeping all other variables at their mean. In other words, under the same conditions of on-time performance, crowding, and passenger activity, route 99 users are far more likely to be satisfied. Accordingly, characteristics of a limited-stop route service that are not captured in our model, such as the significantly lower travel time that is offered by a limited stop service, has an important impact on a customers' satisfaction levels. Time savings associated with limited-stop route service are well documented (*6; 10*), and evident by the scheduled running time of both routes.

On-time performance was not a statistically significant predictor of overall satisfaction in our model, rather increases in passenger activity and passenger loads were found to negatively impact a users' satisfaction overall. Routes 99 and 9 are ranked first and fourth respectively among the most highly used bus routes in the Translink network. To meet this passenger demand, peak hour headways are approximately 3.5 minutes and 5 minutes on routes 99 and 9. Therefore, strategies to mitigate the negative impacts of crowding on these routes are recommended, for example reductions in fares at off-peak hours, or increasing the frequency of service or the types of buses operated to have a higher carrying capacity. A total of 77,000 boardings in a day along these two routes is also high enough to start discussions of converting the type of service offered along this corridor to light rail with exclusive right of way.

Regular monitoring of customers' perception of service through the collection of customer satisfaction surveys is one of the most widely used and recognized tools in the industry to directly capture the customers' perception of service quality (*2; 29*). Accordingly, how surveys are collected and the specific questions included in questionnaires are critical for the collection of high quality and meaningful data. In this study context, the survey administered by Translink is designed to first ask customers about their rating of the quality of transit service in the Greater Vancouver Region and then asked detailed questions regarding their last trip in the past seven days, specific to each mode that was used. By linking satisfaction data to operations data of the past seven weekdays corresponding to when the respondent was interviewed, we were able to predict the respondents' overall satisfaction with transit service as a function of operations data. However, we were unable to find any statistically significant relationship between these operations variables and the individuals' satisfaction with their last bus trip since the actual date was not given as well as boarding locations and direction. This finding suggests that these individuals did not accurately recall their last trip, rather their last experience with transit explains their overall satisfaction levels and their attitudes towards the service quality in general, which they experienced in the past seven days. Accordingly, this survey design employed by Translink provides transit agencies with knowledge of the users' attitudes towards transit, rather than their satisfaction levels with that specific trip. Therefore, if data were collected immediately after a trip, so other trips cannot bias them, we expect that the data could be aptly linked to operations data for a better understanding of customers' satisfaction with transit service. This would also enable us to overcome the limitations in our methodology, specifically with averaging seven days of trips and averaging trips of both directions. More detailed information regarding an individuals' last trip would significantly improve the ability to combine operations and customer satisfaction data.

Results of this study are expected to be applicable to other transit agencies, both for agencies that currently operate limited bus stop services, or those that are considering the implementation of such a service. The study results demonstrate that customers of the limited-stop service are very satisfied users despite high passenger activity levels and crowding and lower on-time performance. These higher satisfaction levels are most likely related to the time-savings experienced by these users compared to local bus service and the high frequency of service that makes excess waiting time not noticed much by users.

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