Comparison of Urban Paratransit Systems in Canada

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ABSTRACT

Levels of service provided to disabled persons by urban paratransit systems in cities across Canada, where the level of service is determined as a function of the number of rides provided relative to the population of each city, are compared. Service levels are then related to estimates of basic demand that could be expected in each city and to the estimated capacities of each system to provide service. This may be useful to managers of paratransit systems for justifying the need for additional funds or vehicles, for highlighting areas with the potential for improvement, and for explaining difficulties in coping with existing demand.

The term urban paratransit system, as used in this paper, refers to a parallel urban transit system put in place to provide accessible urban transportation services to disabled people who, because of their disability, find it difficult if not impossible to use the regular public transit system. A typical paratransit system consists of a small fleet of vans or buses, some of which are equipped with mechanical lifts and wheelchair tie-downs.

Levels of service found in cities across Canada, where the level of service is determined as a function of the number of rides provided relative to the population of each city, are compared. Service levels are then related to estimates of basic demand that could be expected in each city and to the estimated capacities of each system to provide service. Issues related to efficiency and economy will not be covered; the focus is on demand and supply questions only.

A methodology for estimating the disabled population in a city is presented. It is based on the relationship between age and the incidences of transportation disabilities and uses results from a nationwide survey entitled "Special Needs in Public Transportation" undertaken by Statistics Canada in August 1983 on behalf of the Canadian Transport Commission. Based on this analysis, the proportion of the population that is transportation disabled appears to vary little across Canada.

The goals of the paper are to demonstrate that there are broad differences in the levels of service found in communities across the country, and that there are large amounts of unsatisfied demand in many population centers. In addition, it is hoped that the results presented in this paper will prove useful for city and regional planners, administrators, and operators of paratransit systems for determining potential demand and adequate service levels for their communities in relationship to others.

SAMPLE

This study covers cities and metropolitan centers in Canada with populations of more than 50,000. The sample size (about 50) is both large enough to be useful and small enough to be easily analyzed. In addition, the paratransit systems of these cities form a relatively homogeneous group in that they are, with few exceptions, all multivehicle systems operating long hours parallel to an existing urban transit system. They provide door-to-door service; allow trips for any purpose when space is available; and offer both a subscription service, where the user books once for regular, usually work-related, Monday-to-Friday trips, and a single-trip reservation service, where the user books each trip separately. This service may be called demand or advance, depending on the length of the prebooking period, which can vary anywhere from 0.5 hour to 2 weeks.

DATA SOURCES

The basic operating statistics for each city were provided by the Canadian Urban Transit Authority, which regularly surveys the paratransit operators, and the Ministry of Transportation and Communications for Quebec, which maintains statistics on that province's systems. Other supplemental information was gathered through a telephone survey of actual operators. The section on demand estimation uses statistics from the 1981 Census and the Canadian Labour Force Survey of August 1983, both conducted by Statistics Canada. In addition, some results are used from the "Special Needs in Public Transportation" survey that was jointly sponsored by the Canadian Transport Commission and Statistics Canada in August 1983. The purpose of this survey was to determine the number of transportation-disabled people in Canada; the assistance they require when traveling by air, rail, or intercity bus; and the barriers or difficulties they encounter.

Another source of data was the information directory, "Urban Transportation Services for Physically Disabled Persons in Canada," put out by the Canadian Rehabilitation Council for the Disabled in December 1981. It contains passenger and operating statistics for both large and small paratransit systems in Canada. There are major problems with some of the data in the directory, because the questions were interpreted in various ways by respondents to the survey. Thus the directory has been used only as a source of supplemental information in this study. However, it is mentioned here because it formed the original impetus for this work and was used as the basis for a preliminary analysis.

When the information directory first became available it was hoped that the user statistics provided in it would provide the basis for an educated guess concerning the number of transportation-disabled Canadians. However, a preliminary investigation of the statistics revealed some rather curious figures. For example, many small cities provided numerically more rides than did many much larger cities. Some systems had most of their clients in wheelchairs (e.g., 90 percent); others had very few (e.g., 10 percent). Services with very restricted eligibility criteria provided more rides per capita than did many services with less restrictive eligibility criteria. Eligibility criteria themselves varied a great deal from place to place. For example, some systems do not carry disabled children, others will not carry the mentally disabled, still others do not carry the blind, and so forth.

Eventually it was decided to abandon the attempt to estimate the number of disabled persons and to concentrate instead on simply trying to understand and explain the figures observed. This study developed from that work, notwithstanding that along the way more reliable and comprehensive sources of data became available. Unless otherwise sepcified, the paratransit data used in this study are for 1982.

ANALYSIS OF SERVICE LEVELS

To compare the levels of service provided in each population center, the following usage rate was defined:

Usage Rate = R/P

where R is the number of rides provided per year and P is the total population of center served by paratransit system. Thus, if one city were twice as large as another, it would have to provide twice as many rides as the smaller city to have the same usage rate.

It was mentioned earlier that the eligibility criteria used by each system to determine who may use the service vary. Many systems restrict service to those with physical disabilities, such as people who use wheelchairs or mechanical aids of some kind--people who find it impossible or extremely difficult to board a bus. Thus, blind, mentally retarded, disoriented, epileptic, or deaf individuals who for nonphysical reasons may find it impossible or difficult to use a regular public transit system would not qualify. Other systems will accept, perhaps, the blind but refuse the mentally disabled or vice versa. Others will refuse to allow disabled children to use the service. There is no pattern to this; there are no federal guidelines; where provincial guidelines exist, individual operators within a province interpret them in various ways.

To provide a reasonable basis of comparison, systems were grouped into three categories: those that provide service to the physically disabled only, those that in addition allow other transportation-disabled individuals to use the service, and a small group that has broad eligibility criteria and that also provides a school bus service to disabled school children. The third category seems necessary because, although most school boards in Canada provide their own school bus service for disabled children, a few boards contract this out to the local paratransit system. These trips are not separated in their operating statistics, and the vehicles used are part of their overall operations. In addition, the number of school children may be small, but their daily trips add up quickly and can form a sizable portion of overall trips provided. The nature of the trips (many-to-one, one-to-many) allows for quite efficient scheduling and routing. Thus, it was decided to keep this group in its own category.

Figure 1 shows a plot of usage rates by each of the three eligibility categories described. For those systems with the highest usage rates within each category, usage rates do in fact increase as eligibility criteria broaden. However, within a category all usage rates appear, and many systems that provide rides for the mobility disabled alone still achieve much higher usage rates than many systems with broader eligibility criteria. The top services approach usage rates of 0.4 if they are restricted to the mobility disabled and 0.5 with broader eligibility criteria.

DEMAND ANALYSIS

The question arises of whether the basic demand for paratransit service could vary so dramatically from place to place as to explain the differences in the level of service shown in Figure 1. In other words, it is possible that all systems are responding equally well to the demand and need for paratransit service, and the differences observed in the usage

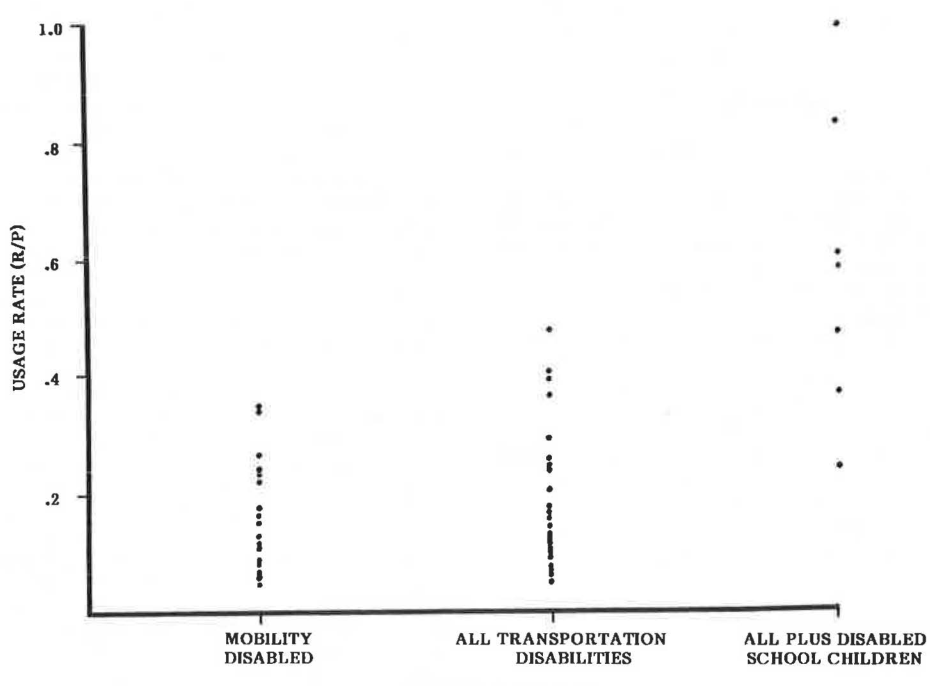

FIGURE 1 Usage rates by eligibility criteria.

rates reflected only differences from city to city in the incidences of transportation disabilities?

An initial analysis suggests that there is no dramatic difference in the proportion of the population that is disabled in the various localities across Canada. Direct statistics on the number of disabled people in each city are not available. However, results from the "Special Needs in Public Transportation" survey do show a strong relationship between age and disability. As is shown in Figure 2, the elderly make up approximately 10 percent of the population in general but form 82 percent of the disabled population. Children, on the other hand, make up about 23 percent of the general population but only about 5 percent of the disabled. Percentage-disabled figures for each major age group follow and are plotted in 5-yr age groupings in Figure 3.

Age Group (yr)	Percentage Transportation Disabled
0-14	0.5
15-64	1.1
65+	14.7
All ages	2.3

It should be noted that the "Special Needs" survey did not include the age group 1-14 years. In this study the estimates for children aged 1 to 14 are based on the average for those aged 15 to 29.

The implication of these statistics for the future is rather sobering but need not be covered here. What these statistics do provide is a relatively simple way of estimating the percentage of disabled one can expect to find in a city, based on

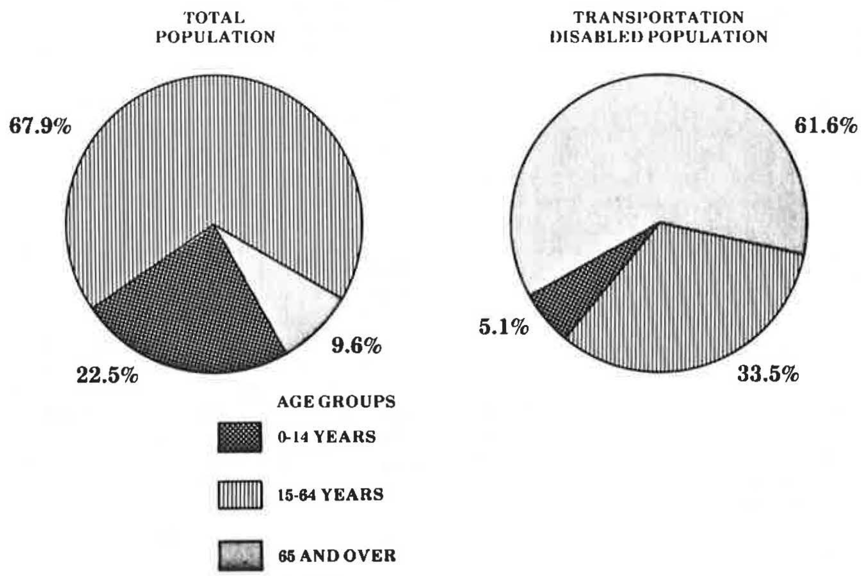

FIGURE 2 Transportation disability statistics.

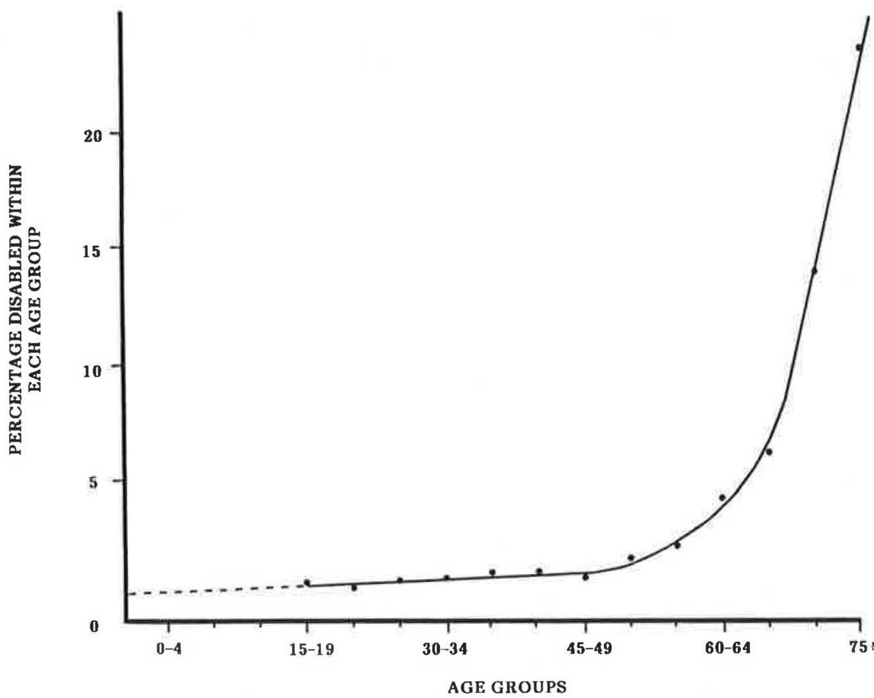

FIGURE 3 Percentage transportation disabled by age group.

the percentage of elderly living there. The percentage disabled in the 0-64 age group is estimated to be 1.0 percent, and for those 65 and older it is 14.7 percent. Thus, if city A had P_A percentage of its inhabitants 65 and older, then the estimated percentage disabled, P_D, would be

$$P_D = 0.010 * (1 - P_A) + 0.147 * P_A \quad (1)$$

This is a linear equation and is plotted in Figure 4.

For each city in the sample one can estimate the percentage of disabled people from percent elderly census information and then determine a scaling factor, λ, defined as

$$\lambda = \text{\% Disabled in City A/\% Disabled in Canada} \quad (2)$$

For example, if a city has 13 percent of its population aged 65 or older, then from Figure 4 its estimated disabled population would be 2.77 percent of its total population. The Canadian average percentage disabled is 2.31 percent. So this city would have a scaling factor of $\lambda = 2.77/2.31 = 1.20$ or an estimated disabled population 20 percent higher than average. Its usage rate would have to be 20 percent greater than the usage rate for a city with precisely the national average of disabled people if the two cities were in fact providing the same level of service to their transportation-disabled communities. To compare cities, a scaled usage rate can be defined as

$$\text{Scaled Usage Rate} = \text{Usage Rate}/\lambda \quad (3)$$

which adjusts each usage rate to the equivalent usage rate one would expect to see if the same level of service were to be provided in a hypothetical city with exactly the Canadian average number of transportation-disabled people.

Usage rates for all cities in the sample were rescaled in this manner and replotted as shown in Figure 5. (Scaling factors will be provided by the author on request). If true demand for service were driving each of the various systems, and service levels were in fact very similar, when differences in demand levels had been taken into account, one would have expected to see the scaled usage rates show a tendency toward grouping or bunching about some natural usage rate for each category. No such grouping, or even an indication of movement toward grouping, can be observed. This is not surprising, because an examination of the λ values shows that differences of more than 20 percent in the proportion disabled are rare. Correcting for expected differences in the number of disabled people in a community can be considered fine tuning at this state, or perhaps of interest mainly to individual operators in determining how well demand is being met. But the evidence at hand does not support the assumption that usage levels are currently determined by the demand or need for service. Systems do not appear to be demand driven, and many systems are operating well below the levels one would expect to see if equivalent and first-rate service were available across the county.

It should be noted that this demand analysis is necessarily rather crude. It implicitly assumes that an increase or decrease in the proportion of the population who are disabled translates directly to an equivalent increase or decrease in the demand or need for paratransit service. In reality the connection may be more tenuous. The average disabled individual of working age may wish to use a paratransit service far more often than a disabled person over 65. If true, this would have the effect of minimizing any differences in the resulting demand one could expect between cities even where there are differences in the proportion of disabled individuals, if such differences in the proportions were related solely to different age profiles. Also, there may in fact be some cities with much higher disability incidences, even when age demographics are taken into account. For example, severe polio epidemics many years ago might have increased the number of disabled in a particular city, or hazardous working conditions that may have existed in mines or smelters might affect disabled statistics in a city. In addition, the "Special Needs" survey omitted people in institutions that may, as a matter of public policy or economics, have all been centered in a particular city within a region. Be that as it may, detailed disability statistics by city are, to the best of our knowledge, simply not available, and the best information available suggests that demand differences do not vary enough from city to city to explain the differences in usage rates observed.

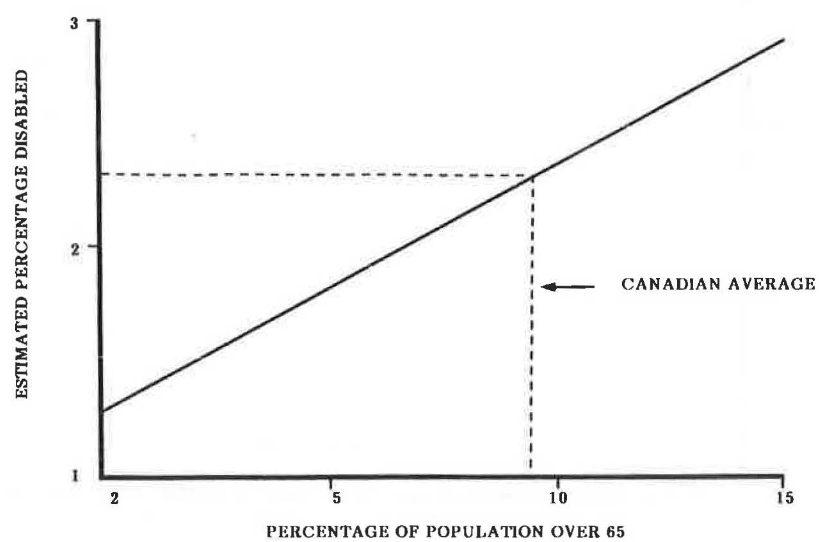

FIGURE 4 Predicting transportation-disabled population as a function of the percentage of elderly.

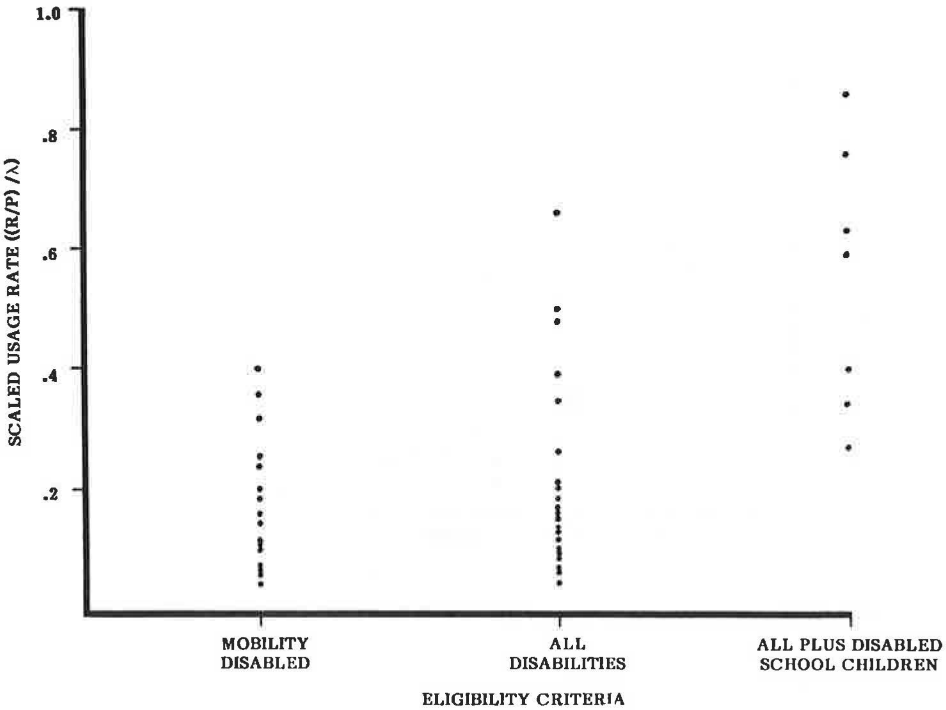

FIGURE 5 Scaled usage rates by eligibility criteria.

SUPPLY ANALYSIS

If it is not demand that determines service levels, perhaps it is supply. In this section the relationship between supply and service levels is investigated.

The number of vehicles is used as a measure of the capacity of a system to provide service. At first glance this may appear to be a rather crude measure of capacity because some vehicles are much larger than others. However, a review of the most commonly used measure of system efficiency, passengers per vehicle-hour, used in paratransit systems across Canada shows values that range from about 2 to 5, all of which can be achieved by a small vehicle, even a car or taxi. Thus, although large buses in theory can carry more people, it is questionable whether paratransit systems are able to use this extra capacity to any appreciable extent. For the kinds of gross effects under examination here, it was decided that vehicle counts were an adequate measure of capacity.

To allow for meaningful comparison between cities with different populations, the ratio of people to vehicles was used as a relative measure of capacity:

People-to-Vehicle Ratio = P/V

where P is the population of center and V is the number of vehicles in paratransit service.

A few paratransit systems make use of taxis to provide some rides. Where this occurs the vehicle counts for that city were scaled up to reflect the proportion of rides provided via taxis. That is,

$$V(\text{scaled}) = V \times [R(\text{fleet}) + R(\text{taxis})]/R(\text{fleet}) \quad (4)$$

where R(fleet) is the number of rides provided per year by paratransit vehicles and R(taxis) is the number of rides provided by taxis.

Figure 6 shows a plot of usage rates (i.e., rides per year per total population) against the people-to-vehicle ratio. The relationship, although not perfect, clearly shows that high usage levels are associated with low people-to-vehicle ratios, and vice versa. From the graph one can see that in order to reach usage levels of 0.4 to 0.5 one needs at least one vehicle for every 15,000 people in the general population, that one in 12,000 would be better, and that very few systems attain such ratios.

One might think that the variability observed about the line in Figure 6 reflects differences in operating efficiencies, with those systems above the line more efficient and those below less efficient. But at least some of the variability appears to be explained by another cause, for, when systems farthest from the line were investigated, it appeared that those much above the line in general had the shortest distance to cover per passenger; that is, an average vehicle distance per passenger of about 3 to 5 km, whereas the average vehicle distance per passenger is defined as the total number of kilometres covered by all vehicles in a year divided by R, the number of rides provided. Conversely, those systems farthest below the line generally had much longer vehicle distances to cover per passenger--on the order of 12 to 18 km.

Intuitively the longer the distances to be covered the smaller the number of passengers that can be carried in any given time. This is confirmed in Figure 7 that shows a plot of average vehicle distances per passenger against passengers per vehicle-hour statistics for each system. As average vehicle distances per passenger increase, passengers per vehicle-hour statistics decrease, and vice versa. From conversations with paratransit operators, it seems that passengers per vehicle-hour statistics are often used to compare the relative efficiencies of different systems. Figure 7 shows that such comparisons can be misleading and should not be used in isolation. Perhaps passengers per vehicle-hour statistics should be used mainly for measuring the effect of operating changes within a system, all other things being equal. However, one can imagine artificial methods of boosting this statistic (for ex-

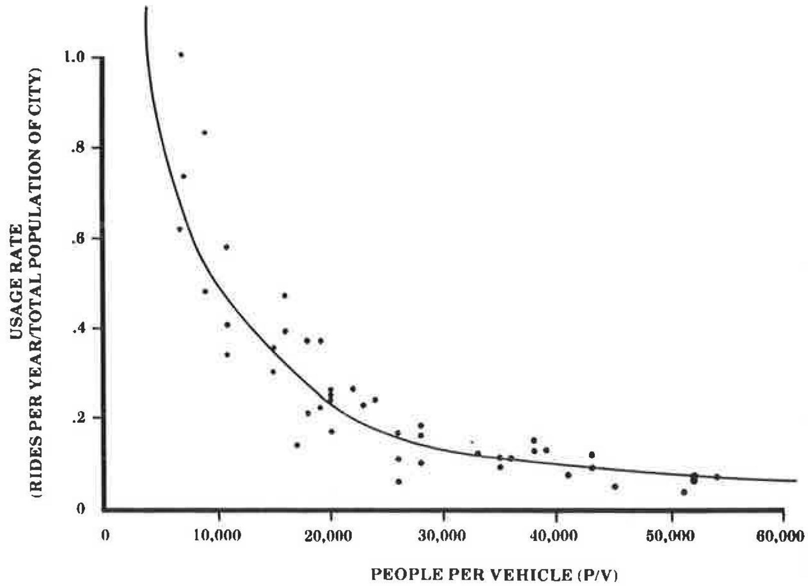

FIGURE 6 Usage rate versus vehicle ratio.

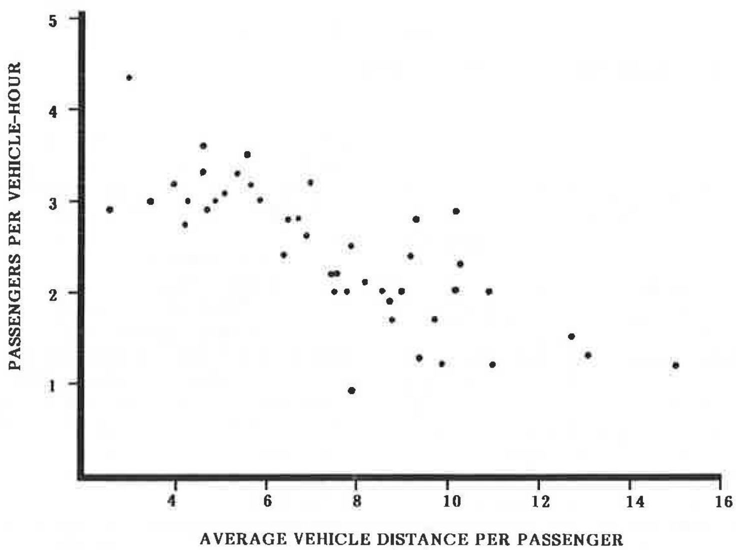

FIGURE 7 Passengers per vehicle-hour versus average distance.

ample curtailing off-peak-hour service or restricting the area served) that would boost the passengers per vehicle-hour statistics but degrade service.

To study the distance effect further, Figure 8 shows separate plots of those systems with short or long average vehicle distances per passenger. It is clear that at least some of the variability observed in Figure 6 is explained by the relative distances the various systems must cover in providing service. Other factors that are not included in "distance" but that also may help explain the variability include traffic congestion and network effects. For example, two cities might have identical populations and paratransit vehicles, but, because of where disabled users live, where and when they want to travel, the area covered by the city, and the road network, the average trip might take 45 min in one city and cover 10 km whereas in the other city it might take 15 min and cover 5 km.

It should be noted that this study counts all vehicles, including "spares," which puts those systems with old or unreliable vehicles at a disadvantage because they may have to keep a much higher proportion of their fleet on standby. Also, there is some variation in the number of hours of operation among systems, particularly for paratransit systems in smaller cities because these usually match the hours of operation of the regular urban transit system that may not operate, or may have reduced hours, on weekends.

Therefore, although there are, no doubt, differences in operating efficiencies among systems, there is no reason to think these differences are great. What evidence there is, in fact, suggests that most systems are doing the best they can with the vehicles they have at their disposal, that service levels are determined to a large extent by the number of paratransit vehicles a system has, and that many operators (including, incidentally, those in some of our largest cities) are operating at levels that meet only a small fraction of the potential demand.

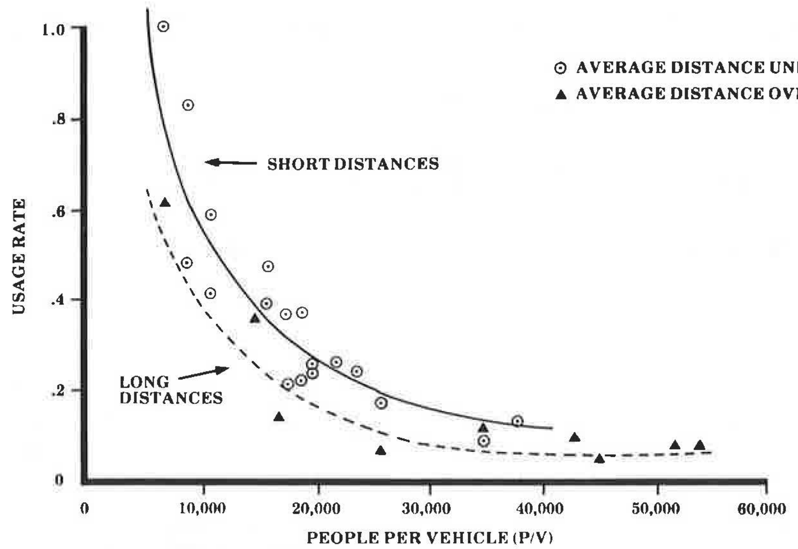

FIGURE 8 Usage rate versus vehicle ratio for short- and long-haul operations.

Thus, many operators have the unhappy task of rationing a scarce resource. This may explain to a large degree some of the, at first glance, arbitrary and inconsistent eligibility criteria that have been observed. A paratransit system manager might be loathe to widen eligibility criteria when a system does not have enough facilities to handle the existing demand. These and other congestion indicators are discussed next.

CONGESTION INDICATORS

Congestion indicators include

1. Stringent eligibility criteria--Systems accept and reject various disability groups in an apparently haphazard manner. Such groups include the blind, the mentally disabled, disabled children, and the deaf.
2. Restrictive procedures and usage results--One system allows a user to take at most three rides per day. Another requires bookings to be made in effect 2 weeks in advance of the trip, but only confirms the trip 24 hr in advance. Another allows "social" trips during off-peak hours only. Another allows only wheelchair users to use the demand service.
3. High levels of complaints--Complaints are mainly about booking problems.
4. High refusal rates.
5. High cancellation rates--These seem to be related to long advance booking periods. Disabled people may not know in advance if their health will allow the trip or even if they will still want or need the trip, but to guarantee the trip it must be reserved long in advance.
6. Long waiting lists--These exist particularly for subscription service.
7. Black hole syndrome--Many operators are not really aware of where their system is in relation to the true demand for service. Many of the indicators contribute to artificially suppressing the demand for service to the point where many operators, regardless of their position on the service-level curve, feel that if they just had "one more vehicle" they could handle the demand. When that "one more vehicle" arrives, it is completely swallowed up with extra demand within a month or two, and the system appears to be back where it was.

CONCLUSIONS

Major conclusions are that service levels do vary dramatically from system to system in a way that does not appear to be explained by possible differences in the level of demand but in a way that is directly related to the size of paratransit fleets. There are high levels of unsatisfied demand across the country and a chronic shortage of fleet capacity. It seems that the various paratransit systems exhibit no strong differences in efficiencies.

It is to be hoped that the results presented in this paper will prove useful to operators and urban transportation planners in monitoring and comparing the levels of service that are provided. Many operators may not know where their system stands in relation to basic demand and to other systems, and such information would be useful. In the past measures such as passengers per vehicle-hour were the statistics on the basis of which comparisons were made, and from results presented in this paper it would appear that such comparisons can be misleading if used in isolation from other factors. There is reason for concern that efforts at improving service in some paratransit organizations may be focused on improving efficiency, as measured by passengers per vehicle-hour statistics, when a more fundamental problem may exist; namely, the lack of vehicles. It is hoped that this paper will encourage discussion of this point.

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