Mobility Impacts of Transportation Improvements for the Elderly and Handicapped

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A framework is presented for considering the mobility benefits of improved transportation for the elderly and handicapped. Estimates of latent demand are presented, along with data from operational projects that suggest that actual demand for more travel by the elderly and handicapped may be very small compared to the latent demand figures. The small size of impacts makes quantification of the resulting mobility changes by means of average before-and-after trip rates impractical. A cross-sectional disaggregate modeling approach is suggested instead.

In recent years, widespread recognition that many people without automobiles are poorly served by currently available transit service has led to programs at all levels of government designed to improve the mobility of such people. In particular, the elderly and handicapped have been the focus of numerous programs. All of this activity and expenditure makes it very important to measure the effects that various approaches have on the mobility of the target populations.

A federal program that ought to provide an opportunity for adding to the existing body of knowledge in this area is the Urban Mass Transportation Administration's (UMTA's) Service and Methods Demonstration (SMD) program. The SMD program has as one of its five formal objectives the improvement of the mobility of transit dependents. In the 1970s this has focused on the elderly and handicapped. Projects designed to benefit the elderly and handicapped have been funded in at least 12 cities to date and more projects are in the planning stage (1, 2).

First, a framework is presented to show various types and measures of mobility changes that may be expected to result from improved transportation for the elderly and handicapped. Data are then presented on the estimated magnitude of need, or latent demand, and likely impacts of improved transportation. Some results from SMD projects and other elderly and handicapped transportation projects relating to measuring mobility changes are presented. The results demonstrate the difficulty and expense that will be involved in gaining a good understanding of the mobility impacts of these projects. Several suggestions are presented for future work.

BENEFITS AND MEASURES

The five dimensions of travel used to classify the possible user benefits of a special transportation service for the elderly and handicapped are listed below.

Dimension	Benefit
Frequency	More total trips More trips by project mode More optional trips Increase in frequency of travel to old or substitute destinations
Destination	Increase in total destinations Farther destinations (increase in average trip length or wider spread of trip lengths) Better destinations (inaccessible by former mode)
Timing	More trips at convenient times
Mode	Fewer trips by undesirable mode Lower disutility due to mode shift: Cost Time Safety Attitudinal
Purpose	Ability to engage in new or better activities

In addition to these user benefits, important benefits may accrue to others. For example, relatives and friends of project users may be relieved of providing rides; they also may enjoy more frequent visits and a new attitude born of independence on the part of project users. Social service agencies may be able to make more efficient use of their resources to provide better programs and spend less on transportation, which is peripheral to their main function; their services may become available to more potential beneficiaries.

The immediate benefit of removing barriers to transportation ought to be improved accessibility to destinations and activities, that is, the option to travel more, and more easily. From the point of view of measurement, we are primarily concerned with the extent to which this option is exercised, the greater observed mobility, because this exercise requires some efforts and therefore reveals that the trip is actually of some value greater than the effort required to make it.

Concentrating on observed changes in travel behavior (that is, mobility), the most obvious aspect of mobility is the amount or frequency of travel. Other aspects are travel distance and variety. Travel frequency, or trip rate, is hard to measure, or even define, with precision. The following discussion is concerned primarily with predicted and measured changes in trip rates. This is the most obvious measure of mobility and probably the easiest with which to deal. Reliable results, even about total trip rates, are difficult to obtain.

ESTIMATING NEED AND LIKELY IMPACT

The elderly and handicapped, on the average, make far fewer trips than the general population. A survey of 724 elderly and handicapped persons in Portland, Oregon, showed daily trip rates of 1.4 one-way trips/person for elderly (65 and over) with no apparent transportation-related handicap, and 1.0 daily one-way trip/person for people of all ages with transportation-related handicaps, compared to a national average daily trip rate of 2.2 one-way trips/person (3). Abt Associates found a rate of 1.13 one-way trips/d for handicapped persons in the Boston area (4). Two studies in California urban areas show higher trip rates: 1.47 for elderly in Los Angeles County (5) and 1.46 for persons with transportation handicaps in the AC Transit service

Table 1. Estimates and observations of demand for additional travel by the handicapped and elderly.

Source	Group in Question	Method	Additional Daily One-Way Trips/Person
Washington, D.C.	Handicapped	Direct questioning	1.06[a]
Chicago, Illinois	Handicapped	Direct questioning	0.66-0.70[a]
Rochester and Albany, New York	Elderly	Gap analysis	0.3-0.4 (0.7-0.9 for automobileless elderly)[a]
Oakland, California, and nearby cities	Transportation handicapped	Gap analysis	0.5[a]
Oakland, California, and nearby cities	Transportation handicapped	Direct questioning	0.14[a]
Oakland, California, and nearby cities	Transportation handicapped	Likelihood of use	0.1[a]
Danville, Illinois	Elderly and handicapped	Project records, on-board survey	0.01[b]
Minneapolis, Minnesota	Handicapped unable to use regular bus	Project records	Less than 0.05[b]

[a]Estimate. [b]Observation.

Table 2. Transportation handicapped travel rates.

Variable	One-Way Trips/ Typical Week	No.	Variable	One-Way Trips/ Typical Week	No.
Sex			Labor force status		
Male	11.4	107	Work full-time	16.7	35
Female	9.5	188	Work part-time	13.1	21
Age			Student	22.4	15
10-17	30.0	8	Homemaker	10.7	28
18-24	12.2	19	Retired or not looking	7.6	176
25-54	12.0	77	Unemployed	8.7	22
55-64	11.8	68	Income ($)		
65+	6.6	123	Under 5000	8.0	84
Automobiles in household			5000-9999	8.9	49
0	9.0	73	10 000-14 999	9.7	38
1	8.3	115	15 000-24 999	12.0	44
2	11.1	79	25 000+	19.6	26
3+	17.8	30	Severity		
Driver's license			Slightly TH	13.0	102
Yes	12.3	147	Moderately TH	10.6	98
No	8.1	148	Severely TH	6.8	97
			All TH	10.2	297
			U.S. average	15.2	
			Bay Area average	18.6	

area (Oakland and nearby cities) (6). Various estimates and observations of additional daily one-way trips are given in Table 1.

The elderly as a group, handicapped or not, as well as the transportationally handicapped of all ages as a group, travel substantially less than the general population. These averages mask a great deal of heterogeneity in both groups. Table 2 shows this with results from the study performed for AC Transit (6), based on a telephone survey of people ages 10 and over with transportation handicaps (TH). The Los Angeles data (5) and Portland data (3) show similar variability for the elderly. Although certain subgroups have trip rates as high as or higher than the national average, trip rates for similarly defined subgroups of the general population are even higher. New York State data for people ages 20 to 64, with one automobile available and annual incomes over $8000, show daily trip rates of 3.66 in Rochester and 3.44 in the Albany area (7). These data certainly suggest that a substantial desire for more travel might be present.

Two general approaches for predicting the actual amount of increased travel that would result from improved transportation for the elderly and handicapped are (a) estimation of travel needs, which may be defined as the amount of increased travel that would result from accessibility to a means of travel comparable to automobiles, and (b) estimation of increased travel that would result from provision of good, usable transit service. The second number, presumably, will be much smaller than the first. The size of these estimates provides the best currently available basis for planning. They also will tell us how to design experiments and data-gathering activities that will permit useful evaluations of the mobility impacts of improved transportation for the elderly and handicapped.

The simplest method of estimating need, or latent demand, is simply to ask people if they would like to make more trips and, if so, how many. Studies in Boston and Washington, D.C., which asked handicapped people about what they would do if low-cost, barrier-free transportation were available (8), showed more latent demand for social and shopping trips and other relatively discretionary trips than for the more necessary purposes of work, school, and medical trips. This fits the expectation that, given limited means to travel, the most necessary trips will be given priority. It was found that the handicapped in Washington, D.C., would make an additional 0.53 round trip/d (1.06 one-way trips/d) if a free, fully accessible, ubiquitous transit service were available.

Michaels and Weiler (9) used a similar procedure to estimate latent demand for the handicapped in the Chicago area, which resulted in an estimated desire for 0.33 to 0.35 round trip/d (0.66 to 0.70 one-way trip/d). Rather than refer to a particular transportation system, Michaels and Weiler asked respondents how many trips, in addition to those reported, they would have liked to make in the last 2 d, and then factored this number by the respondents' estimates of what percentage of these desired trips were not made purely as a result of transportation problems.

A more objective way to estimate latent demand is gap analysis, which compares the travel rates of two groups who are similar, except for automobile availability. Such an analysis by Yukubousky and Politano

(7), which controlled for age, income, and urban versus rural residence, produced an estimated latent demand by urban automobileless elderly of less than 0.7 to 0.9 one-way trip/d. Applied to the 43 percent of households whose heads aged 65 and over have no automobile (10), this would translate to an average of 0.3 to 0.4 one-way trip/d for all elderly.

A related calculation can be performed using the data from the work for AC Transit, presented in Table 1. The average Bay Area weekly trip rate of 18.6 one-way trips/person is higher than virtually every subcategory of the transportationally handicapped, even those in households with three or more automobiles. The TH as a group make 8.4 trips/week less than the general population in the Bay Area. We can estimate the amount of the difference explainable by various factors by calculating the expected average TH trip rate if the TH had the socioeconomic profile of the general population, assuming each TH subgroup retains its surveyed trip rate. If the TH had the income profile of the United States, an average trip rate of 11.4 trips/week would result; if the TH had the labor force profile of the United States, an average rate of 14.9 trips/week would result. Using only labor force status as an explanatory factor, a gap of 3.7 one-way trips/week, or 0.5 one-way trip/d, remains compared to the Bay Area average. Compared to the national average of 15.4 trips/week (11), the gap per week is only 0.5 one-way trip/person (or daily, 0.1 one-way trip/person). If the labor force and income effects were combined, this gap might be reduced somewhat.

The question must be asked: How much of this gap is due to transportation barriers as opposed to other factors? One such factor is adaptation to a lifestyle that minimizes the need for travel, which would be more difficult no matter what service were available. Another is the presence of barriers in the world beyond the transportation system. The most telling statistics in this regard are the trip rates for various automobile ownership levels. Only in households with three or more automobiles is the surveyed TH trip rate significantly higher than for the TH as a whole.

If demand for improved public transportation by the elderly and handicapped were comparable to most of the estimated latent demand values just presented, it would be easy to observe and quantify the impact of such improvements on people's travel patterns, since the impacts would be almost as great as current total travel rates. Evidence that is now accumulating from around the country shows much smaller impacts, which are very hard to quantify. Some of these results suggest much lower rates for latent demand as well as likely demand for a real service.

Our work for AC Transit employed two methods of estimating likely additional travel. The first was a conservative version of the direct-questioning method used in the Abt and Michaels/Weiler studies. Transportationally handicapped respondents to a random sample telephone survey were asked if there were any places they needed or wanted to go, to which they now had trouble getting. Only if the answer was yes was the respondent asked to name the place and the frequency of desired travel to that place. Based on the reported frequencies of desired travel, an implied additional weekly trip rate of 0.5 round-trip/person was calculated (0.14 daily one-way trip/person). A mail-back survey with a similar question produced an additional weekly trip rate of 1.4 round-trip/person (0.4 daily one-way trip/person). This higher rate is most likely related to the fact that all respondents to this second survey had to take some initiative to answer the survey. Both rates, however, are less than most of those previously presented, despite probable inclusion of many trips that are already being made. In fact, only 27 percent of the telephone survey respondents indicated that there were any places they would like to be able to reach more easily.

Examination of responses to both surveys shows that subgroups of the TH with greater disabilities and lower current mobility rates than average did request more trips than other respondents. This supports the validity of the questioning method and suggests that the most significant amounts of need are concentrated among the most severely limited subgroups of the TH.

A second calculation is based on respondents' stated attitude toward transit service and mobility differences among severity groupings. All respondents were presented with a list of possible improvements to transit service and asked which would be necessary or helpful to them. A transit service that included the most extensive changes was then described and the respondents asked how certain they would be to use such a service. Choices ranged from certain to definitely not. Respondents were also divided into three severity groups of equal size, based on their ratings of how difficult they found 10 transit-related functions. Table 3 gives reported transit trip rates for each of these severity groups as a function of stated likelihood of using improved service (6). It is apparent that the people most likely to use improved service are precisely those who already use existing transit service. A very few converts to transit use may be expected; however, we expect more frequent use on the average due to improved service. The calculation of the effect of providing more accessible transit service looks within each likelihood of use category, using that as an indicator of how transit-oriented people are, and then assumes that people's transit trip rate moves up to that of people in the next less severe severity category. Based on answers to other questions it appears that trip rates for the slightly TH would not increase significantly. The result is an estimated weekly increase of 0.94 one-way trip/TH person or 1.44 one-way trips/moderately or severely TH person/week. This assumes that "each time rode transit" is a round trip; in fact, about a third of responses appear to be one-way trips. Correcting for this, we estimate potential increased weekly transit use at 0.7 one-way trip/TH person (0.1/d).

These two calculations produce results much lower than those generally quoted as the latent demand for travel by the elderly and handicapped. Assuming that charging a fare would reduce even these demand levels, however, produces results that are in reasonable agreement with experience.

OBSERVED INCREASES IN MOBILITY

Most transit services for the elderly and handicapped offer a very low level of service. Long advance notice is required, service areas and allowable trip types are severely limited, or capacity is inadequate to meet demand. At least two systems are currently operating in the United States, however, that offer a high level of service.

One such project is the Danville, Illinois, SMD project, in which the elderly and handicapped are subsidized to ride on an existing shared-ride taxi service (12). Danville is a self-contained rural center of 43 000 people in east-central Illinois. All Danville residents ages 65 or over or handicapped were eligible for the program, which served all destinations in and around the city of Danville. Eighty-nine percent of eligible persons reported no physical problems using taxis. For 13 months

Table 3. Times rode AC Transit by severity and likelihood of using improved service.

Likelihood of Use	All TH Times	All TH No.	Slightly TH Times	Slightly TH No.	Moderately TH Times	Moderately TH No.	Severely TH Times	Severely TH No.
Certain	3.9	101	5.1[a]	35	3.9	38	2.4	28
Very likely	1.0	72	1.5	31	1.1	25	0.1	16
Maybe	0.5	49	1.0	13	0.5	15	0.2	21
Probably not	0.1	41	0.2	13	0.1	12	-	16
Definitely not	-	12	-	3	-	2	-	7
All likelihoods	1.8		2.5		2.0		0.8	

[a]Of all slightly TH respondents, those who indicated they are certain to use improved service rode AC Transit an average of 5.1 times last week.

Table 4. Danville: mean project use by type of user.

Variable	Fraction of Total Users	Monthly Trips/ User
Age and handicap		
65 and over, handicapped	0.18	3.7
65 and over, not handicapped	0.62	3.1
Under 65, handicapped	0.20	6.1
Alternative transportation available		
Not driver/receives no rides	0.18	5.9
Not driver/receives rides	0.60	4.1
Driver/automobile available	0.22	1.3 (lowest)
Primary handicap		
Emotionally disturbed	0.08	6.4 (highest)
Walking problems/aids	0.07	4.3
Arthritis	0.05	4.0
Cardiac ills	0.03	4.6
Mental retardation	0.03	3.4
Blindness	0.02	6.3
Household income per person ($)		
Less than 2500	0.28	4.1
Less than 5000	0.62	3.8
5000 to 10 000	0.09	3.3
Over 10 000	0.01	3.6

between December 1975 and January 1977 service was available 24 h/d, 7 d a week, at an average user discounted fare of $0.31/trip. In January 1977 regular fares were increased and the project discount decreased. The average wait time for a ride averaged under 10 min from the time the dispatcher received a telephone request. Participants were permitted to make trips worth $20 at the regular fare level, or about 16 one-way trips/month. We acted as evaluation contractor for the Transportation Systems Center and UMTA.

Table 4 summarizes the ridership of the project by type of user as of July 1976, by which time ridership levels had nearly stabilized (11). Users are those who have used the project at least once, which was about 83 percent of those registered to use the project after 14 months and 40 percent of those eligible. The average user took 3.8 one-way trips/month on the project, which is 3.1 one-way trips/month for each registered person, or 1.3 one-way trips monthly/eligible person (0.04/d). Focusing only on the handicapped, use rates are slightly higher than average, but only a third of the estimated handicapped population has registered, resulting in an average trip rate of 0.3 weekly one-way trip/handicapped person (0.05/d). In general, people who ought to have more need, or are more mobility limited, use the service more, but absolute ridership levels are very low for all groups.

A second transit service that offers a high level of service to handicapped users is Project Mobility (PM), operated by the Metropolitan Transit Commission of Minneapolis-St. Paul (13), which began operating as a 1-year demonstration program in November 1976. The service is door-to-door, with a nominal 2-h advance-notice requirement and is available to a narrowly defined eligible population living in a 16.3-km^2 (6.3-$mile^2$) area near downtown Minneapolis. This target area was chosen because it contains large concentrations of potential users. To use the system people must use some mobility aid or have a doctor's certificate showing inability to use the existing bus system. For a 35¢ fare, users may ride anywhere within a 9.7-km (6-mile) radius of downtown Minneapolis. PM operates between 6:00 a.m. and 10:00 p.m. on weekdays, 9:00 a.m. and 12:00 p.m. on Saturdays, and 8:00 a.m. and 11:00 p.m. Sunday. The service uses 12 Grumman buses with lifts, which can handle the existing demand, even providing some immediate request service. It is estimated that 3400 people, or 5.6 percent of the target area population, are eligible to use PM. After 6 months of operation, 22 percent of the estimated eligible population had registered to use the project. In 1 month 11 percent of the eligible population actually used the project, so far making a maximum of 1251 trips in a week. This amounts to about 1.6 weekly one-way trips/registered person, or 0.4 weekly one-way trip/eligible person (0.05/d).

The trip rates per target population for both of these projects are very low compared to all but the most conservative latent demand estimates presented earlier, despite the high levels of service offered and low fares. They are, however, much higher than those observed in other special transit services for the elderly and handicapped, which offer lower levels of service.

To arrive at an estimate of increased mobility, we must still determine how much of the observed travel in Danville or on PM is new travel and how much would have been made by other modes. An on-board survey of Danville project users (12) asked respondents how they would have made the trip currently in progress if the taxi discount program were not available. Only 15 percent said they would not have made the trip at all, and 35 percent said they would have used another mode (primarily walk or driven by relatives and friends), and 50 percent said they would have made the trip by taxi at full fare. Answers to such a hypothetical question are certainly open to doubt; however, the results are consistent with other data collected in Danville. In particular, an increase of 15 percent in total taxi patronage, with 30 percent of taxi patronage being project trips, is consistent with the statement that 50 percent of project trips would have been made by taxi, anyway.

The users of the Danville discount program may well deserve a purely monetary savings in travel costs, and freedom of dependence on rides can certainly be called a benefit as well. However, from the point of view of measuring and understanding changes in travel behavior, it is discouraging that only 15 percent of project trips appear to be new trips, since this implies that the overall monthly increase in total trip-making is only 0.6 one-way trip/person (0.02/d) for project users and only 0.2 monthly one-way trip/person (0.01/d) when averaged over all eligible persons. These increases are far lower than even the most conservative estimates of latent demand, despite the high level of service offered.

MEASURING AND UNDERSTANDING MOBILITY CHANGES

The increased travel rates just cited appear quite small. Two reasons may be (a) any form of public transportation has trouble attracting a significant portion of elderly and handicapped travel, much as with the general population, and (b) most elderly and handicapped really do not need to travel much more than they already do, barring large-scale changes in employment patterns, which are probably beyond the power of transit improvements to bring about. These results begin to assign an order of magnitude to the effects that we may expect transportation improvements to have on the travel behavior of the elderly and handicapped.

In order to understand the travel behavior of the elderly and handicapped, trips actually made by individuals should be related to those individuals' life situations and the means available to them for making trips. That the changes induced by projects offering a high level of service are so small means that acquiring the needed measurements for this understanding will be difficult and expensive. There are three fundamental reasons why this is so:

1. Trip making by individual elderly and handicapped persons is extremely variable over time,
2. Searching out a sample of individuals who are in the population of interest can be difficult and expensive, and
3. Changes in trip making due to exogenous factors are likely to be greater than the small changes created by transportation improvements.

The seriousness of these difficulties became apparent in the course of our work as evaluation contractor for the taxi discount program in Danville, and an SMD project for elderly and handicapped in Portland, Oregon (the LIFT). It was planned initially to conduct home interviews of people in the target populations, including questions about trip making over several days, before and during the operation of the project. Comparisons of trip making at the two points in time were to be used in looking for the effect of the project on mobility patterns. Once the pre-implementation surveys had been completed, and initial data about project use were available, we realized that this plan would not work for the reasons just enumerated. These evaluations were redesigned to be of a less formal nature, and the measurement problems involved were studied in hope of designing a workable study plan into a future SMD project.

In Danville, people were interviewed as they registered to use the project. This has obvious problems from an experimental design point of view but equally obvious cost advantages. In Portland, a random sample of households was screened, by telephone or in person, to look for transportationally handicapped people. A functional definition was used, which employed 10 specific transit-related activities, based on work by Abt Associates (8). Approximately eight households were screened for every one transportationally handicapped person identified. Respondents in both cases were asked about all trips made in the period immediately preceding the interview. Danville respondents reported an average of 1.18 one-way trips/d for yesterday, with a standard deviation of 1.31. Portland respondents made somewhat more trips with a higher standard deviation. Our survey results in the Bay Area also confirm that standard deviations are somewhat higher than measured daily trip rates.

To see the implications of the high standard deviations, one can apply standard statistical formulas to see how large a sample would be required to reduce the variation in the mean sample trip rate to a level that would permit measurement of changes in trip rates as small as those that we expect (as low as 0.01 daily one-way trip/person). If independent pre- and post-implementation samples were used, 93 000 people (twice the population of Danville) would have to be interviewed merely to distinguish the change from zero, much less to establish its size with any confidence. If a daily change of 0.04 one-way trip/person was expected (the PM rate, assuming no mode shift), samples of 5800 would do.

The observed variation in sampled trip rates has two sources: (a) variation in time of each individual's trip making, and (b) differences among individuals. The first source of variation can be reduced by observing more days of travel by each individual. The second source of variation, in a before-and-after study, can be eliminated simply by reinterviewing the same people, at least to the extent that individuals' behavior remains consistent over time.

The first source is partly a matter of measurement error. Even assuming that each individual has some true average trip rate over the long run, observations of trips in a given time period will vary considerably around the true rate. This may be more of a problem with the elderly and handicapped than with the general population, due to their making fewer and less frequently repeated regular trips than other people, in particular far fewer daily work trips. Data from the Portland survey support this. Transportationally handicapped people classified the frequency of their trips as follows: daily—11 percent, frequently—19 percent, weekly—16 percent, and occasionally—53 percent. It is not surprising, then, that calculations based on correlations among Danville respondents' reported trips on three consecutive days show that about 60 percent of the observed variation in 1-d trip rates is due to variation over time in individuals' trip making. This measurement error can be reduced by observing longer periods of time; accurate trip data from a week probably would reduce variances, and hence required sample sizes, by over half.

Unfortunately, the Danville data show that the long-term variability (i.e., over several months) may be as great as or greater than the short-term variability. When 246 people in Danville were reinterviewed an average of 6 months after their initial interview, a correlation of only 6 percent between their observed 1-d trip rates at the two times was found. In other words, 94 percent of the variation in their trip rates between the two time periods is due to variation over time in each individual's trip making.

These observations would imply that the second source of variation, that due to differences among individuals, accounts for only 6 percent of the observed long-term variation in 1-d trip rates. We calculated that for accurate 7-d measurements, differences among individuals would account for about 13 percent of long-term variation. Thus, while sampling more days of travel can reduce variation significantly at one point in time, reinterviewing the same individuals before and during a project will leave very large amounts of variation in the observed changes. Hence, very large samples would still be required to measure small changes in average trip rates. Even to distinguish a daily change of 0.01 trip/person from zero would still require samples of 32 000 people (2000 for a daily change of 0.04 trip/person).

The problem of relating changes to transportation improvements, as opposed to other changes in people's lives or conditions, remains to be addressed. Experience in working on demonstration projects shows that the number of outside influences that can affect a project is so great that no amount of measurement can hope to permit statistical isolation of their effects in a before-and-after study design. The most obvious factor is weather. Even making measurements a year apart in the same season cannot guarantee against widely different weather conditions at the time of the before-and-after measures. Given the small changes under study and the sample sizes required to measure those changes, even when differences among individuals are accounted for, these considerations appear to rule out before-and-after measurements of average target-population trip rates as a practical method of understanding the effect of transportation improvements on the travel behavior of the elderly and handicapped.

How, then, can experiments of the type funded by the SMD program be used to develop the knowledge that is needed? Two improvements on the study design just described may prove useful. These are (a) better targeting of before-and-after measures and (b) use of disaggregate modeling techniques with statistical controls.

The first suggestion is an obvious refinement on before-and-after measures of average trip rates. Experience in Danville and Minneapolis and survey results from our work for AC Transit show that demand for increased travel is, in fact, greatest among groups with the lowest current mobility rates. Table 4 shows that the project trip rates in Danville were higher for handicapped compared to nonhandicapped, for low-income people compared to higher income people, and for those with no automobile available. The Danville home interview data show lower trip rates for these people than for project registrants as a whole. Because only project registrants were interviewed, the effect is somewhat muted. Table 2, from the AC Transit survey of the transportationally handicapped, also shows lower trip rates for these groups than for the whole sample. Standard deviations for the subsamples are also proportionally lower than that for the sample as a whole. The effect is most notable for the group with the greatest degree of handicap (the severely TH). By sampling a group with lower current trip rates, and hence low variation in trip rate, on which a project is expected to have greater than average impact, required sample sizes could be reduced by about one-half. It still would be necessary to search out several thousand respondents of the desired type and to interview them about at least a week of travel, preferably using a trip diary. The danger of exogenous factors making observed changes impossible to attribute to the project would remain.

The best approach is probably to abandon a before-and-after design altogether. If there is a group of people to whom the service is not available, they can serve as a control group. Although not a control in a strict sense, statistical methods can take advantage of variation in the characteristics of both groups in order to isolate the effects of the project. In order to account for differences among individuals, individual rather than aggregate data on people and their travel should be used in a disaggregate modeling framework. This approach, rather than simply attempting to eliminate this source of variation, uses it to increase the explanatory power of the relationships estimated, which connect the characteristics of individuals and their opportunities for travel with their observed trip making. By making all measurements during the same period of time, the effect of unaccounted for variables can be minimized.

For example, one might use least squares regression to estimate an equation

$$T_i = f(S_i, A_i, Q_i) \qquad (1)$$

where for each individual surveyed,

T_i = total trips by all modes per week,
S_i = a vector of socioeconomic variables,
A_i = a vector of variables representing the availability of modes other than the project mode, and
Q_i = a vector of variables representing the level of service on the project mode and its availability.

If $Q_i = 0$ represents no project-mode service available to an individual, then $f(S_i, A_i, 0)$ may be interpreted as an individual's hypothetical trip rate if the project mode did not exist. Averaging over any real or constructed population subgroup, $\overline{f(S_i, A_i, Q_i) - f(S_i, A_i, 0)}$ may be considered the trip rate difference due to the project mode. This approach permits inferences to be drawn about the features of the project mode, which account for the observed effects, and how changing project features might alter observed effects.

There are several special transportation projects in operation that allow such a study design to be carried out. Any project with a waiting list due to capacity restraints would serve, as well as projects implemented in one part of a city and not others. The results of such a modeling effort would provide more than simply a measure of latent demand and mode shifts. If properly executed, the results should provide an understanding of the differing needs of subgroups of the diverse elderly and handicapped population, as well as provide a marketing tool that would help to target future improvements to reach those who most need them.

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Use of Taxicabs for Transporting the Handicapped: Dade County Experience

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This paper describes the special transportation service program designed to provide transportation services to handicapped residents of Dade County, Florida. Private, for-hire operators of taxis and lift-equipped vans transport approved handicapped users, who are too disabled to use regular public transit, anywhere in the county for $1.00 for a one-way trip. This report reviews the program's initial concepts, stated goals, and objectives and describes how the program has worked. User application forms, user trip vouchers, vehicle travel records, and a telephone survey of a random sample of program users provided data to assess user characteristics and trip-making patterns during the first 10 months of operation. After 10 months, the program had over 3400 approved users, 45 percent of whom were 65 years old or over. Out of 56 552 trips, 17 percent of the trips were made by wheelchair-bound users, 74 percent by transferable users, and 9 percent by companions. Disabled persons used a cab in 80 percent of the cases, and lift-equipped vans accounted for the remaining 20 percent of the vehicle trips. The average cost per person per trip was comparable with those reported in Atlanta and Denver for special handicapped services ($9.56/person in Dade County). The special transportation service program has proven to be successful in Miami and has the potential of being successfully implemented in other areas. The trip-making characteristics and operating data found for the 10-month monitoring period could prove useful to other communities planning transportation for handicapped residents.

The lack of adequate transportation services for the elderly and physically disabled is a national problem. The physical disabilities of these two groups limit their access to existing public transit systems. This problem has two components: (a) an inability to get to transit areas, and (b) an inability to use existing transit equipment.

Federal legislation to promote the transportation needs of the elderly and handicapped has been part of national policy since 1970, when the Urban Mass Transportation Act of 1964 was amended to include section 16. The amended act states that elderly and handicapped persons have the same right as others to use mass transportation facilities and services, and special efforts should be made in the plan and design of mass transportation facilities and services.

The Mayor's Advisory Board on the Physically Disabled, a citizens' advisory organization, in Dade County, Florida, was contacted by the Dade County Office of Transportation Administration in 1973 to establish a separate transportation service for the physically disabled. The advisory board worked with the Office of Transportation Administration to develop the Special Transportation Service (STS) program. The study design developed for the program was premised on the use of paratransit services offered by privately operated for-hire taxicab and lift-equipped van systems and was designed to accommodate persons too physically disabled to use regular line-haul bus services operated by the county's Metropolitan Transit Agency (MTA).

Dade County's stated goal was to provide public transportation facilities for the transit handicapped who is presently unable to achieve a reasonable degree of mobility in meeting his or her personal needs. The STS study design proposed a series of service objectives for a demonstration program based on specific trip purposes. The service objectives emphasized the provision of transportation for purposes not being met by other public or private nonprofit social service agencies. These were based on the assumption that trip priorities of handicapped persons would be much the same as for nonhandicapped persons if a suitable paratransit system were available. The result was an emphasis on providing services for work and school trips followed by medically oriented trips and a variety of shopping trips. The fifth objective was to provide nonessential trips that enrich and enhance the quality of life, such as trips to religious centers, recreation facilities, or friend's homes. As will be shown later, initial assumptions of handicapped user trip purposes were not always correct.

Late in 1975, the Office of Transportation Administration established a program manager's office and publicized the program widely. Initially, 20 000 application forms were distributed to as many social service and public information agencies as possible. The forms could be mailed back by potential users, who were certified by a review process as to their eligibility to participate in the program, the type of transit service they were eligible for, and whether they were transferable