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RESEARCH RECORD 784

Providing Transportation Services for the Elderly and Handicapped

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COMMISSION ON SOCIOTECHNICAL SYSTEMS
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Coordination and Consolidation of Agency Transportation

JON E. BURKHARDT

The coordination or consolidation of the transportation operations of social service agencies is a strategy that has substantial intuitive appeal. Coordination has often been proposed as a means of eliminating duplication and waste, saving money, serving unserved groups, and expanding services. Statutory and regulatory obstacles to coordinating agency transportation systems exist and are discussed in this paper. They can be surmounted, as shown in demonstration projects, but the coordination process is more costly, complex, and time consuming than had been imagined. The intended benefits of coordination will probably be achieved only if certain preconditions are met and if precise coordination strategies are followed. Coordination should be viewed as one of a variety of means for improving the mobility of the transportation disadvantaged.

Efforts to coordinate transportation services are receiving a great deal of attention these days. From such efforts, it is apparent that coordination can sometimes--but not always--be beneficial.

It is very important to determine the reasons for coordination at the outset of planning any coordinated transportation system and to communicate these reasons to all parties that will be involved. Coordinated transportation systems presumably create demonstrable benefits vis-à-vis uncoordinated, specialized, particularized transportation. Generally, the following reasons are put forth as rationales for coordinating transportation services: (a) to eliminate the overlap and duplication of service (to the same population groups in the same geographic area), (b) to fill gaps in service, (c) to save money by eliminating duplication and by achieving economies of scale usually reserved for larger operations, and (d) to improve and expand service. Although all of these reasons apply generally as advantages of coordinating transportation services, each reason applies to greater or lesser degree depending on (a) the geographic and demographic characteristics of the area served (e.g., urban versus rural), (b) the type of social service provided (e.g., a multiservice agency that serves several different client groups or a single-purpose agency that provides a discrete service to one categorical client group), and (c) the size and scope of the transportation service provided (e.g., a large fleet of vehicles serving many clients at different times of the day and/or week for different purposes or one vehicle serving a few clients at the same time each day for one purpose).

This paper will discuss a few of the many issues involved in coordination. We will examine preliminary observations from the U.S. Department of Health, Education, and Welfare (HEW) coordinated transportation demonstration, review the results of a study of statutory and regulatory barriers for the U.S. Department of Transportation (DOT), and discuss some overall observations derived from other field work.

TRANSPORTATION DEMONSTRATION PROGRAM

This section summarizes some of the evaluation results for the first 14 months (June 1977 through July 1978) of a two-year demonstration program sponsored by the Office of Human Development Services (OHDS) of HEW (1). Thus, the tentative and interim nature of these comments must be emphasized. More conclusive findings will be available next year.

The program's purpose is to show that coordinating or consolidating existing transportation services at the local level can enhance both the quality and quantity of human service transportation; its overall goal is to effect national policy and programming.

The design of the transportation demonstration program reflects the OHDS premises that (a) existing transportation services provided to OHDS populations through federal, state, and local sources can be coordinated at the local level with minimal incentive monies and (b) coordination or consolidation of transportation activities will increase efficiency (by reducing duplication and total systems costs) and effectiveness (by reducing fragmentation and improving access to services). Thus, the program's specific objectives are to develop practical approaches to coordination at the local level, explore and test service delivery systems and organizational methods for coordinated transportation, develop and test methods for coordination with existing public and private transportation providers, and identify statutory, regulatory, and administrative barriers to coordinated transportation.

Five demonstration grants were awarded in June 1977 to these agencies:

1. Northwest Arkansas Human Services, Inc., Fayetteville, Arkansas (site A);
2. Grand Rapids Transit Authority, Grand Rapids, Michigan (site B);
3. Community Action Council of Howard County, Maryland, Inc. (site C);
4. Greater Jacksonville Economic Opportunity, Inc., Jacksonville, Florida (site D); and
5. Westchester County Department of Transportation, Westchester County, New York (site E).

Overview of the Demonstration Sites and Projects

The five grantees were selected from 48 applicants that had responded to a public notice of a competitive award. The guidelines for the applicants screened out agencies that had already begun to coordinate transportation services in their communities. In selecting applicants that had no previous experience, OHDS was working with the most difficult--and probably the most typical--type of local agencies that may undertake coordination attempts in the future.

The projects provide a range of coordination concepts (see Table 1). The clearinghouse concept, Project Respond in Fayetteville, allows the participating agencies the greatest amount of flexibility and requires the least amount of commitment. In

Table 1. OHDS transportation demonstration projects: coordination concepts.

	Site				
Proposed Concept	A	B	C	D	E
Information and referral	X	X			X
Clearinghouse for ridesharing and time sharing	X				
Coordination of operations		X		X	
Consolidation of vehicle operations			X	X	X
Purchase of transportation services				X	X
Centralized dispatching		X	X	X	
Centralized maintenance	X	X	X	X	X
Centralized purchasing	X	X	X	X	
Planning assistance					X
Funding assistance	X				

Grand Rapids, certain functions (e.g., dispatching) are consolidated, but most trips are still provided by agencies that act independently of one another. The local transit authority is the grantee. The Urban-Rural Transportation Alliance (UTA) in Howard County has achieved the greatest degree of consolidation; it has completely taken over the transportation budgets and vehicles of the participating agencies to provide services as an independent entity. In Jacksonville, several coordination concepts are being approached simultaneously by Ride, Inc., including the consolidation of several agencies' resources and services, coordination with others, and purchase-of-service agreements with still others. The local transit authority has been involved in planning the sytem and is expected to take part in operations during the second project year. The Westchester Coordinated Transportation Project (WCTP) is incrementally consolidating human service agency operations and eventually plans to implement a countywide paratransit system that will serve clients as well as elderly and handicapped persons who may not be social-service-agency clients. The text table below gives further details on funds awarded by OHDS for coordination of transportation services.

Element	Funding ($)
Lowest site award	
First year	45 949
Second year	52 285
Highest site award	
First year	99 279
Second year	114 992
Total demonstration funds to sites	803 900
Technical assistance funds	
HEW	389 435
DOT	156 000
Evaluation funds	331 331
Overall demonstration costs to date	1 680 666

Preliminary Findings from HEW Demonstration

Achievements

The outstanding accomplishment of the demonstration projects to date is that they have managed to overcome many institutional, administrative, and perceptual barriers and have begun providing transportation service despite the problems involved. To be sure, the full potential of coordination or consolidation has yet to be realized. For example, although the unit costs for transportation should decrease after coordination (2), that has not been the case in four of the projects. Some projects have reduced their original unit costs and increased their productivity since beginning coordinated operations, although not to a level below that existing before coordination.

Coordination

It was easier for the projects to coordinate agencies than vehicles or trips. The two consolidated systems showed the greatest progress toward their coordination objectives.

Progress Toward Demonstration Objectives

In general, the objectives of the OHDS coordinated transportation demonstration program have not been met at this time, although substantial progress has been made in understanding the problems of and barriers to coordination. For the most part, coordinated transportation efforts have not been more efficient or effective than uncoordinated transportation operations. Consequently, the program has not yet demonstrated practical approaches to coordination. Furthermore, greater coordination with existing public and private transportation providers has not been achieved. Analysis of demonstration activities shows a need for substantial technical assistance at the local level. Thus, the premise that minimal OHDS funds are required to stimulate and implement coordinated transportation appears doubtful according to the data now available.

Coordination Process

The overriding theme emerging from the findings of the first year's efforts is that coordination is a more costly, complex, difficult, and time-consuming process than had been imagined, largely for the following six reasons.

1. It took much longer to develop the coordinated systems than had been expected. Although all five grants were awarded on June 1, 1977, transportation operations did not begin for 8-12 months. Delays of this magnitude had not been expected. In addition, it should be noted that the grantees had actually begun working toward an operational coordinated transportation system 5-6 months before the OHDS grants were awarded (and this was with the aid of the OHDS technical assistance contractor). In view of the activity before the grant award, a more accurate assessment of the time required to start up these coordinated transportation systems would be 12-17 months.
2. All five projects had major difficulties with staffing at every level. Not until four months after the grant award did all five projects have directors on board; this delayed administrative, planning, and development activities. By far the most difficult staffing area for all projects was that of drivers and dispatchers. Since driver salaries (an operational expense) could not be paid out of the OHDS grant, which was primarily for administrative purposes, the projects were dependent on staff pooled from participating agencies (in two sites) or the Comprehensive Employment and Training Act (CETA) or other public employment programs (in two other sites).
3. Few proposed participating agencies were actually participating in transportation operations at the end of the first project year. At three of the five demonstration sites, fewer than half of the agencies listed in the grant proposals were actually participating in any project activities other than advisory or policy board meetings. More participation in providing or purchasing transportation has been expected. Major contractual difficulties were encountered in two areas: (a) legal commitments from agencies to carry out previously agreed-on coordinating activities and (b) contractual commitments from major federal and state funding sources. Without signed contracts, many of the agencies were not legally or financially able to participate. Thus, implementation of transportation operations and related coordination activities (e.g., dispatching, maintenance, and purchasing) were delayed.
4. Vehicle maintenance proved to be a serious problem for consolidated systems. Both consolidated projects experienced vehicle maintenance problems related to the condition of vehicles pooled from participating agencies. Repair and maintenance of these vehicles added to the first-year costs for both projects.
5. Licensing and certification procedures were more complex and time consuming than expected. Generally, social-service-agency transportation services are not regulated by any state entity because

they do not carry the general public and do not charge fares. However, even though no money is collected directly from passengers, payment structures necessary for coordinated operations may be considered a form of fare, depending on state law. As a result, two grantees found it necessary to apply for common-carrier licenses and one had to apply for an invalid-coach permit in order to carry nonambulatory persons. In each case, considerable time was spent, and no resolution was reached by the end of the first project year.

6. The federal capital assistance process was too lengthy for delivery of vehicles. Early in the first project year, each project recognized the need for capital equipment to supplement the vehicles that were pooled or shared (depending on the method of coordination attempted) at the five demonstration sites. The bidding, licensing, and procurement procedures associated with obtaining capital assistance through the Urban Mass Transportation Act are complex. Even projects linked with transit authorities were confronted with unforeseen problems as part of the capital equipment procurement process. In fact, the OHDS two-year demonstration grants will have terminated before the delivery of vehicles that could expand the projects' services in two of the projects.

Transportation Operations

Each demonstration project has shown improvements in the short time that services have been available. In general (but not always), coordination has increased and the number of riders served has increased. Costs per unit of service have also increased, but not much. Current trends suggest that improvements might continue.

Despite these definite achievements, room for improvement exists in other areas. Some projects are serving large numbers of riders; others are running nearly empty vehicles. Providing reliable, high-quality service has sometimes been a problem because of inexperienced dispatchers and because of assortments of vehicles in various states of repair. Compared with transportation services before coordination, there has not been much success in reducing the unit transportation costs of participating agencies, although some participants at some sites are already receiving monetary benefits from coordination. Compared with similar paratransit operations across the country, two of the demonstrations have done remarkably well in providing efficient services within a short time. These same two projects, the consolidated systems, showed the highest scores to date on almost all performance measures.

Costs Before and After Coordination

Costs to agencies participating in the demonstrations more often increased than decreased after coordination (the reverse was expected). The increase was apparent even after adjustment for inflation. Decreases in costs to participating agencies occurred only at sites that had consolidated operations.

Comparative Performance Indicators

In August 1978, trip costs ranged from $2.88 per trip to $29.24, as shown in Table 2. The costs per trip are acceptable for two of the five projects; the others should be improved. Costs per vehicle mile were generally good. Productivities (passengers per vehicle mile and passengers per vehicle hour) were generally low. Overall, the projects did not obtain as much mileage per month from their vehicles as other systems did, but one demonstration (Jacksonville) was operating at a high level of passengers per month.

Table 2. Operating statistics of OHDS coordinated transportation demonstration projects as of August 1978.

Measure	Lowest Value	Highest Value	Acceptable Range[a] Low	Acceptable Range[a] High
Efficiency measures				
Cost per one-way passenger trip ($)	2.88	29.24	1.50	3.50
Cost per vehicle mile ($)	0.60	1.96	0.40	1.00
Cost per vehicle hour ($)	11.88	44.91	9.00	18.00
Load factor (%)	–	–	15	35
Operating ratio	–	–	0.25	1.0
Effectiveness measures				
Passengers per vehicle mile	0.07	0.32	0.20	3.0
Passengers per vehicle hour	1.54	4.12	4.0	18.0
Annual passengers per service area population	–	–	3.0	20.0
Other descriptors				
One-way passengers per month	354	11 141	1000	8000
Monthly vehicle miles per vehicle	1321	1847	2500	7500

[a] The derivation of this range is discussed elsewhere (1).

Possible Elimination of Major Problems Remaining

Three general problems have yet to be resolved at many of the sites: (a) finding continued funding for the projects, (b) reducing the unit costs, and (c) obtaining additional resources (including vehicles and drivers). These problems are obviously interrelated and revolve around one issue: Can the projects achieve enough financial success to attract additional and continued support? That has not yet happened at any site. Whether it will in the time remaining is uncertain. Equally uncertain is the possibility of overcoming specific problems at the individual sites.

Possible Changes in Performance Measures

The performance measures of the projects (that is, efficiency and effectiveness) should improve during the second year. In some cases, the improvement might be dramatic. The many political and organizational problems encountered by the projects left little time for actual transportation operations. Transportation services should improve once they become the focus of attention and activity. Thus, although the projects have not yet achieved the demonstration program's objectives, more should be accomplished during the second year.

Summary

Since the evaluation of the second year's activities is not yet complete, and since three of the five projects are entering into a third year of HEW demonstration assistance, some of the observations about the first year's results may change when the demonstration period is viewed as a whole. Whether coordination of transportation services is beneficial in the long run remains to be demonstrated.

STATUTORY AND REGULATORY BARRIERS TO COORDINATION

Many social service agencies may be unwilling to consider interagency coordination (for transportation purposes) because they perceive such activity to be inconsistent with the policy or statutory mandate of their federal and/or state funding source (3,4). Since these perceptions (which may or may not be accurate) color social-service-agency response to coordination attempts, it is important that persons planning, implementing, and operating the projects have a good working knowledge of the federal and state statutes and regulations governing the programs to be coordinated.

Analysis of the federal statutes that govern the programs that are known to spend the largest amounts of money on transportation--Urban Mass Transportation Act of 1964, as amended [sections 2, 3, 5, 8, 13c, and 16b(1) and b(2)]; Rehabilitation Act of 1973, as amended; Mental Retardation Facilities and Community Health Centers Construction Act of 1963, as amended (Developmental Disabilities Program); Social Security Act (Title XX and Title XIX); Older Americans Act of 1965, as amended; and Community Services Act of 1974, as amended, including the Head Start and Community Action Programs--shows that the kinds of barriers that arise include funding (nonfederal match, funding ceiling, and planning) and services (eligibility, geographic coverage, method of payment, fees or contributions, and service restrictions) (5).

Nonetheless, none of these barriers constitutes an overwhelming obstacle to coordination; they merely require time and effort to circumvent. Coordination can be achieved, but there is a need for considerable interaction between planners and operators of coordinated transportation systems and state and local administrators of the federal programs early in the planning process. This interaction can help answer questions regarding (a) the feasibility of coordinating with a particular program, (b) the time and effort required to obtain the participation of a program, and (c) the costs versus the benefits (to the system) of coordinating with certain programs. Furthermore, interaction is required to resolve the following issues related to the program components.

Funding

The Nonfederal Match

Key questions about nonfederal matching funds include the following:

1. Who is required to meet the nonfederal cash match? Is it the state, the locality, or a combination of state and locality (and what ratio for each)? Can the match be met by a local provider (rather than the locality)?
2. Who is required to meet the in-kind match? Can it be a local service provider or administering agency or a combination of the two?
3. Can the in-kind or cash match be provided through private donations or only through public sources?
4. How is the in-kind match valuated?
5. Are there possibilities of waivers of all or part of the nonfederal match under certain conditions (i.e., Community Action Program waivers for multijurisdictional projects and poverty areas)? How would such waivers affect the agency's participation in a coordinated transportation system?

Title XX Funding Ceiling

Planners and operators who wish to obtain Title XX funding should thoroughly investigate the state's relationship to its Title XX ceiling, because that relationship will affect the possibility of using Title XX funds for coordinated transportation. This issue should be discussed with the appropriate officials of the state Title XX agency before obtaining participation commitments from local agencies that expect such funding.

If the state is near or at its ceiling, the key questions are the following:

1. Have Title XX funding sources been (or will they be) transferred to another title of the Social Security Act (e.g., Title XIX or Medicaid) to pay for certain services?
2. To which title have the funds been transferred? Is transportation funded under the title? Can the funds be used for coordination services?
3. If Title XX funds can be obtained, for how long can such funding be expected? (States approaching their ceiling are often unwilling to undertake new program initiatives that may not be sustainable in a year or two.)

Planning

Planners and operators of coordinated transportation systems should first determine whether the state planning and budget processes (for the programs being considered for participation in the system) are linked or whether the budget process precedes the planning process. Because of the nonfederal matching requirements imposed on federal-state programs, the budgetary process is often the point at which service priorities are established. Thus, the state budget process could be the key point of entry for a coordinated transportation system seeking funding through any of the federal-state formula grant programs.

If the coordinated system wishes to be considered for funding as a service project (as opposed to an ancillary service), the state plan process must be investigated with the state agency so that an application can be made to the appropriate funding source at the most propitious time.

Other key information regarding planning includes the answers to the following questions:

1. Are there state (or local) planning or budget requirements over and above the federal requirements?
2. What impact do these requirements have on the participation of the state or local agency in a coordinated transportation system?
3. How do such requirements affect the development or operations of the coordinated system?

Services

Eligibility

In most cases, the eligibility issue can be dealt with by negotiating purchase-of-service contracts with the program in question. However, in the case of consolidation, where the system depends on the pooling of agency vehicles and other resources (manpower, funds), methods of overcoming certain limitations posed by eligibility requirements must be investigated with the appropriate state or local agencies. Examples include limiting vocational rehabilitation services to current program recipients and limiting Community Action Program and Head Start services to low-income groups.

Either the state Title XX agency or the service provider (under a purchase-of-service contract) may determine eligibility. Because of the staff time and expense involved (especially for individual determinations), a coordinated transportation system that receives Title XX funds may wish to have the state make all eligibility determinations. However, such policies are at the state's option, and the local provider must generally conform to them. Therefore, consideration should be given to state determination policies early in the planning stages of a coordinated system to allow for adequate staff and time for such activities. The options regarding eligibility determination should be discussed with the state Title XX agency, because the option that has been adopted by a state on any one of the determination issues can have an impact on the development and operation of coordinated transportation services.

Geographic Coverage

When a program for participation in a coordinated or consolidated transportation system is considered, careful attention should be given to the geographic boundaries in which the program must operate. The answers to the following questions will facilitate effective planning. Does the program operate within specific jurisdictional boundaries (cities, counties)? Under what conditions can these boundaries be crossed for service provision? If the boundaries cannot be crossed, coordination can still be implemented in some cases. Some possible alternatives include (a) a purchase-of-service contract for a specified area within the larger areas served by the system, (b) time sharing or ridesharing among two or more agencies operating vehicles within one jurisdiction (e.g., county), and (c) a mixture of consolidation (pooling of vehicles) in one jurisdiction with purchase of service in areas outside the program jurisdiction. (This alternative depends on a system that has the vehicles and other resources necessary to accommodate such a mix.)

The barrier that will be most difficult to overcome in this regard arises when the coordinated system serves an area smaller than the service area covered by the program agency. In some cases, the program will not be willing (or able) to purchase a service or pool vehicles for only part of its target population.

Method of Payment for Service

This issue is crucial to the effective development of a coordinated system, not only because the way a program pays for service could obviously have financial implications for the system, but also because planning and operational delays and legal problems can occur if a coordinated system attempts to comply with certain payment methods.

Fees or Contributions

Some questions about fees and contributions include the following: Is the collection of fees or fares permitted? Is the collection of fees or fares permitted or required for only certain members of the client population (e.g., Title XX)? Are voluntary contributions encouraged for client payment for service? What are the limits of such voluntary activity (e.g., are "suggested" amounts of contributions permitted)? Can the program agency purchase bulk tickets for transportation-service clients or is that considered cash assistance and prohibited? Are the fee policies of the program agency consistent with those of other agencies participating in the system?

Service Restrictions

The restrictions placed on service delivery under the various programs should be examined in terms of their implications for barriers to coordination. For example, Section 13c (the labor- and wage-protection requirements for Sections 3, 5, and 18 of the Urban Mass Transportation Act) should be studied for its impact on the coordination of (a) mass transit with social-service-agency transportation (e.g., union versus nonunion social-service-agency drivers and dispatchers, the displacing of transit personnel by social-service-agency volunteers or part-time personnel as drivers and dispatchers) and (b) "hands-on" service required for certain types of severely physically or mentally impaired riders. In addition, the Section 13c clearance process (through the U.S. Department of Labor) is a lengthy one that could affect the implementation or start-up of a coordinated system. Consequently, clearance timing should be taken into account during the planning process.

State rehabilitation agencies are required to develop and maintain written policies for the vocational rehabilitation services they provide or support, including transportation. These policies should be carefully reviewed and discussed with appropriate state agency personnel in terms of their implications for coordinated transportation. State policies and procedures for transportation provided under the Developmental Disabilities Program, although not required by federal regulation, may exist and should also be reviewed.

As noted earlier, Title XX does not permit federal financial participation for medical or remedial care (except for family planning) unless such care is an integral (but subordinate part) of another Title XX service under the state plan and "not available to the individual under the state's Title XIX Medicaid plan" and the individual or provider is not eligible for payment under Title XVII (Medicare). This restriction virtually prohibits coordination between Titles XIX and XX transportation services. Furthermore, it affects the inclusion of programs other than Title XX in a coordinated system, since many clients of the federal-state social service programs (e.g., aging, rehabilitation, and mental health) are eligible for both Title XX and Medicaid services. It is essential that this issue be carefully investigated with both the Title XX and Medicaid state agencies.

COORDINATION STRATEGIES

The difference between successful and unsuccessful coordination attempts often depends on the ability of the implementers to specifically identify and use appropriate coordination strategies. Clear understandings of which strategies are being used for which purposes are crucial.

The major types of coordination strategies are to reduce actual expenses on capital equipment, overhead, and direct costs; to increase amount of service to specific areas or populations; to increase efficiency through lower unit costs, increased labor productivity, and improved vehicle utilization; and to improve provision of services (effectiveness) through greater productivity, increased service quality, better financial management, greater local political support, and other means. The choice of a particular strategy is dependent on the problems that have been identified in the service area (6).

Each of the strategies is, of course, subject to further substrategies in implementation. For example, overhead expenses could be reduced by consolidating the following kinds of functions: dispatching, bookkeeping, systems management, scheduling, and financial applications. (Consolidation here probably means releasing some persons from jobs they currently perform and expecting others to work harder at those jobs.)

The benefit of identifying particular strategies is that it changes coordination from a general concept into a specific plan. When someone says, "I want to reduce direct costs by lowering system maintenance charges," it is very easy to see whether this has been accomplished or not. Making the objectives specific helps make them possible to achieve.

ASSESSMENT

The technical criticisms against coordination as a panacea are compelling. The basic selling point for coordination has been that it saves money (7). In fact, this is not in general true--it is only in very special circumstances that coordination costs less. Coordination is more costly and time consuming and less universally applicable (8) than any of us had initially anticipated. There are substantial front-end costs of planning and administration that generally will not (or cannot legally) be borne by any of the participants. There are certain agencies that have not made their transportation expenses explicit for the valid reason of not being able to include a line item in their budget for transportation. Other agencies have developed "deals" to get clients to their destinations at less than full costs. Such agencies cannot benefit from a system that makes all costs explicit and fully chargeable. To force other agencies into a formal purchasing structure reduces their flexibility for special trips. In addition to such problems, it also appears that (a) coordination between social service agencies and existing public and private transportation providers will be more difficult than previously assumed and (b) substantial federal aid will be necessary to fund the staff and technical expertise needed to make coordination work.

Coordination can work extremely well in specific instances. Such instances must include the following kinds of conditions:

1. Consolidation of the transportation programs of some but not all of the social service agencies in an area;
2. The existence of one lead agency that has substantial cash or cash potential to handle problems such as vehicle maintenance and cash flow;
3. Adequate billing and accounting procedures;
4. An available outside authority able to fund the initial planning, start-up, and technical assistance;
5. Commitment and involvement of local government officials; and
6. Strong and skilled project management.

When these requirements are met, cost savings through coordination are possible. Coordination could then also generate other benefits, among them releasing certain agencies from the responsibility of providing transportation, allowing them to purchase services instead; increasing the quality (especially the reliability) of transportation services; and stimulating the coordination of nontransportation services by human service agencies.

CONCLUSION

Coordination is a useful concept in some but not all instances. In order for the potential cost savings in transportation operations to be realized from coordination, substantial planning and administrative expenditures are necessary. However, because of certain fiscal structures, volunteer contributions, or special service requirements, some agencies will never benefit from coordinating their operations with those of other service providers, whereas coordination will enable others to substantially increase the amount of services they deliver.

When we began operating specialized transportation systems, we had a definite objective in mind. It is possible to become so wrapped up in the intricacies of implementation techniques--like coordination--that we lose sight of the original objective. Coordination is only one of the many steps along the way to achieve a broader goal--increased mobility for those who are not able to provide their own transportation. It is time we refocused our attention on ways of increasing mobility.

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Characteristics of Dallas, Texas, Taxicab Patrons: Results of a 1977 Survey

MELISSA A. EISENBERG AND WILLIAM G. BARKER

This paper presents the results of a survey of taxicab riders in Dallas, Texas. Besides a socioeconomic profile of the taxi ridership, differences and similarities among certain identifiable groups are also given. For this analysis, taxicab riders are first classified into two basic groups: residents and nonresidents. Resident taxicab patrons are further divided into three categories: transportation disadvantaged, middle-income persons, and the affluent. The sex, race, income, trip purposes, and availability of alternative modes of transportation of these different groups are compared. Respondents to the questionnaire were asked whether they would have taken the trip if the fare were higher by specific amounts. The resulting sensitivity of demand to higher fares is analyzed by income and trip purpose. Finally, the paper reports the responses regarding alternative transportation modes. Significant differences are noted between residents and nonresidents.

Information about taxicab users is scarce, and recent data on Dallas taxicab ridership appear to be almost nonexistent. However, in order to develop policy proposals that would facilitate the efficient use of taxis and provide better service to consumers, a basic knowledge of the market and demand characteristics is necessary. This report presents a socioeconomic profile of taxicab ridership, identifies the major user groups based on these characteristics, and examines the important differences between these groups for Dallas, Texas, from data collected through an in-cab driver-administered survey conducted August 9, 1977. The last section of the report discusses the demand for taxis in Dallas and compares the use of cabs with that of alternative modes of transportation. Of particular interest is the apparent impact of the rental car on taxicab ridership levels.

DALLAS SURVEY

Dallas, Texas, has three taxicab firms that provide local service to residents of and visitors to the city: Yellow Cab, Terminal Cab, and State Cab. As Table 1 indicates (1), there were more than 2 million taxicab riders in Dallas in 1976. These statistics do not include, however, any of the 268 124 passengers carried in 1976 by Surtran Taxicab, which then provided service almost exclusively from the Dallas-Fort Worth Regional Airport to Dallas, Fort Worth, and surrounding communities.

Fares, service levels, and cab appearance are regulated by the city of Dallas. Almost all of the drivers are independent owner-drivers, with the exception of a small number of company drivers with Yellow Cab. All three companies provide radio dispatching.

Table 1. Dallas taxicab statistics, 1976.

Company	Number of Cabs	Total Kilometers	Total Paid Kilometers	Total Trips	Total Passengers
Yellow Cab	300	15 947 860	7 192 485	958 992	1 372 180
Terminal Cab	181	3 772 665	1 649 358	404 155	626 816
State Cab	15	1 161 862	471 847	61 578	80 760
Total	496	20 882 387	9 313 690	1 424 725	2 078 756

Survey Approach

After months of research, including an analysis of a 10 percent sample of Dallas taxicab trip sheets for May 18, 1977, the survey was conducted on August 9, 1977. An in-cab, driver-administered questionnaire was used; i.e., the taxicab driver gave the questionnaire to the passenger, who, in turn, completed the form and returned it to the driver at the end of the trip. Of the 410 questionnaires distributed, 385 (94 percent) were returned, and 296 (72 percent) were usable.

Questionnaire

The questionnaire forms were printed on both sides of heavy-stock paper; one side was to be completed by Dallas residents and the other side by Dallas visitors. Each questionnaire had questions about the location of the patron's residence so that a check could be made to make sure the appropriate form was completed. Of the 296 usable questionnaires, 184 (62 percent) were completed by residents and 112 (38 percent) by visitors. [Copies of the questionnaires are available from the North Central Texas Coucil of Governments.]

Distribution Procedures

As mentioned previously, taxicab drivers were asked to distribute the questionnaires, which were to be completed by patrons while they were in the cab. An attempt was made to distribute the forms in approximate proportion to the number of trips normally carried by the three firms (Yellow: 66 percent, Terminal: 26 percent, State: 8 percent). In driver meetings that were held about one week before the survey date, drivers were orally instructed about the survey procedures. They were asked to fill in the date, cab number, and trip number (corresponding to the trip number from the trip sheet) on each of the 10 forms that each driver received. Trip characteristics from the trip sheet would later be matched with the survey forms. Drivers were asked to give a survey form to each of their first 10 patrons on August 9, 1977.

RIDER PROFILE

The first analysis of the data consisted of compiling a profile of the users of Dallas taxicabs. Such terms as age, sex, race, and income were examined.

Most Dallas taxi riders are of working age, although the young and the elderly are important user groups as well. Over half of all Dallas taxicab riders are between the ages of 22 and 45, and almost one-fourth are aged 46 to 64. Four out of every five riders belong to these two age categories. The age distribution of taxicab users is given in the text table that follows.

Age	Percent
21 or under	8.3
22-45	58.8
46-64	23.6
65 +	9.2

Slightly over half of the respondents are female, and more than three-fourths of those surveyed are white. These figures closely resemble the sex and race distributions for the city of Dallas in 1977 (2). The following table displays these results.

Characteristics	Taxicab Riders (%)	1977 Area Population (%)
Sex		
Male	48.2	51.0
Female	51.8	49.0
Race		
Black	19.1	23.2
White	76.8	70.1
Other	4.1	6.7

Dallas taxicab riders are most likely to earn less than $10 000 annually; 52.2 percent of the users who responded to the income question reported their yearly earnings at $10 000 or under. This percentage is disproportionately high compared with the income distribution for the resident population in these categories. As will be shown later, most higher-income patrons are nonresidents, thereby further emphasizing the significance of the number of low-income riders. Results of research in other cities have also shown that low-income persons make intensive use of taxis (3,4). In addition, one out of every five resident taxicab patrons surveyed indicated that he or she was handicapped to some extent.

Kirby and others assert that nonresidents constitute a substantial taxi user group in many cities and that "the size of this segment of the market will probably vary markedly from city to city, depending on the city's importance as a tourist or business center, or as an interurban transportation interchange point" (5). In light of Dallas' importance as a regional commercial and trade center, as well as its emergence as a major convention city, it is not surprising to find that 36 percent of those surveyed were nonresidents. The survey date was chosen by Dallas officials as being "typical" with regard to convention activity.

The person most likely to be found in a Dallas taxicab is, thus, a white, female Dallas resident between the ages of 22 and 45 who has an annual income of $5000 to $10 000. She may have been able to use another form of transportation for that particular trip but found it more convenient to ride a cab. She probably is not handicapped.

TRIP CHARACTERISTICS

For the purpose of analysis, the day was divided into four time periods based on the results of an earlier report about trip characteristics in the city of Dallas (6). Of all taxicab trips, 81 percent are made between the hours of 4:00 a.m. and 7:00 p.m. Most are single-passenger trips, although 22 percent consist of two or more riders. The average trip length is 8.05 km (4.83 miles), and the mean fare is $4.19. Evidence from reports in other cities indicates that there is little variation in the number of riders throughout the day, although slight peaks are exhibited during early morning, lunch hour, and late afternoon times (7). A large majority of cabs were hailed by telephone request (78 percent), but pickups constituted a substantial proportion (22 percent).

The work trip is the single most important trip purpose. Of the persons responding to the survey, 26.9 percent indicated their trip to be for this reason, and reports of taxicab use in other large cities substantiate this finding (4). The next most important trip purpose is business other than to work; 21.1 percent of taxi riders used cabs for this reason. Medical-related trips, shopping trips, and trips to the airport each account for approximately 10 percent of the ridership. Other important trip-purpose categories include trips from the airport, trips for entertainment, and trips for family or personal business. The survey results of trip distribution by purpose are displayed below.

Purpose of Trip	Percent	Purpose of Trip	Percent
To work	26.9	Personal or family business	4.2
Business other than to work	21.2	Vacation	1.4
Doctor or dentist	10.8	Visit	1.4
Shopping	10.4	School or church	0.5
To airport	9.4	Other	3.4
From airport	5.7		
Entertainment	4.7		

IDENTIFIABLE GROUPS

Dallas taxicab riders can be classified into two basic categories: residents and nonresidents. Differences between the two groups in terms of sex, race, income, trip purposes, and availability of alternative modes of transportation are identified in the following discussion. Resident taxicab patrons are further classified into three groups: transportation disadvantaged, middle-income, and affluent.

Nonresidents

As mentioned previously, 36 percent of the respondents were nonresidents. This category includes primarily businesspersons, since 74 percent of the nonresidents indicated that business was the purpose of their trips to Dallas. Of the nonresidents responding, 93.3 percent are between the ages of 22 and 64 and one-third earn more than $25 000 per year, although all income categories are represented (see Table 2).

A substantial difference between the resident and nonresident subpopulations surveyed is in the proportion of males and females. In contrast to the nonresident distribution, 64 percent of the resident taxi users are female, and 46 percent of resident women riders do not have driver's licenses. Thus, nonresident cab riders tend to be white males of a working age and are likely to belong to higher income groups. These statistics strongly suggest that important differences exist between resident and nonresident cab riders.

Residents

For purpose of analysis, resident taxicab patrons will be classified into three broad and somewhat overlapping categories based on the rider-frequency patterns exhibited by the various income groups, as well as the findings of earlier research. They are (a) the transportation disadvantaged (includes the elderly, the handicapped, those in lower income groups), (b) the middle-income riders (those earning between $10 000 and $15 000 annually as of August 1977), and (c) the affluent riders (those whose annual earnings are greater than $15 000). Social

Table 2. Characteristics of resident and nonresident cab riders.

Attribute	1977 Dallas Population (%)	Taxicab Rider Survey (%)	
		Residents	Nonresidents
Age			
21 or under	40.5	9.9	5.3
22-45	33.6	53.9	68.0
46-64	18.0	22.7	25.3
65+	7.9	13.5	1.4
Race			
Black	23.2	24.0	10.2
White	20.1	71.0	87.2
Other	6.7	5.0	2.6
Sex			
Male	51.0	36.0	71.0
Female	49.0	64.0	29.0
Yearly income ($000s)			
<5		33.1	4.0
5-10	36.0[a]	33.8	22.7
10-15	19.0	14.6	17.3
15-25	27.0	11.5	22.7
25+	18.0	7.0	33.3
Driver's license			
Yes		54.0	94.0
No		46.0	6.0

[a]This figure also includes those with annual incomes of less than $5000.

and economic characteristics of each category will be examined to facilitate a better understanding of the motivational differences in taxicab use among Dallas residents.

Transportation Disadvantaged

Although people aged 65 and over constitute 7.8 percent of the population in Dallas, they account for 13.5 percent of the taxicab ridership (8). Similarly, whereas 6 percent of the city's population is handicapped, 20 percent of the resident taxi-survey respondents reported some limiting physical disability. Together, the two groups accounted for 29 percent of the resident cab riders on August 9, 1977, a disproportionately high amount considering that they make up only 13 percent of the population. Thus the taxicab appears to be an important means of mobility for the elderly and particularly the handicapped.

A vast majority of older and handicapped cab patrons are female. The percentage of women in these two groups is disproportionate to the number of women in the city's population as well as in the sample population. Females constitute 74 percent and 84 percent of the handicapped and elderly taxicab patrons, respectively. The characteristics of elderly and handicapped resident taxicab users are given below.

Characteristic	Elderly (%)	Handicapped (%)
Sex		
Male	16.0	26.0
Female	84.0	74.0
Income ($000s)		
<5	50.0	45.8
5-10	27.8	33.3
10-15	11.0	0.0
15-25	5.6	16.7
25 +	5.6	4.2
Monthly use of cabs		
Once or less	10.5	14.8
2-3 times	42.1	37.1
4-10 times	26.3	29.6
More than 10 times	21.1	18.5

More than three-fourths of the elderly do not own automobiles or possess driver's licenses (77.8 percent), and 83.3 percent could not have driven themselves. Most of those over 65 years of age could have used another form of transportation, however; 71.4 percent said they could have obtained a ride in another automobile, and 60 percent could have ridden a public bus. On the other hand, the handicapped riders surveyed have greater access to private automobiles than do the elderly. Half of the handicapped respondents reported that someone in their household owned a car, although 63 percent of these respondents do not have driver's licenses. Of the handicapped respondents, 77 percent could not have driven themselves, 64 percent could have been a passenger in another automobile, and half would have been able to take a bus.

Another type of transportation disadvantaged, the low-income group, in Dallas consists predominantly of younger adults and females. Most taxi riders who earn less than $10 000 per year are 22-45 years of age, and approximately two-thirds are women. Of all resident taxi riders surveyed who had annual incomes under $10 000, approximately 29 percent are black and almost all of the remaining low-income patrons are white.

Taxicab patronage among the transportation disadvantaged is characterized by a moderate rate of rider frequency. Of all those whose annual incomes are $5000 or less, over one-half reported using cabs four or more times per month, and 45.4 percent of those earning between $5000 and $10 000 ride taxis this often. Rider frequency is greater for those in the lower-income bracket, and substantial differences are exhibited in three of the frequency categories. Rider frequencies, automobile ownership, and possession of driver's permits for lower-income residents are shown below.

Characteristic	Annual Income (%)	
	Less Than $5000	$5000-$10 000
Monthly use of cabs		
Once or less	16.3	34.1
2-3 times	30.2	20.5
4-10 times	20.9	22.7
More than 10 times	32.6	22.7
Own car		
Yes	41.5	61.4
No	58.5	38.6
Driver's license		
Yes	32.6	58.1
No	67.4	41.9

Of the low-income resident cab patrons surveyed, there is a large group of frequent riders who use taxis primarily to travel to work. Many of these people could not have driven themselves, ridden in another car, or taken a bus; many are from households that have no car. Over half are female. Kirby and others attribute the widespread use of taxicabs among low-income persons to "the lack of any cheaper nonautomobile alternative with comparable flexibility," since some demand cannot be accommodated by means of the fixed schedules inherent to public transit (5).

The transportation disadvantaged (elderly, handicapped, and low-income) are an important class of taxicab users in the city of Dallas, accounting for approximately 70 percent of the resident ridership. The group is characterized by a low incidence of automobile ownership; a disproportionately large number of females, elderly, and handicapped persons; low annual incomes; and a moderate rate of rider frequency. A substantial number of these people are dependent on the taxicab for certain essential trips, particularly for medical and work trips, and many have no alternative mode of transportation. More than three-fourths of those considered to be transportation disadvantaged rated the taxicab service in the city of Dallas as either good or excellent.

Middle-Income Taxi Riders

The number of middle-income taxicab riders in the survey (14.6 percent) is closely proportional to their number in the population in Dallas (19.0 percent). Middle-income residents use cabs more regularly than those in other income brackets; almost three out of every five ride taxis four or more times per month. Nearly three fourths of the people in this income group are age 22 to 45. Except for the very affluent, fewer women are found in this group than in any other, and more whites belong to it than to the other income categories. Social and economic measures of the middle-income taxicab ridership are displayed below.

Characteristic	Percent
Age	
21 or under	0.0
22-45	73.7
46-64	15.8
65 +	10.5
Sex	
Male	42.1
Female	57.9
Race	
White	94.7
Black	5.3
Other	0.0
Monthly cab use	
Once or less	21.0
2-3 times	21.0
4-10 times	32.2
More than 10 times	36.9
Own car	
Yes	63.2
No	36.8
Driver's license	
Yes	68.4
No	31.6

A large number of middle-income respondents indicated that their residences were in North Dallas, and many reported living in the Park Cities. During the past few years, thousands of apartment communities have been established in these areas, thus increasing the population density and the traffic congestion. Many of the new complexes cater to young adults and, from the data, it seems reasonable to believe that a large number of the middle-income patrons reside in the new areas. Approximately two-thirds of these respondents possess driver's licenses and own automobiles, although this same number said that they could not have driven themselves for the trip. Half would have been able to ride a public bus and 38.5 percent could have been a passenger in another car.

The taxi trip purpose most often cited by this group was to work, and the next most frequent reason for using taxis was business other than to work. One-fourth of all business trips are made by people in this group, a disproportionately large amount relative to their percentage in the survey sample.

Intensive use of taxicabs is made by females in this income group. Although they constitute a little over half of the middle-income ridership, females account for nearly three-fourths of the most frequent taxi users. Almost half (45.4 percent) of the females in this group were traveling to work.

Frequent ridership, particularly by females, characterizes taxicab patronage among middle-income persons. These people are relatively young and use the cab primarily for the journey to work, although business trips constitute a substantial proportion of all rides undertaken by people in this group.

Affluent Riders

Cab users who earn over $15 000 per year constitute 18.5 percent of the resident taxi ridership. Several other reports have found disproportionately large numbers of affluent taxi riders, although, as previously discussed, most of the affluent Dallas users are not residents. The group of upper-income resident cab patrons is characterized by lower rates of rider frequencies than those exhibited in other groups. One-third of those who earn over $15 000 annually use taxis four or more times monthly, and 37.5 percent said they ride cabs less than once a month.

Although nearly three out of every four riders in the $15 000-$25 000 income category are female, this pattern is dramatically reversed in the $25 000 and over bracket, in which 88.9 percent of the riders are male. Only among the very wealthy do males constitute a larger percentage of the taxicab patronage. Almost 71 percent of the affluent riders are age 22 to 45, and more than four-fifths are white. The spatial distribution of affluent riders resembles their distribution in the city; more than 50 percent live in North Dallas.

As expected, the overwhelming majority of cab riders who earn over $15 000 annually belong to a household in which some member owns an automobile, and more than 83 percent of them possess driver's licenses. However, almost half of those in the $15 000-$25 000 income bracket and two-thirds of those who earn more than $25 000 reported that they would have been unable to drive themselves on that particular trip, and even more could not have obtained a ride in another car. Several upper-income passengers indicated that they would have been unable to use a bus for the survey trip.

In light of the high incidence of automobile ownership, it is surprising to find so many of this group unable to have driven themselves for the trip during which the survey was administered. Kirby asserts that extensive taxicab use is made by professionals and managerial workers for business meetings, lunches, and other daytime appointments (5). It is often faster, easier, and cheaper to use a taxicab than to deal with traffic congestion, parking shortages, and parking costs. Earlier reports have documented the widespread use of cabs by professionals and managerial workers, and one-fourth of the affluent resident taxi patrons surveyed gave business other than to work as their purpose. Beimborn found that 26.7 percent of the taxicab ridership in Chicago is composed of professionals, technicians, and managerial workers (9). The figure was 48.3 percent for New York in 1969 (3). Low rider frequency for this group suggests the use of taxis for irregular or unexpected trips.

EFFECT OF HIGHER FARES ON DEMAND

Included on the Dallas questionnaire was an item that asked respondents whether they would have used a taxi for that particular trip had the fare been increased $0.50, $1.00, or $2.00. Below are the results for taxi riders who responded to this question.

Increase in Cost	Percentage Willing to Pay: Residents	Nonresidents	All Patrons
$0.50	94.8	92.9	94.3
$1.00	84.3	88.2	85.5
$2.00	76.1	86.2	79.8

The sensitivity in demand to higher fares can also be estimated by income and trip purpose, as shown in Figures 1 and 2. For residents, an increase of $0.50 beyond the original fare would bring about the greatest decrease in demand among those earning $15 000 to $25 000 and those using cabs for shopping. In most cases, fare increases up to $1.00 bring about the greatest reduction in demand for taxi service for categories of income and trip purpose. However, cost does not affect behavior among the affluent until a $2.00 increase is reached, and demand from people using taxis for medical purposes is not responsive to cost increases beyond $1.00. Results of the analysis also show that the percentage of people willing to pay a higher fare generally increases as the original fare becomes greater.

Figure 1. Demand for taxicabs at higher fare by income (residents).

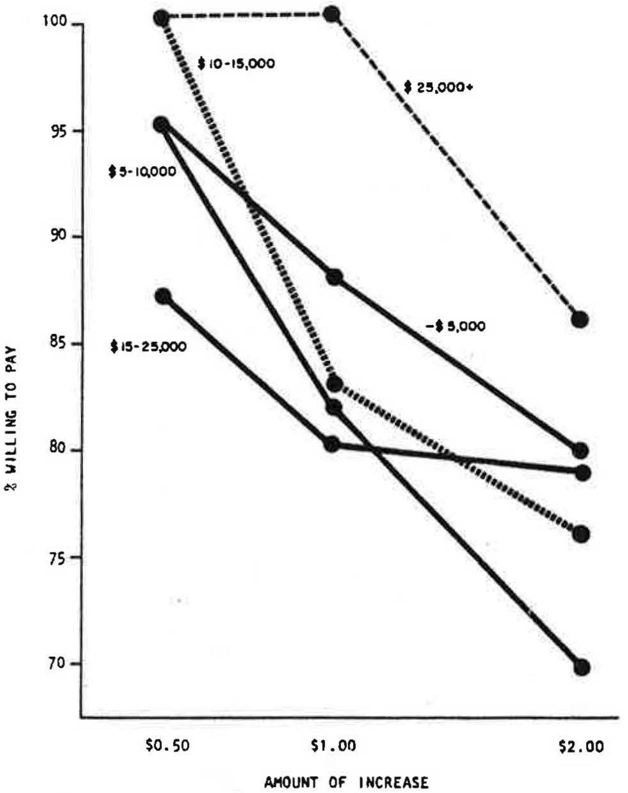
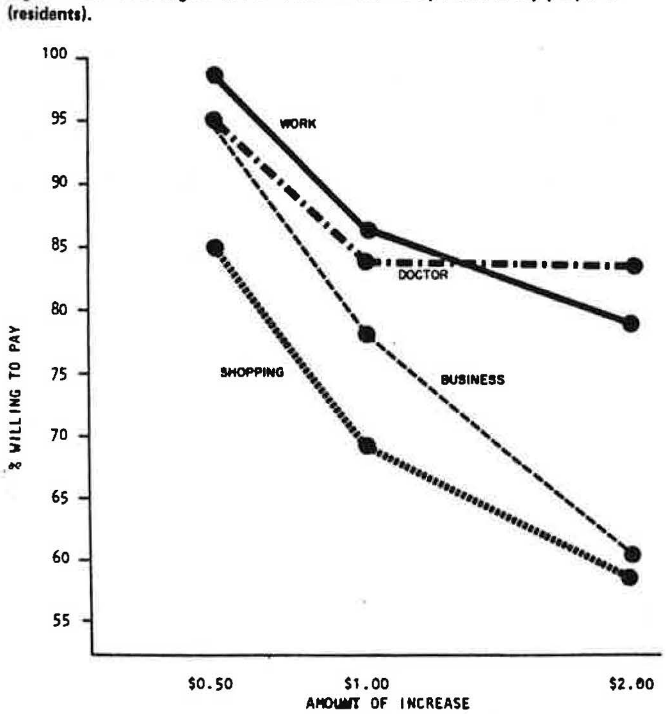


Figure 2. Effect of higher fare on taxicab demand by selected trip purposes (residents).



An examination of the correlation matrix of the variables in this analysis reveals no single factor that accounts for a large proportion of the variance in willingness to pay higher cab fares. From Figure 2, it can be seen that the number of trips taken by residents for business and shopping would be the most severely reduced by fare increases, while trips to work and to the doctor would decrease the least. For visitors, convenience is a primary impetus for taxicab use, and the benefits of the taxi are seen to outweigh the costs even at high price levels. Residents, on the other hand, are more aware of transportation alternatives and, when fares become high, it is likely that they are diverted to other modes.

ALTERNATIVES TO THE TAXI

In recent years, the rental car has gained in importance as an alternative to the taxicab. In order to examine the impact of higher taxi fares on other forms of transportation, survey respondents were asked to indicate their alternative transportation mode had they been unwilling to pay higher prices for their trips. Again, because substantial differences are expected to exist between residents and nonresidents, the two groups will be examined separately.

The most frequently cited alternative among resident taxicab riders is the bus. Of those refusing to pay a higher cab fare, 41.5 percent said they would use public transit; 37.7 percent would use a personal car. Less than 4 percent of these people would rent an automobile, and 5.7 percent could walk instead of ride. Only 3.8 percent of those refusing to pay more would forgo the trip entirely. Most of the demand diverted to public transit would consist of people who have low annual incomes and the proportion of those who indicate the bus as their alternative tends to decrease with increasing income. A positive relationship exists between the number of those specifying private cars as their option to the cab and income; as annual income increases, so does the percentage of those diverting to personal automobiles. Slightly over one-fourth of the car owners unwilling to pay more for their trip would choose to ride a bus, but most would prefer to drive. A majority of the taxicab trips for work and medical purposes would be undertaken by car; however, most business and shopping trips would be made by bus. In summation, among residents unwilling to pay higher cab fares, the automobile would be the preferred alternative among upper-income persons, car owners, and people traveling to work and to the doctor. Public transit would be used by lower-income groups, those without automobiles, and people traveling for business purposes. The rental car is unimportant to residents as an alternative to the taxicab because the cost, even to frequent riders, would be unreasonable compared with other options.

To nonresidents, however, the rental car is an extremely feasible alternative, preferable even to public transit in many cases. Half of those surveyed would rent an automobile if they were unwilling to incur higher taxicab fares; the next most popular choice (27.8 percent) is the bus. The private automobile and walking each received an 11.1 percent response as the alternative mode to the taxicab for nonresidents. It is often easier for one unfamiliar with the city to determine where it is he or she must go and the best route to take by car rather than try to figure out which bus comes closest to the destination, as well as how to catch it. Flexibility and ease outweigh costs and make the rental car a feasible alternative to the taxicab among nonresidents. High taxicab fares are no doubt beneficial to the rental-car business.

SUMMARY OF FINDINGS

Taxicabs are an important component of the transportation system in Dallas to residents as well as nonresidents. Taxicabs are used by people from all social and economic backgrounds, although particularly intensive use is found among females, the elderly and the handicapped, people of middle incomes, and visitors to the city.

Cabs are used out of convenience as well as necessity. Examining the possible changes in taxicab use with respect to fare reveals that cost is least prohibitive to the very affluent and to those going to work and to the doctor. Rider frequency appears to be more closely related to trip purpose and the availability of alternative transportation than to earnings.

POSTSCRIPT

Since this survey was taken in August 1977, several changes have occurred in the Dallas, Texas, taxicab scene. First, the Dallas-Fort Worth regional Airport was opened to all taxicab companies in January 1979. Before this, only Surtran taxicabs had been allowed to pick up at the airport and all others could drop off only. Now, all registered cabs may pick up and drop off both at the airport and in town.

A rate increase was instituted in the spring of 1979. This increased the Dallas taxicab fare for a 5-mile trip by about 30 percent. One of the reasons this fare increase was instituted was to attract additional taxicabs into service. As of December 1979, the number of licensed cabs in Dallas was 780, which is up considerably from the time of this survey.

ACKNOWLEDGMENT

This study could not have been accomplished without the advice, cooperation, and work of a number of people. In particular, we wish to acknowledge Susan Wade, formerly with the North Central Texas Council of Governments, who was responsible for the design, administration, and encoding of the survey. Essential to Ms. Wade's work was the assistance of Mildred Cox, Phil Brown, Gary Green, Al Pierce, and Peggy Kirby, all with the city of Dallas. The contributions of Karl Kuhlman of Yellow Cab, Ezell Randall and Leo Bennett of Terminal Cab, and the many taxicab drivers who participated in the survey were, of course, the basis of the study and are sincerely appreciated. The data-processing assistance of David Henry of the North Central Texas Council of Governments is gratefully acknowledged.

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Development of Design Standards for Public Transportation Services for the Transportation Handicapped in Large Urban Areas

JOHN C. FALCOCCHIO

This paper is concerned with the analysis of transportation variables from the viewpoint of the elderly and handicapped. The purpose of this analysis was to develop a set of functional design parameters that are responsive to the travel needs of transportation-handicapped persons. The transportation variables considered in this paper include walking distance, waiting time, service reliability, availability of seats in waiting areas and/or in the vehicle, safety, accessibility of vehicles and/or system, and fare. User interviews were obtained from a pool of riders of a specialized transportation service (Easyride) that operates in Manhattan's Lower East Side. Each measure of a transportation variable was rated by the interview sample by using a semantic scale, and tolerable (acceptable) levels for each variable were identified for each of six groups of age-handicap categories. The service design standards that emerge from this study recognize that the locomotive capabilities of elderly and handicapped persons differ according to the severity of handicap. These travel needs are identified for each level of transportation handicap considered and are quantified in terms of the suggested design guidelines.

Existing urban transportation services do not meet the special travel requirements of the elderly and physically disabled because these systems were designed and built according to standards that are adequate for the adult nonhandicapped population (1). As a result, many elderly and physically handicapped persons (i.e., wheelchair users and others who have severe mobility problems) tend to find these systems inaccessible, uncomfortable, or inconvenient to use. Many perceive these systems as not safe for travel because of fear of physical harm that might result from a fall or from personal assault by would-be muggers. Others find these systems too costly to use. Because of these conditions, the elderly and the handicapped suffer from a lack of personal mobility and are denied access to vital services and other opportunities.

This paper is based on a study (2) in which the transportation requirements of a group of elderly and handicapped travelers were analyzed. The service variables considered in the study included elements of travel comfort, convenience, safety, and cost. These service variables were measured for different age and handicap travel markets by using a semantic scale. The findings of these measurements serve as the basis for the identification of service design standards that are responsive in meeting the travel needs of the transportation-handicapped market groups considered.

BASIC COMPONENTS OF A TRANSPORTATION SERVICE

A transportation service may be viewed as consisting of three basic components: (a) the vehicle, (b) the operating system, and (c) the requirements imposed on the user. These three components of service must be considered jointly in the physical planning for service improvements, and their interaction must recognize the importance of user requirements that should be the determinants of design standards for accessible vehicles and accessible systems. (An "accessible vehicle" is one the traveler can enter, ride, and exit; an "accessible system" is one that permits the traveler to get to the vehicle from an origin or to a destination from the vehicle.)

The requirements of a handicapped user of a transportation service are highly dependent on the characteristics of the system and the vehicles used in the system. Vehicles may be of different designs, sizes, or shapes. However, their main features may be described according to whether they are accessible to wheelchair users and to those who have severe difficulties in climbing steps. System characteristics, on the other hand, vary significantly and the type of service provided will affect system accessibility. Transportation systems may be characterized in terms of routing (i.e., fixed, flexible, or fully independent of routing patterns), schedule (fixed, variable, or demand responsive), origin stop to destination stop (curb to curb, door to door, or through door to through door), etc. Each of these service patterns will impose different requirements on the potential user in terms of waiting time, walking time, seating, and climbing or descending steps or stairs, etc. It is clear then that transportation services useful to the transportation handicapped must be designed and operated to meet the capabilities of the handicapped.

These system-related user requirements may be expressed in terms of the following variables:

1. Convenience: (a) reliability, (b) waiting time, (c) transfers, (d) ease of getting on and off, (e) walking distance;
2. Comfort: (a) heating and ventilation, (b) noise, (c) sudden stops or turns, (d) having a seat;
3. Safety: (a) fear of falling, (b) fear of muggings; and
4. Cost: fare.

By using a sample of handicapped riders, it was possible to measure how each variable affects their ability to use a transportation service. [The sample-selection methodology and the characteristics of the interview sample are described elsewhere (2).] The sample consisted of users of a fully accessible paratransit service known as Easyride that is operated by the Vera Institute of Justice in the Lower East Side of Manhattan, New York City. For the purpose of this analysis the transportation handicapped (n = 126) have been classified into six travel-market groups:

1. EWC = elderly persons who use wheelchairs (n = 20)
2. ES = elderly persons who have severe difficulty in climbing steps (n = 31),
3. EM = elderly persons who have minor difficulty in climbing steps (n = 26),
4. NEWC = nonelderly persons who use wheelchairs (n = 25),
5. NES = nonelderly persons who have severe difficulty in climbing steps (n = 13), and
6. NEM = nonelderly persons who have minor difficulty in climbing steps (n = 11).

Handicap severity was self-assessed.

An additional sample (n = 24), designated TR839, of nonelderly nonhandicapped graduate students of the Polytechnic Institute of New York was inter-

Table 1. Weighting of comfort, convenience, safety, and cost variables.

Variable	EWC	NEWC	ES	NES	EM	NEM
Comfort						
Heating and ventilation	8.2	7.6	4.6	6.5	6.6	5.4
Noise	8.3	6.8	6.8	6.4	6.5	8.9
Sudden stops, turns, etc.	10.2	10.9	6.8	4.7	8.0	6.5
Having a seat	NA	NA	14.9	11.9	13.4	14.2
Convenience						
Reliability	12.7	11.7	9.9	9.5	8.5	9.4
Waiting time	10.7	10.5	9.1	9.5	8.7	9.2
Transfers	6.3	6.6	4.9	6.3	5.4	1.4
Ease of getting on and off	13.5	9.9	10.8	10.6	7.0	9.9
Walking distance	3.4[a]	5.1[a]	13.2	13.7	11.2	11.7
Safety						
Fear of falling	12.6	12.7	8.2	8.6	8.6	9.4
Fear of mugging	5.0	7.6	3.7	5.7	8.7	6.5
Cost						
Fare	9.1	10.6	7.1	7.6	7.4	7.6

[a] Distance covered by wheelchair. Most wheelchair users felt this variable is not important because they usually ride a door-to-door service.

viewed by using the same questionnaire that had been administered to the Easyride users. The purpose of this task was to compare the perceptions of the two groups in measuring the bus, subway, and taxi modes in terms of the travel comfort, convenience, safety, and cost variables.

The questionnaire used for the elderly and handicapped group was administered only to the users of the Easyride service. A user was defined as an individual who has taken at least one trip with Easyride. Questions were asked of Easyride users to determine their levels of satisfaction with the transportation variables enumerated above. This was done not only for the Easyride service but also for other forms of transportation available in the Lower East Side, such as buses, subways, taxis, and Ambulette vans (a medical-oriented transportation service that operates door to door). However, only those responses that were based on actual experience with a particular mode were recorded. Thus, for example, no evaluation of the subway mode was possible by the wheelchair users since this group cannot use the New York subway.

METHOD OF ANALYSIS

The responses obtained from the personal interviews were processed by computer by using the Statistical Package for the Social Sciences (SPSS), and the results of the analysis are summarized in graphic form below. A five-interval semantic scale was used to record responses.

FINDINGS

Reliability

Service reliability refers to that measure of service performance that relates to whether a trip can be made when needed by the user. If the service is unreliable, this means the passenger may arrive late at his or her destination, may not travel to where he or she would like to go, or may be forced to allot more time for travel than necessary by arriving early in order not to miss an appointment.

Reliability was valued as very important by the respondents. From Table 1 it may be seen that wheelchair users value it second to the fear of falling and the remaining groups value it third most important, below having a seat and walking distance.

One way of measuring the impact of service reliability is given in Figure 1. For each of the age-handicap classifications, the relationship between the length of delay and the impact of this delay on the average traveler is plotted. This is done for three typical trip purposes: medical trips, social visits, and shopping trips.

It may be seen that, in general, when lateness exceeds half an hour the service is perceived to be somewhat upsetting to extremely upsetting. There does not seem to be much difference in the effect of delay according to trip purpose. However, a delay experienced for medical-related trips seems to generate more concern.

Another trend that emerges from these relationships is that the effect of delay is perceived more negatively by those who have lower disability levels. This conclusion tends to be supported by the reaction pattern of those in the TR839 group, who perceive the effect of delay more critically than their elderly or handicapped counterparts.

Waiting Time

Waiting time is closely related to service reliability. In this discussion it is used to measure the effect of scheduled waiting time and is intended to measure a passenger's reaction to waiting, given that one knows the expected arrival time of the vehicle.

Figures 2 and 3 show the perceived impacts of waiting time for the sample groups. Those who have severe physical disabilities, as might be expected, have the greatest problem with having to wait while standing. Having to wait standing even for a few minutes upsets this group. For those who have minor difficulties, waits longer than 10 min present serious problems. When people are seated, however, waiting becomes a problem for waits longer than 20 min. The elderly seem to be more patient than the nonelderly, in general, but this pattern is not very pronounced. The importance of this attribute, as shown in Table 1, ranges from 8.7 to 10.7 and is very similar to the weight given to reliability.

Transfers

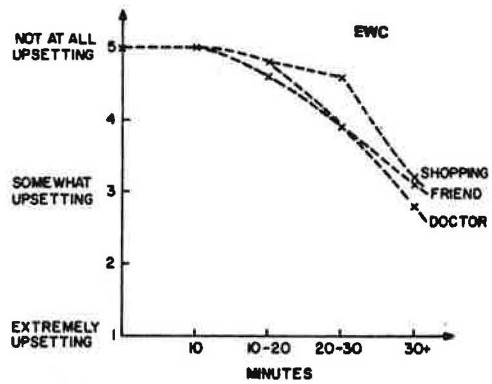
The act of transferring from one vehicle to another, as part of a trip, received a wide range of reactions. Figure 4 shows the results of the evaluations given by the sample to the need for transferring during travel. When one transfer is involved, the majority of the respondents indicated only a mild disapproval of the requirement. In this regard, it is necessary to note that the ratings do not necessarily follow what would be expected. For example, whereas it would be logical to expect that the level of dissatisfaction with the need for transferring would increase with increasing disability, this is not borne out by the data. Although it is difficult to explain the reasons for these apparent inconsistencies, one possible explanation may be with the fact that those who currently travel without having to transfer (i.e., wheelchair users) could not relate to this question. However, those with minor handicaps (i.e., EM), who are more likely to use different modes or vehicles in their daily travel, see the transfer requirement as more of a problem.

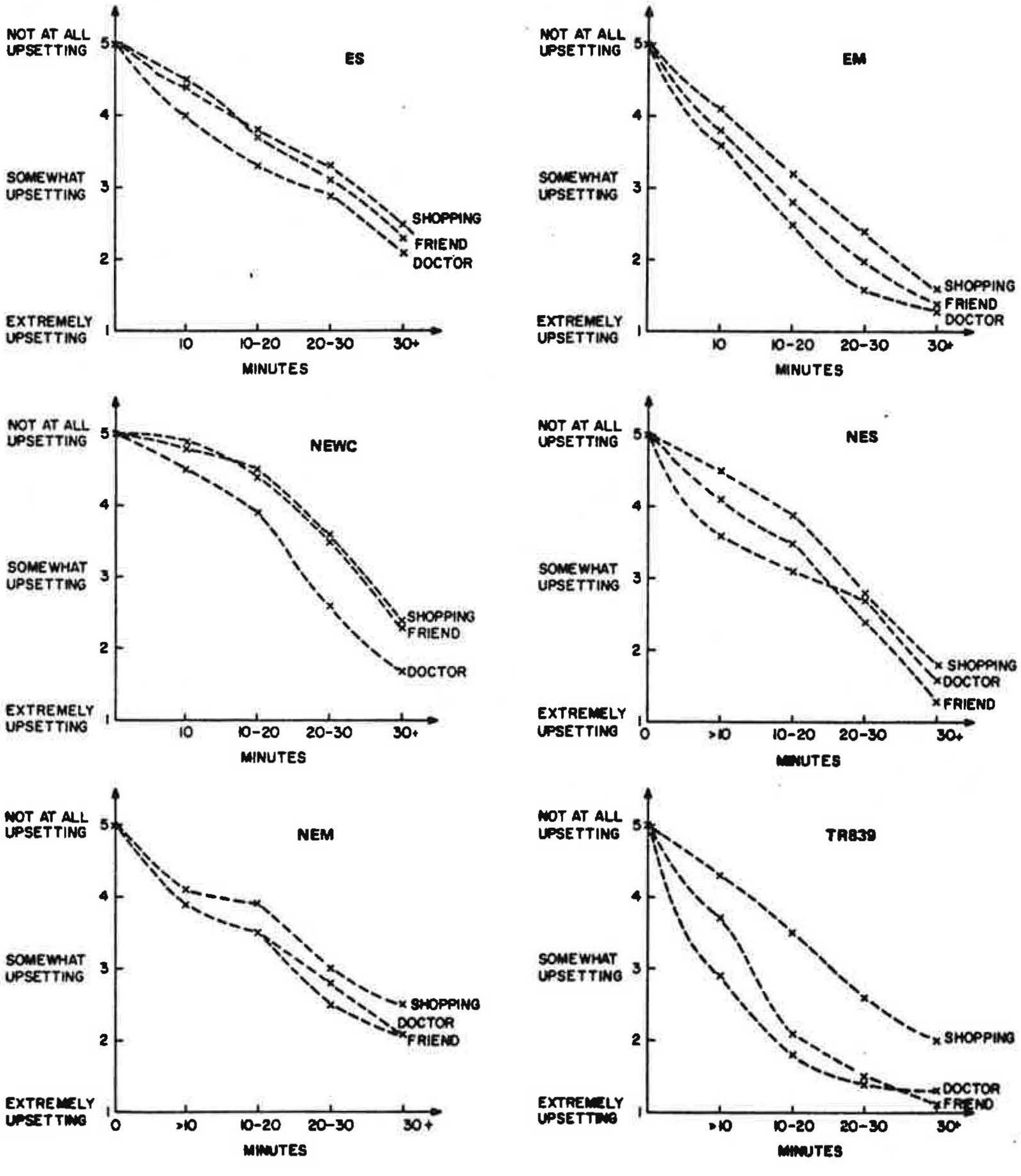
Getting On and Off, Up or Down

Vehicle accessibility and the problems experienced by the severely handicapped in getting on or off a vehicle are viewed as some of the most critical aspects of transportation service by the handicapped who are in a wheelchair or who have severe problems in climbing steps.

Figure 5 describes the kinds of problems

Figure 1. Responses to "Suppose you are meeting a friend, visiting the doctor, or going shopping; how upsetting would it be if the service is late by 10 minutes or less, by 10-20 minutes, etc?"





perceived in each mode and associated infrastructure (such as stairs or escalators). Easyride is viewed as the most easily accessible mode by all the respondents. The Ambulette accessibility is perceived as presenting some to little difficulty by the EWC and NEWC users and little or no difficulty by the ES users. Some of the wheelchair users have cited occasional difficulties in using Ambulette vehicles whose ramps were not wide enough to accommodate large wheelchairs.

The taxi and automobile tend to generate similar reactions from the EWC group; reactions range from some difficulty to great difficulty. In this connection, lack of sufficient space between the front and back seats was mentioned, as well as how the wheelchair is "just slammed down in the trunk" by the taxi driver. The problems with taxi and automobile accessibility by the ES and NES groups are similar and range between some difficulty and very little difficulty. The EM and NEM groups have slightly fewer problems in getting in and out of taxis and automobiles.

The bus is not accessible to those in wheelchairs. Those who have severe problems (ES and NES) experience great difficulty in using the bus, and those in the EM and NEM groups find it somewhat difficult to get on or off. In this regard, several comments were made that the bus driver does not pull over to the curb at bus stops and that the driver frequently fails to activate the step-down mechanism of the "kneeling" buses.

The subway system was divided into three components: stairs, escalators, and the vehicle. Those in wheelchairs said that they cannot use the New York subway at all. Those who have severe problems in climbing steps (ES and NES) cite stairs, escalators, and vehicles as being too difficult or impossible to negotiate. Those who have minor difficulties seem to have very little problem with escalators but experience great difficulty with stairs. However, in this group only the elderly view vehicle access as presenting great difficulty; those who are not elderly seem to experience very little difficulty with the subway car.

Figure 2. Responses to "Does it bother you when you have to wait standing at a bus stop or terminal?"

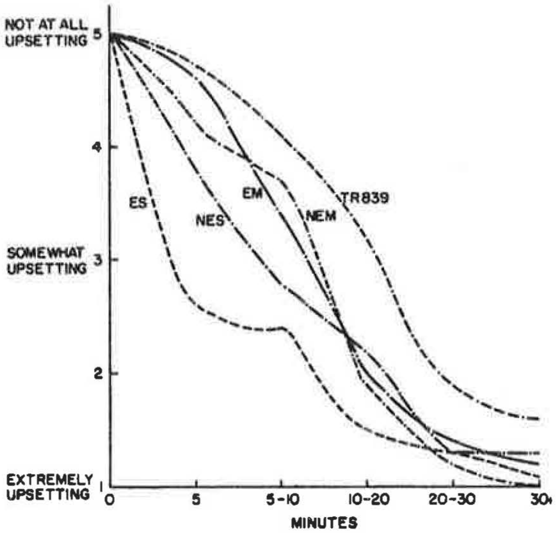
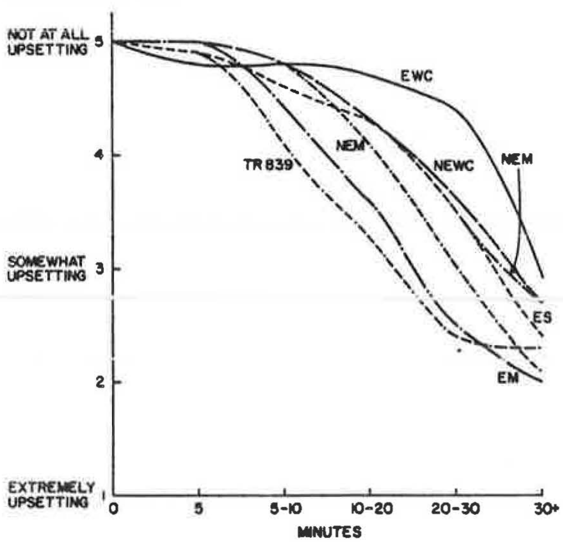


Figure 3. Responses to "Does it upset you when you have to wait sitting at a terminal or bus stop?"



Walking Distance

Figure 6 shows the range of problems experienced by the nonwheelchair sample about walking distance. It may be seen that the severely handicapped find walking one block or less (one city block is approximately 400 ft) somewhat to mildly upsetting; those who have minor difficulties find the need of walking one to three blocks somewhat to mildly upsetting. Thus, it appears that for system design purposes the service area of a fixed-route transit service is limited to half a block for those who have severe difficulties and to one and a half blocks for those who have minor difficulties.

As seen in Table 1, the importance of walking distance is at the top of the list, along with the need to have a seat in the vehicle.

In comparison, the TR839 group viewed walking distances of four to six blocks as mildly upsetting. This corresponds very closely to the quarter-mile

Figure 4. Responses to "Would you be upset if on a trip you have to transfer from one vehicle to another?"

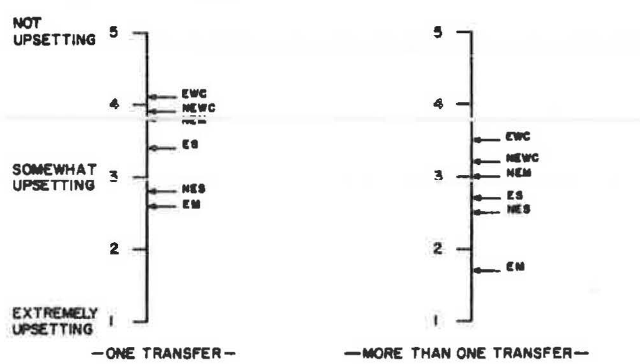
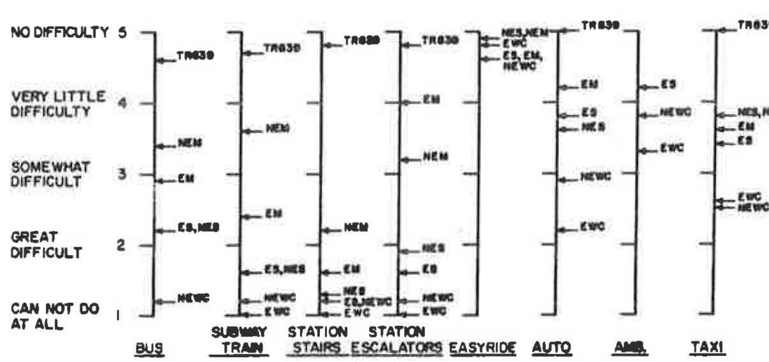


Figure 5. Responses to "With how much difficulty can you get on and off (up or down) each of the following vehicles?"



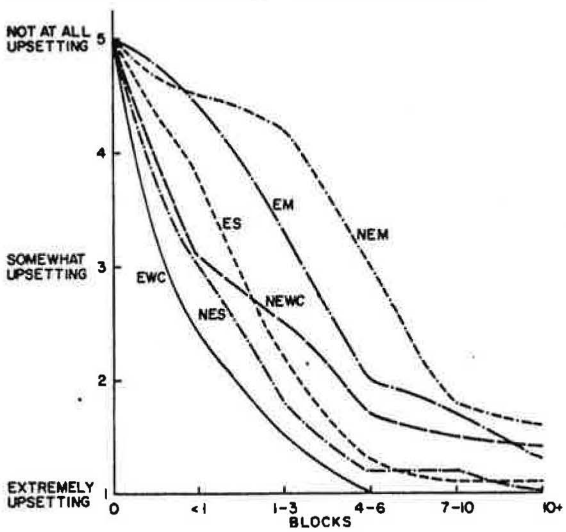
limit used to establish the walk-to-bus primary service area.

Heating and Ventilation

The comfort level for each mode of travel experienced by the respondents is shown in Figure 7. All users rated the Easyride service as providing an acceptable level of comfort. For the bus service and non-air-conditioned subway, the experience ranges between uncomfortable and sometimes uncomfortable. Taxi and automobile modes were found to provide acceptable levels of comfort.

It should be noted that the evaluation of these transportation services is based on the perception that users have of them. The mix of vehicles used in each service may vary so that, although the bus service uses air-conditioned vehicles, it appears that that mode's effectiveness in satisfying the ridership is not high. This may be a result of the rather frequent incidence of malfunctioning units.

Figure 6. Responses to "Would it be upsetting if you had to walk a block (1-3 blocks, etc.) in order to get to a bus stop, meet a taxi, etc.?"



Since the bus and subway are not accessible to wheelchair users, no evaluation of these modes was given by this group. However, for planning purposes, it may be assumed that wheelchair users would react similarly to heating and ventilation levels.

Noise

The responses given to noise are shown in Figure 8. Of all the transportation services considered, the non-air-conditioned subway generates the most negative response. The TR839 group shows the most severe objections to subway noise. The EM users do not seem to be bothered as much as the NEM users. A sense of general satisfaction is expressed with the air-conditioned subway cars, however. This is encouraging, since the New York City Transit Authority is proceeding to replace old vehicles with new air-conditioned ones.

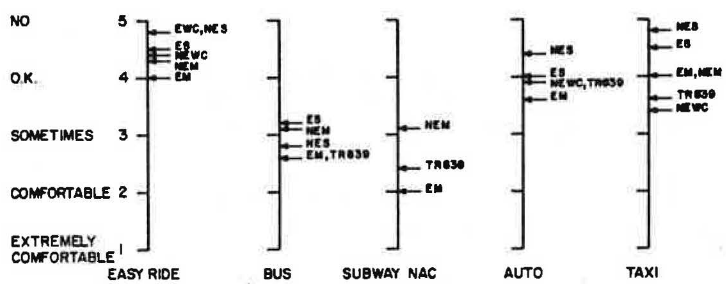
The importance given to the noise attribute is shown in Table 1, where it may be noted that the relative weights given to this item vary from 6.4 for the NES group to 8.9 for the NEM group.

In conclusion, it appears that vehicle noise is not perceived to be a serious problem by most of the respondents sampled, except for those who might use the IRT subway trains. Finally, it should be noted that reactions to noise do not seem to be dependent on either the age or the handicapped status of the traveler. It appears that this attribute is not seen as a problem by the average user and that any variation in responses is more a function of general opinions of the services than it is of actual performance as measured in the field.

Sudden Starts, Stops, and Turns

This attribute measures the operating features of the vehicles that result from driver performance under prevailing traffic conditions. Figures 9 and 10 show the ratings given by the users to each service. The bus service is perceived to have the highest levels of discomfort by the NES group and the taxi service by the NEWC group. These findings indicate a need for training drivers to avoid maneuvers that result in sudden stops, turns, etc. The weight given to this attribute ranges from 4.7

Figure 7. Responses to "When you ride a bus (subway, etc.), does the heat or lack of ventilation make you very uncomfortable, moderately uncomfortable?"



Note: NAC = not air-conditioned.

Figure 8. Responses to "Does noise make you uncomfortable when you ride a bus, taxi, etc.?"

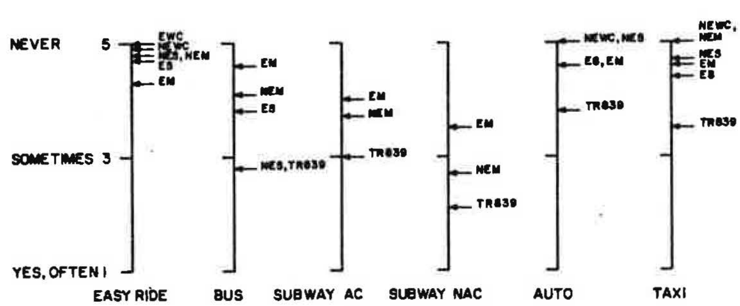


Figure 9. Responses to "Are sudden stops, starts, or turns uncomfortable to you when you ride seated?"

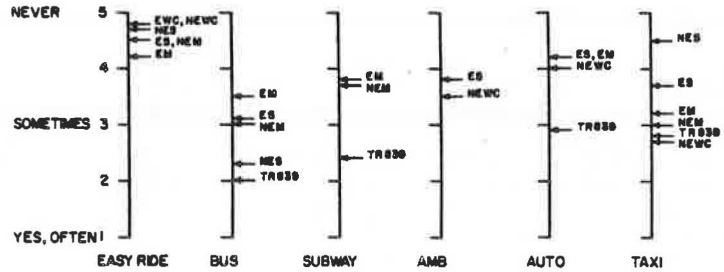


Figure 10. Responses to "Are sudden stops, starts, or turns uncomfortable to you when you ride standing?"

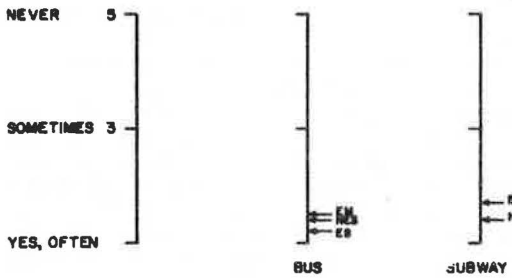


Figure 11. Responses to "(a) How important is it to you to have shelters at bus stops? (b) How important is it to you to have a seat while waiting for a bus?"

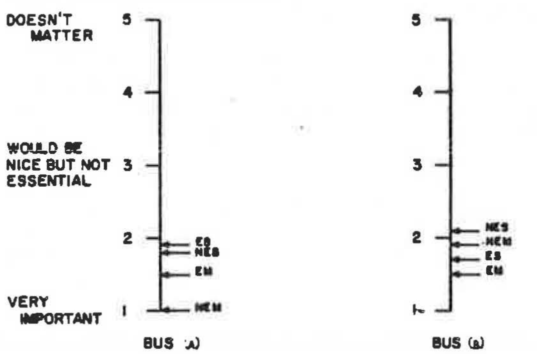


Figure 12. Responses to "How uncomfortable would it be for you to ride the bus, subway, or Easyride when you can get a seat?"

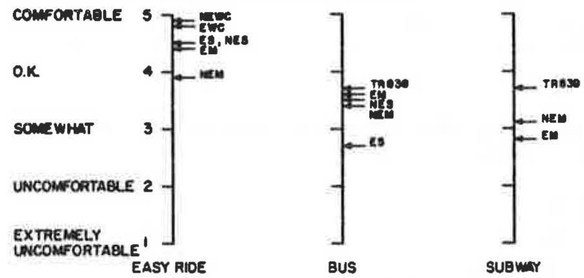
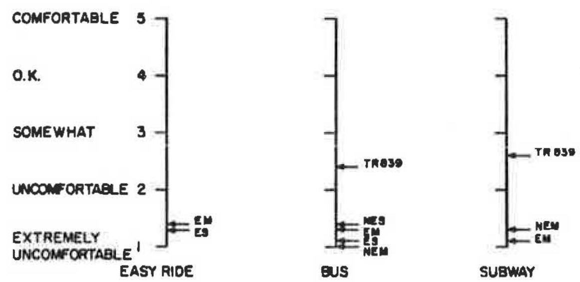


Figure 13. Responses to "How uncomfortable would it be for you to ride the bus, subway, Easyride, when no seats are available?"



for the NES group to 10.9 for the NEWC group.

The negative reactions of standees to the effect of sudden stops, turns, etc., are shown in Figure 10 for the bus and subway modes. These findings indicate that it is essential for the EM, NES, or ES rider to have a seat in the bus or subway. In the Lower East Side this is hardly possible during the rush hours.

In conclusion, it appears that there is a need to improve driver performance, especially for the taxi and bus modes.

Having a Seat

This attribute is very important for those who are not in wheelchairs. From Table 1, it may be seen that the ES, EM, and NEM groups view it as the most important of all attributes considered.

The availability of a seat was analyzed for different components of travel: while waiting for a vehicle, while riding on a vehicle, and as a function of time.

Seats at a Terminal

All of the Easyride respondents felt that it was very important to have a seat as well as a shelter at bus stops (Figure 11). In fact, it appears that the presence of a seat tends to offset the negative impact of waiting for a vehicle by significant amounts (Figures 2 and 3). The elderly and handicapped are more adversely affected by the lack of a seat than are those who are nonelderly and handicapped.

For purposes of comparison, it will be noted that there seems to be no need for a seat for those who are neither elderly nor handicapped (TR839 group) for periods of up to a 20-30 min wait. For waits longer than half an hour, seat availability becomes important (Figures 2 and 3).

Seats Available in the Vehicle

Figures 12 and 13 show that not having a seat while riding would be very uncomfortable for all of the handicapped groups (as well as for the TR839 group, but to a lesser extent). When a seat is available, however, the bus and subway services provide moderate levels of comfort (2.7-3.4 points out of a maximum of 5 points). Those who are elderly tend to experience the greatest discomfort during a bus or subway ride.

Safety

This variable was evaluated by the respondents for

Figure 14. Responses to "Are you afraid of falling or being in an accident when you use any of the above vehicles?"

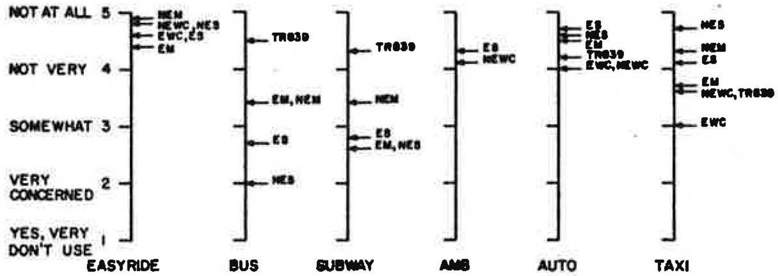


Figure 15. Responses to "Are you concerned about muggings or a holdup when you travel using any of the above vehicles?"

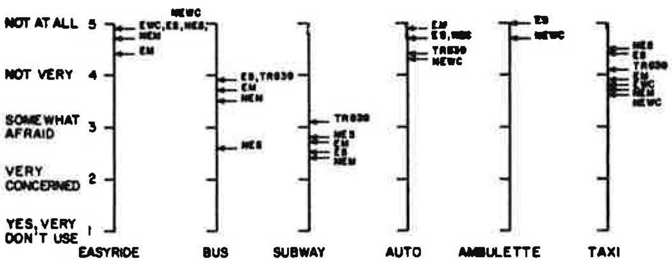
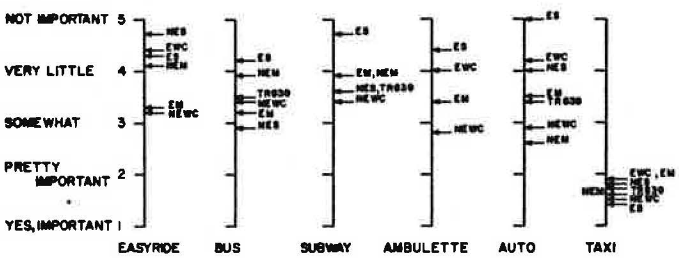


Figure 16. Responses to "Is travel cost important in deciding whether to use a bus, subway, taxi, etc.?"



two types of concerns: the fear of falling (or being in an accident) in using any of the services considered and the fear of being subjected to an act of personal assault during a trip.

Fear of Falling or Being in an Accident

This attribute is shown in Figure 14. The bus service is seen as unsafe by all groups. The typical responses range from very concerned (NES) to somewhat concerned (ES, EM, and NEM). Similar observations are made for subway service. For the taxi mode, only those who are elderly and in wheelchairs (EWC) are somewhat concerned about the fear of falling or being in an accident. Easyride, Ambulette, and the automobile are seen as the safest modes.

Fear of Muggings

Figure 15 shows that most people are in agreement in expressing fear of being assaulted during subway travel. Their responses vary from somewhat afraid to very concerned. Only the NES group expresses these same feelings for the bus service. The other groups think of the bus as providing a safer environment (responses range from not very concerned to somewhat afraid). Most people are not very concerned about personal safety during travel in a taxi and feel almost no fear when they travel by Easyride, Ambulette, or private car. It is interesting to note that the TR839 group does not exhibit significant differences from the elderly and handicapped sample for the subway, bus, taxi, and automobile modes.

Cost

The cost of traveling by any of the transportation services was assessed in terms of whether the amount paid influences the choice of mode or, presumably, making the trip at all.

It is not surprising to see in Figure 16 that all of the responses indicate that the taxi fare is an important element in a traveler's decision on whether to use that service. The responses for Easyride range from somewhat important to not important. It should be noted that the $0.30 round-trip fare charged to Easyride users cannot be burdensome in that it is not a mandatory fare. However, the $2.00 fare charged for work trips could be somewhat burdensome.

Although the use of Ambulette service is expensive (a minimum of $33.00 per round trip), reactions vary from very little to somewhat important because most, if not all, users are eligible for Medicaid and are therefore not charged for the service. However, Ambulette fees for non-Medicaid recipients and for trips other than for medical purposes are set at a rate much higher than $33.00 per round trip--even if the one-way distance is fairly short (i.e., 3-5 miles).

The $0.50 round-trip fare charged by the transit system is viewed with some to little concern in the decision to travel by bus or subway.

EMERGING SERVICE DESIGN STANDARDS

It has been shown that transportation services have varying levels of effectiveness in meeting the needs of the traveler who has a handicap. Of the service variables considered in describing the overall performance of a system, we have identified what the users can "endure" and what they cannot.

Transportation services have been analyzed by considering the joint coupling of the system's characteristics with the user's ability in coping with them. This was done for five types of transportation services: (a) door-to-door group-riding modes (Easyride and Ambulette), (b) door-to-door private mode (taxi that is phoned for), (c) quasi-door-to-door private mode (taxi that is hailed), (d) fixed-route transit bus, and (e) subway service. In addition, the mobility characteristics and variables for user's comfort, convenience, and safety have been examined for six types of age-handicap subgroups or travel submarkets. The results of these analyses were shown in the preceding sections.

The findings of these analyses are summarized in this section in the form of design parameters, suggested guidelines, or standards. Table 2 presents an emerging set of criteria that should be considered in the evaluation of an existing transportation

Table 2. Emerging transportation design standards for various age and handicap travel markets.

Service Characteristic	EWC	NEWC	ES	NES	EM	NEM	All Groups
Maximum walking distance (blocks)	0.5	1.5[a]	0.5	0.5	1.5	1.5	
Seating	NA	NA	Yes	Yes	Yes	Yes	
Transfers	NF	NF	NF	NF	1	1	
Maximum waiting time (min)							
Standing	NA	NA	1	3	10	10	
Seated							15
Accessibility							
Stairs							NF
Escalators	NF	NF	NF	NF	Yes	Yes	
Bus steps	NF	NF	NF	NF	Maybe	Yes	
Lift or ramp							Yes
Taxi step	NF	NF	Maybe	Maybe	Yes	Yes	
Reliability (late arrival) (min)	30	20	10	10	10	10	
Sudden stops in traffic							
Seated							Driver training required
Standing							NF
Noise (dBA)							70-80
Heating and ventilation							Air conditioning
Round-trip fare ($)							0.50
Shelters at stops							Yes

Note: NA = not applicable; NF = not feasible.

[a] Assumed upper limit for trips that do not involve negotiating curbs or similar obstacles.

service or in the planning for a proposed service improvement for the handicapped.

The service characteristics considered in Table 2 were found by the handicapped to be of critical importance while traveling. This, therefore, represents a set of necessary conditions that a particular service should meet in order to serve the travel needs of a particular travel submarket. These conditions, it should be noted, must be met simultaneously to satisfy the requirements of a transportation submarket. For example, having a fully accessible bus for NES travelers is not sufficient to assure that their mobility needs are met if they must wait standing more than 3 min for the bus, if they do not find a seat in the vehicle, or if they must travel a distance greater than one half block to or from the bus stop.

On close examination, this table suggests that not all transportation modes can be expected to effectively provide for the mobility needs of the severely handicapped, since operating characteristics such as fixed route, traffic delays, and loading conditions do not allow effective service even if the system had total vehicle accessibility.

What this table suggests is that those who are most severely handicapped require a transportation system that requires a minimum effort by the user (i.e., a door-to-door service). Full-accessibility buses, operating on a fixed route with a fixed schedule, do not meet this requirement. Yet wheelchair lifts on fixed-route buses have been mandated by the Urban Mass Transportation Administration for the purpose of transporting wheelchair-bound persons. This policy may not be in the best interest of the severely handicapped, and in particular of those in wheelchairs, if the trips have origins or destinations that are more than one block away from transit stops.

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Predictive Models of the Demand for Public Transportation Services Among the Elderly

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Models for accurately predicting the travel demands of the elderly are in their infancy. After reviewing the advantages and disadvantages of disaggregate behavior models and of aggregate models, this paper reviews a series of specific aggregate demand models that include service specifications. Both urban and rural models are developed. The results of ordinary least-squares and two-stage least-squares regression methods are compared for their predictive capabilities and agreement with previous findings; both formats are found to have some advantages. Specific models combine high predictive capabilities with generally accepted elasticities of the component variables. These models are ready for immediate application.

Specialized services for transporting the elderly and handicapped have become a major focus of current transportation planning activities. Section 5 of the Urban Mass Transportation Act of 1974 requires reduced transit fares for the elderly and handicapped as a condition for federal transit operating assistance. Federal regulations also require full consideration of these groups in transit system design and operation.

This new emphasis has illuminated several gaps in our knowledge of appropriate systems. In particular, apart from evaluation studies (1,2) on the effect on demand of reduced fares for the elderly, there has been a dearth of research on demand elasticities and demand predictive models for transportation services for elderly travelers. Caruolo's compilation of studies of reduced fares (1) shows that travel by the elderly is fairly inelastic; the average fare elasticity is -0.38. However, no comparable elasticities are available for service specifications such as frequencies, reservation times, and other characteristics of transportation services. The study on which this paper is based was undertaken to estimate demand elasticities for public transportation services among the elderly and in the process to develop simple demand models that could be applied to a variety of rural and urban scenarios for predicting transportation demand of the elderly.

DEMAND MODELS

Two basic sets of mode-choice models appear in the literature: the disaggregate or individual trip models (3,4) and the aggregate or traffic-zone-group models (5-7).

Disaggregate Behavioral Models

Disaggregate (quantal dependent variable) models are characterized by the analysis of dependent variables that represent a single occurrence such as a trip. The disaggregate models are called behavioral models because they may be derived by postulating a utility-maximizing behavior on the part of household trip makers. In these models, the household is pictured as estimating the potential net utility derived from making a trip (a trade-off of the disutility derived from the effort and cost involved in making the trip versus the utility derived at the trip destination) and as examining the full range of alternative choices available before actually making a decision to travel.

Although the development of the disaggregate behavioral models has been a significant addition to the transportation-demand-analysis literature, the temptation to oversell these worthwhile models has been irresistible. The fact is that there are good and sensible disaggregate models that have reasonable travel elasticity values, as well as unreasonable models that have elasticity values beyond the level experienced in the price and service demonstrations conducted by the Office of Service and Methods Demonstration of the Urban Mass Transportation Administration (UMTA).

In spite of the popularity of the disaggregate behavioral model, the last year or so has witnessed an attempt at a reappraisal of these models. In a recent article, Oum (8) has shown that the linear multinomial logit models (a) impose many rigid a priori conditions on the elasticities and cross elasticities of demand, (b) result in estimates of elasticities that are not invariant to the choice of the base or modal denominators, and (c) possess severely irregular and inconsistent underlying preference or utility structures. Oum argues for a careful and sensible use of the logit models and for a de-emphasis of some of the ambitious and extravagant claims made about their theoretical superiority. Oum argues, for example, that elasticities should not be computed from these models and that their use should be restricted to standard applications.

To Oum's reservations we must add some of our own. In spite of their claim to be utility-related behavioral models, none of these models is formally derived by maximizing utility functions. Furthermore, the conventional economic theory approach to demand analysis, which places the price variable and the time variables in monetary budget and in time constraints, respectively, is disregarded in the "utility" approach. Finally, and more important, both Theil (9) and Nerlove and Press (7) argue that simultaneous choices--such as the choice of more than two transport modes--cannot be estimated by means of single-equation estimation techniques such as the maximum likelihood approaches currently being used by the transportation mode-choice modelers, since to do this would result in biased coefficients in the estimated models.

Aggregate Models

In aggregate models, the dependent variable represents a group of observations in which individual trip data are grouped into traffic zones. The major criticism of these models as compared with disaggregate models is their statistical inefficiency (aggregate models need more data to obtain a fixed confidence level).

This paper presents the development of aggregate direct demand models, whose internal structure is of the Cobb-Douglas type. These demand models estimate ridership directly without requiring any aggregation process. The choice of an aggregate direct demand model was dominated by considerations of data availability. The basic data used to estimate the models consist of a survey of the total passengers transported and the service specifications of 335 transportation projects that served the elderly during 1976. These projects responded to a mail survey of projects funded by the Administration on Aging of the U.S. Department of Health, Education, and Welfare (HEW) and by UMTA. Because the survey--to ensure high response rates--contained no questions on trip purposes or on origin-destination patterns, the direct demand analysis that follows focuses on aggregate travel data. Thus, it is impossible to apply disaggregated behavioral trip-making models (3), which require a more refined and specific trip-purpose data base.

AGGREGATE DIRECT DEMAND MODEL

Formulation

The demand schedule for elderly travelers' use of public transportation services (both regular and specialized bus services) conveys information on the amount of passenger ridership attracted by a transportation project or system as a function of fare charges and the level of service offered by the system, as well as the ridership attracted by its competing services.

Essentially the demand model specifies that the number of riders attracted by a transportation service depends on several factors, such as

1. Need or potential market--represented by the number of the elderly in the service area or the number of elderly poor;
2. Specifications of transportation services--represented by frequencies for fixed-route systems, reservation times for demand-responsive systems, and fares and bus miles for fixed-route and demand-responsive systems;
3. Linkage to other social services programs--represented by whether the transportation service transports elderly passengers to the nutrition project sites or to similar sites for the delivery of social services;
4. Competing transportation services--represented by the existence of another transit-type service or a large or medium-large social-service-related transportation system that serves the same service area; and
5. Service-area characteristics--represented by whether the service area is urban or rural and by its residential densities.

The elements that affect demand for bus transportation services for the elderly may be summarized in the following function:

$$\begin{aligned}\log ELDPASS_i = {} & b_0 + b_1 \log(ADBUSMILES_i) + b_2 \log(ELDPOP_i) \\ & + b_3 \log(ELDPOOR_i) + b_4 \log(FARES_i) \\ & + b_5 [(FR_i) \times \log(FREQ_i)] \\ & + b_6 [(DR_i) \times \log(1/RESTIME_i)] + b_7 (COMP_i) \\ & + b_8 (NUTR_i)\end{aligned} \tag{1}$$

where

$ELDPASS_i$ = one-way elderly passenger trips per month for system i;
$ADBUSMILES_i$ = adjusted monthly vehicle miles operated to serve elderly passengers [computed by multiplying the regular monthly bus miles by the proportion of elderly passengers out of total passengers, as in $ADBUSMILES_i = (ELDPASS_i/PASS_i)(BUSMILES_i)$, where $PASS_i$ = total passengers (elderly and nonelderly) for system i and $BUSMILES_i$ = total monthly bus miles for system i; this procedure was necessary because some of the transportation projects analyzed served other target groups as well];
$ELDPOP_i$ = elderly population in the service area covered by transportation system i (thousands of persons);
$ELDPOOR_i$ = elderly population in the service area covered by system i who are poor (numbers of persons);
$FARES_i$ = one-way elderly-passenger fares per trip for system i (cents);
FR_i = 1 if the system i is a fixed-route system, 0 if not;
DR_i = 1 if the system i is a demand-responsive system, 0 if not;
$FREQ_i$ = average round trips per month for system i (in the case of a demand-responsive system, the frequency variable is 0);
$RESTIME_i$ = system design specification for reservation time (days) (measures the days in advance that the user must reserve the use of the system);
$COMP_i$ = 1 if system i is in competition in its service area with a transit service or with a social-service-related transportation system that carries more than 2500 elderly passengers monthly, 0 if not; and
$NUTR_i$ = 1 if transportation services to nutrition sites amount to at least 10 percent of the elderly-passenger trips in urban areas, 0 if not (in rural areas, this variable was assigned a value of 1 if services to a nutrition site were delivered by transportation system i, 0 if not).

The variable definitions shown above present two alternative need variables--the elderly population and the elderly poor. The elderly population is a more general estimate of need since it includes the elderly who have physical or health barriers to mobility, a status that is not necessarily correlated with income. For example, the simple correlation of elderly residents' personal income with restrictions on mobility is only -0.12 among the elderly in Houston, Texas (10), which indicates that to define the elderly who need transportation assistance solely on the basis of income excludes numerous people who need such services. The rural elderly who have restrictions on mobility includes from 15 to 25 percent of the rural elderly, depending on the region of the country (11,12). Both of these concepts of need will be investigated in this paper.

One of the problems associated with the demand function presented in Equation 1 is the uncertainty surrounding the definition of the bus mileage variable as an independent variable. Although it is true that bus miles are not the proper supply variable (which is actually seat miles), there are still significant connotations of supply associated with this bus mileage variable.

Three direct demand models are presented in this paper:

1. An ordinary least-squares model that assumes that bus mileage is an independent variable;
2. A "reduced-form" model, also estimated through ordinary least squares, that postulates that the bus mileage variable is endogenous or jointly dependent; and
3. A simultaneous-equation model of demand and supply estimated through two-stage least-squares estimation methods.

Table 1. Regression analysis results of demand for 163 transportation systems that serve the rural elderly.

Rural Regression Equation	Evaluation Statistic	Independent Variable: Intercept (constant)	log $ELDPOP_i$	log $ADBUSMILES_i$	log $FARES_i$	$COMP_i$	$(FR_i) \times \log (FREQ_i)$	$(DR_i) \times \log (1/RESTIME_i)$	$NUTR_i$	log $ELDPOOR_i$
1	Regression coefficient	-0.251	0.164	0.786	0.023	-0.155	0.087	0.105	0.291	
	Standard error		0.078	0.082	0.060	0.069	0.045	0.044	0.069	
	F value		4.452	90.885	0.145	4.993	3.587	5.690	17.601	
2	Regression coefficient	-0.248	0.167	0.786		-0.159	0.088	0.107	0.287	
	Standard error		0.077	0.082		0.068	0.045	0.043	0.068	
	F value		4.705	91.945		5.386	3.795	6.187	17.657	
3	Regression coefficient	2.061	0.591			-0.241	0.190	0.063	0.466	
	Standard error		0.079			0.085	0.055	0.053	0.082	
	F value		55.946			8.006	11.675	1.371	31.920	
4	Regression coefficient	-0.567		0.800		-0.131	0.083	0.109	0.287	0.121
	Standard error			0.081		0.065	0.045	0.043	0.068	0.064
	F value			95.340		3.989	3.274	6.149	17.446	3.573
5	Regression coefficient	0.953				-0.150	0.171	0.076	0.466	0.478
	Standard error					0.082	0.056	0.055	0.084	0.067
	F value					1.861	9.089	1.861	30.880	51.180

Note: R^2 values are 0.694 for Equation 1, 0.693 for Equation 2, 0.514 for Equation 3, 0.691 for Equation 4, and 0.503 for Equation 5.

Table 2. Ordinary least-squares demand models for 172 transportation systems that serve the urban elderly.

Urban Regression Equation	Evaluation Statistic	Independent Variable: Intercept (Constant)	log $ELDPOP_i$	log $ELDPOOR_i$	log $ADBUSMILES_i$	log $FARES_i$	$COMP_i$	$(FR_i) \times \log (FREQ_i)$	$(DR_i) \times \log (1/RESTIME_i)$
1	Regression coefficient	-0.063	0.100		0.940	-0.069	-0.217	0.173	0.035
	Standard error		0.048		0.042	0.034	0.049	0.020	0.033
	F value		5.031		479.764	4.056	18.982	72.022	1.065
2	Regression coefficient	2.655	0.817			-0.104	-0.478	0.294	0.257
	Standard error		0.060			0.068	0.095	0.038	0.064
	F value		182.876			2.352	25.109	57.893	16.194
3	Regression coefficient	-0.292		0.083	0.954	-0.069	-0.209	0.171	0.032
	Standard error			0.041	0.041	0.034	0.049	0.020	0.034
	F value			3.803	534.893	3.803	17.817	70.522	0.854
4	Regression coefficient	0.875		0.774		-0.098	-0.442	0.296	0.259
	Standard error			0.062		0.071	0.099	0.040	0.067
	F value			153.074		1.904	19.656	53.126	14.932

Note: R^2 values are 0.936 for Equation 1, 0.752 for Equation 2, 0.935 for Equation 3, and 0.728 for Equation 4.

Each of these models is described after a short discussion of the data base.

Data Base

To estimate the demand models already formulated, a data base that covered the ridership and operation characteristics of 335 transportation companies and transportation projects that serve the elderly had to be developed. The data were collected through a mail survey, conducted during the spring and summer of 1976, of projects funded by UMTA and HEW. Some of these systems served only the rural elderly; others accepted nonelderly passengers as well. However, all the systems served trips of several purposes, such as shopping, personal business, health, work, and social services trips; that is, the systems in the data base do not include those HEW-funded projects that serve only social trip purposes. The following text table presents an enumeration of the systems included in the data base. Some projects that included both fixed-route and demand-responsive components have been classified in this table according to their larger system component.

Type of System	Number of Projects: Rural	Urban
Fixed-route	43	111
Demand-responsive	120	61
Total	163	172

ESTIMATION OF SINGLE-EQUATION AND REDUCED-FORM DIRECT DEMAND MODELS

This section discusses the estimation of direct demand models by means of single-equation ordinary least-squares regression methods. Two types of models are estimated: (a) the reduced form, which suppresses the bus mileage variable from the regressions, and (b) the ordinary direct demand model, which includes bus miles as an independent variable. The discussion proceeds first with the demand models for the rural elderly, which are presented in Table 1, followed by the demand models for the urban elderly in Table 2. Note that all the logarithmic transformations presented in Tables 1 and 2 are expressed in base-10 logs, the variables are those previously cited, and the dependent variable is log $ELDPASS_i$.

The most promising rural demand functions appear in Table 1. Three of the functions (rural regression equations 1, 2, and 3) use the elderly population as a demographic variable; in equations 4 and 5 this variable has been replaced by the elderly poor.

The best rural regression equation is 2, which exhibits significant regression coefficients for all the variables and the second-highest R^2. Although equation 1 shows a higher R^2, it also exhibits statistically insignificant fares, which is its main drawback. In fact, the lack of statistical significance of the fares variables is the only disappointing result in the rural transportation demand functions. All the other explanatory variables--elderly population, vehicle mileage, frequencies of service, reservation times, and linkages to nutrition sites--are significant and have the right signs. Rural regression equations 2 and 3 in Table 1, which include ($ELDPOP_i$), outperform in terms of R^2 equations 4 and 5, which include the alternative variable ($ELDPOOR_i$).

Rural regression equations 3 and 5 of Table 1 denote the reduced-form demand equations, in which the vehicle mileage variable is suppressed. These reduced-form demand equations exhibit higher demand elasticities but at a cost of lower R^2 than those equations that contain supply variables. As stated earlier, the best rural equation is the second one, which explains 70 percent of the variance of the passenger experience in the 163 rural transportation systems analyzed.

The most promising ordinary least-squares demand models for the urban elderly appear in Table 2. Urban regression equations 2 and 4 present the reduced-form models; the other urban regression equations represent the ordinary demand model that has supply elements. Because of the colinearity between the ELDPOP and the ELDPOOR variables, these variables are run separately. The best ordinary demand model that has supply elements is urban regression equation 1; the best reduced-form model is urban regression equation 2. These two models outperform others in terms of goodness of fit and statistical significance of the regression coefficients.

Comparison of reduced-form models with the ordinary models that have supply elements reveals that the reduced-form equation, although it exhibits lower R^2s, also increases the statistical significance of some variables, such as the reservation times. In addition, the demand elasticities are higher in magnitude in the reduced-form models. As will be seen later, the elasticities of the reduced-form models are in general agreement with those estimated for the general population by other researchers (6,13,14).

SPECIFICATION AND ESTIMATION OF SIMULTANEOUS-EQUATION MODELS

The problem of including a supply variable (such as vehicle miles) among the independent variables of the demand analysis has been discussed briefly earlier. This problem results from the fact that the patronage of the system and its supply of bus miles are jointly dependent variables.

Jointly dependent variables are those variables that are mutually interdependent so that one affects the other and vice versa, e.g., the passenger variables and the vehicle-miles variable. It is obvious that variations in vehicle mileage affect the patronage of a given system; that is, patronage depends on, among other things, the vehicle mileage supplied. On the other hand, the service provider (whether city transit, private transit company, or social welfare agency) decides on the level of vehicle mileage to supply based on the strength of its expectations of the patronage that the provider can attract. Thus, vehicle mileage also depends on the patronage of the system. As a consequence, both vehicle mileage and patronage may be labeled as jointly dependent variables.

This simultaneity or joint dependency arises as a result of the presence of supply variables (vehicle miles) in the demand curve. In the presence of the jointly dependent variables, ordinary least-squares models result in biased regression coefficients, and thus unbiased simultaneous-equation estimation methods must be applied (15). To resolve the problem of joint dependency of bus mileage and passenger volumes, a simultaneous-equation model was estimated.

The structure of this simultaneous-equation model contains a demand function:

$$\begin{aligned}\ln(\mathrm{ELDPASS}_i) = {} & a_0 + a_1 \ln(\mathrm{ADBUSMILES}_i) + a_2 \ln(\mathrm{ELDPOP}_i) \\ & + a_3 \ln(\mathrm{ELDPOOR}_i) + a_4 \ln(\mathrm{FARES}_i) \\ & + a_5 [(\mathrm{FR}_i) \times \ln(\mathrm{FREQ}_i)] + a_6 [(\mathrm{DR}_i) \times \ln(1/\mathrm{RESTIME}_i)] \\ & + a_7 (\mathrm{COMP}_i) + a_8 (\mathrm{NUTR}_i) \end{aligned} \tag{2}$$

and a supply function:

$$\begin{aligned}\ln(\mathrm{ADBUSMILES}_i) = {} & b_0 + b_1 \ln(\mathrm{ELDPASS}_i) + b_2 \ln(\mathrm{ELDPOP}_i) \\ & + b_3 \ln(\mathrm{ELDPOOR}_i) + b_4 \ln(\mathrm{FARES}_i) \\ & + b_5 [(\mathrm{FR}_i) \times \ln(\mathrm{FREQ}_i)] \\ & + b_6 [(\mathrm{DR}_i) \times \ln(1/\mathrm{RESTIME}_i)] \\ & + b_7 (\mathrm{PRIVATE}_i) + b_8 \ln(\mathrm{POPDEN}_i) \end{aligned} \tag{3}$$

where $PRIVATE_i = 1$ if transportation is provided by a private system and 0 if not, and $POPDEN_i$ = population density in the service area, measured in persons per square mile. The use of the term "ln" in Equations 2 and 3 denotes that natural (Naperian) logarithmic transformations were used on most variables. This change from base-10 logs to natural logs had to be made because the two-stage least-squares regression program used accepted only natural logs.

The specification of the demand curve is identical to the previous specification presented earlier. Increases in demographic variables, in vehicle mileage, and in service specifications (such as greater frequencies and shorter reservation times) are expected, on a priori grounds, to lead to increases in patronage by the elderly. However, the increases in numbers of elderly passengers will be less than proportional, so that demand elasticities lower than 1.0 are expected. Increases in fares and competition with other systems are expected to lead to less than proportional reductions in the numbers of elderly passengers.

The supply curve is more difficult to specify, partly because of the lack of data available on costs of supplying the transportation services. Because of the lack of available data on costs for the different systems, a new variable ($PRIVATE_i$) has been defined as a supply variable. The expectation is that private systems are more subject to the market discipline and thus strive for more efficient operation. This higher private-system efficiency translates into lower unit costs, lower ratios of vehicles miles per passenger, or both. To the extent that private systems exhibit higher efficiency, the introduction of the $PRIVATE_i$ variable will assist in the specification of the supply curve. The supply function specifies that the greater the expected patronage, population to be served, frequency, and reservation times, the greater the supply of vehicle mileage. The higher the fares, the greater the supply; if the system is private, a lower level of vehicle miles will be supplied. In both supply and demand functions, the $ELDPASS_i$ and $ADBUSMILES_i$ variables are specified as jointly dependent or endogenous variables; all the rest of the variables are specified as independent.

The above simultaneous-equation model was estimated by means of two-stage least squares. The two-stage least-squares model (15) used all the predetermined variables in the system in order to estimate a jointly dependent variable, and the predicted value of the jointly dependent variable was introduced among the independent variables of the regression. An example will suffice. In the case of estimating the demand function (Equation 2), first the jointly dependent $ADBUSMILES_i$ variable was estimated as a function of all the other independent or predetermined variables. Next the

Table 3. Two-stage least-squares simultaneous-equation models of transportation demand and supply for the rural and urban elderly.

Explanatory Variable	Model 1 Regression Coefficient	Model 1 Standard Error[a]	Model 2 Regression Coefficient	Model 2 Standard Error[a]
Demand Function for the Rural Elderly[b]				
Intercept (constant)	0.045	1.559	-0.550	1.270
ln $ADBUSMILES_i$	0.695	0.229	0.627	0.277
ln $ELDPOP_i$	0.216	0.139		
(FR_i) x ln $(FREQ_i)$	0.101	0.053	0.102	0.054
(DR_i) x ln $(1/RESTIME_i)$	0.102	0.045	0.102	0.046
$COMP_i$	-0.388	0.166	-0.310	0.153
$NUTR_i$	0.709	0.194	0.749	0.210
ln $ELDPOOR_i$			0.198	0.134
Supply Function for the Rural Elderly[c]				
Intercept (constant)	5.277	0.573	3.138	0.392
ln $ELDPASS_i$	0.313	0.096	0.308	0.100
ln $ELDPOP_i$	0.471	0.080		
(FR_i) x ln $(FREQ_i)$	0.165	0.058	0.143	0.058
DR_i	0.465	0.195	0.468	0.199
$PRIVATE_i$	-0.249	0.321	-0.197	0.331
ln $POPDEN_i$	-0.157	0.050	-0.105	0.046
ln $ELDPOOR_i$			0.381	0.067
Demand Function for the Urban Elderly[b]				
Intercept (constant)	-0.631	1.949	-0.831	0.687
ln $ELDPOP_i$	0.044	0.226		
ln $ADBUSMILES_i$	1.013	0.293	1.010	0.223
(FR_i) x ln $(FREQ_i)$	0.164	0.042	0.164	0.035
(DR_i) x ln $(1/RESTIME_i)$	0.018	0.078	0.018	0.063
$COMP_i$	-0.453	0.216	-0.451	0.168
ln $FARES_i$	-0.067	0.036	-0.067	0.035
ln $ELDPOOR_i$			0.043	0.164
Supply Function for the Urban Elderly[c]				
Intercept (constant)	3.619	0.763	2.081	0.591
ln $ELDPASS_i$	0.495	0.139	0.427	0.178
ln $ELDPOP_i$	0.329	0.109		
(FR_i) x ln $(FREQ_i)$	0.008	0.059	0.026	0.074
(DR_i) x ln $(1/RESTIME_i)$	0.116	0.056	0.131	0.066
$PRIVATE_i$	-0.238	0.167	-0.331	0.205
ln $POPDEN_i$	0.004	0.048	0.013	0.053
ln $ELDPOOR_i$			0.355	0.129

[a]The F-test was not computed for each regression coefficient because it is not available from the Time-Series Processor computer program used in estimating the two-stage least-squares regression.
[b]Dependent variable = ln $ELDPASS_i$; R^2 values are 0.691 for rural model 1, 0.683 for rural model 2, and 0.935 for urban models 1 and 2.
[c]Dependent variable = ln $ADBUSMILES_i$; R^2 values are 0.715 for rural model 1, 0.702 for rural model 2, 0.876 for urban model 1, and 0.849 for urban model 2.

predicted value of $ADBUSMILES_i$ was substituted back into Equation 2 in lieu of the original $ADBUSMILES_i$ variable, and Equation 2 was estimated by using ordinary least squares. This procedure, called two-stage least squares, results in unbiased although inefficient estimates, which lose their minimum variable properties (15).

Analysis of Transportation Demand and Supply for the Rural Elderly

The results of the two-stage least-squares regressions appear in Table 3. Rural model 1 defines need in terms of the total elderly population, whereas model 2 uses the number of elderly poor as a proxy for need. A close examination of both supply and demand functions reveals that ELDPOP is superior to ELDPOOR as an explanatory variable, as supported by the higher R^2 and statistical significance of the functions.

All the demand elasticities presented in Table 3 appear with appropriate signs and orders of magnitude, showing demand elasticities lower than 1.0 in absolute values. These demand elasticities may be contrasted with the previous elasticities estimated through ordinary least squares in Table 1. The effect of the two-stage least-squares estimation is to increase the elasticities of all the variables except $ADBUSMILES_i$, the supply variable whose elasticity is depressed by the two-stage least-squares technique.

In contrast with the demand curve, the supply-curve estimation leaves a lot to be desired, partly because of the lack of cost data in its specification. The variable that identifies private ownership of the system is statistically insignificant, and the sign of the DR_i variable is contrary to expectations. Contrary to first impressions, the sign of the population density variable is correct in the supply elasticities. However, more work is required, particularly in the area of costs, before a supply curve is successfully estimated for transportation projects for the rural elderly. The function derived may be interpreted as just a first approximation.

Analysis of Transportation and Supply for the Urban Elderly

The results of the application of the two-stage least-squares model to the transportation systems for the urban elderly also appear in Table 3. Essentially, although the two-stage least-squares models for transportation of the urban elderly exhibit R^2 levels as high as those for the ordinary least-squares models presented in Table 2, the statistical significance of the demand elasticities is decidedly inferior to that in the ordinary least-squares models.

Both simultaneous-equation models presented show insignificant reservation times and population elasticities; their comparable ordinary least-squares equations in Table 2 show a significant and important population elasticity and mixed results for the reservation-times variable.

The inferior performance of the two-stage least-squares model may be due to the lack of proper specification of the supply function. In fact, the supply function estimates in Table 3 leave a lot to be desired; they show insignificant frequencies of service and population densities. Part of the deficiency in proper specification is, of course, due to the lack of data on costs. Cost data are unavailable for most systems, especially for those funded by monies from HEW.

COMPARISON OF DEMAND ELASTICITIES

As a reference for the comparison of the reasonableness of the elasticities estimated by means of the direct-demand models, Tables 4 and 5 contrast the elasticity estimates from the previous tables with those estimated by other investigators.

The rural transportation models estimated in this study are summarized in Table 4. From the viewpoint of forecasting accuracy, the ordinary least-squares demand models that have supply elements appear superior; evidence is provided by the higher R^2. The two-stage least-squares models are a close second in terms of the R^2 criterion of goodness of fit. In terms of the reasonableness of the demand elasticities, Table 4 shows all the demand elasticities to be reasonable and within the ranges estimated in previous studies (5) for the rural population in general. However, the two-stage least-squares model, which provides unbiased estimates of elasticities, appears to be superior to the ordinary least-squares models in this respect.

The transportation models for the urban elderly are summarized in Table 5. This table shows that

Table 4. Comparison of demand elasticities for the rural elderly.

Variable	Table 1: Ordinary Least Squares, Equation 2	Table 1: Ordinary Least Squares, Equation 4	Table 1: Reduced Form, Equation 3	Table 1: Reduced Form, Equation 5	Table 3: Two-Stage Least Squares, Model 1	Table 3: Two-Stage Least Squares, Model 2	Burkhardt and Lago (5)
$ELDPOP_i$	0.17	NA	0.59	NA	0.22	NA	0.3 to 0.5
$ELDPOOR_i$	NA	0.12	NA	0.48	NA	0.20	NA
$ADBUSMILES_i$	0.79	0.80	NA	NA	0.70	0.63	0.84 to 1.09
$FARES_i$	NA	NA	NA	NA	NA	NA	-0.13 to -0.60
$(FR_i) \times (FREQ_i)$	0.09	0.08	0.19	0.17	0.10	0.10	0.50 to 0.60
$(DR_i) \times RESTIME_i)$[a]	-0.11	-0.11	-0.06	-0.07	-0.10	-0.10	-0.27 to -0.50
$COMP_i$	-0.16	-0.13	-0.24	-0.15	-0.38	-0.31	-0.12 to -0.29
$NUTR_i$	0.29	0.28	0.47	0.46	0.71	0.75	NA

Note: NA = elasticity estimate not available from the relevant demand equation.
[a]The elasticity of $RESTIME_i$ is identical to the elasticity of $1/RESTIME_i$ but has changed signs.

Table 5. Comparison of demand elasticities for the urban elderly.

Variable	Table 2: Ordinary Least Squares, Equation 1	Table 2: Ordinary Least Squares, Equation 3	Table 2: Reduced Form, Equation 2	Table 2: Reduced Form, Equation 4	Table 3: Two-Stage Least Squares, Model 1	Table 3: Two-Stage Least Squares, Model 2	Other Studies: Kraft and Domencich (13)	Other Studies: Nelson (6)	Other Studies: Schmenner (14)
log $ELDPOP_i$	0.10	NA	0.82	NA	0.04	NA	NA	1.10	0.78 to 1.24
log $ELDPOOR_i$	NA	0.08	NA	0.77	NA	0.04	NA		
log $ADBUSMILES_i$	0.94	0.95	NA	NA	1.01	1.01	NA	0.92 to 1.35	NA
log $FARES_i$	-0.07	-0.07	-0.10	-0.10	-0.07	-0.07	-0.09 to -0.33	-0.67 to -0.81	-0.80 to -0.89
$FREQ_i$	0.17	0.17	0.29	0.30	0.16	0.16	0.30 to 0.71	NA	0.08 to 0.29
$RESTIME_i$[a]	-0.04	-0.03	-0.26	-0.26	-0.02	-0.02	-0.30 to -0.71	NA	NA
$COMP_i$	-0.22	-0.21	-0.48	-0.44	-0.45	-0.45	NA	NA	NA

Note: Fare elasticities estimated in other studies include -0.20 estimated by Warner (16), -0.375 by Lisco (17), -0.11 to -0.68 by Caruolo (1), and -0.30 by Hendrickson and Sheffi (4).
[a]The elasticity of $RESTIME_i$ is identical to $1/RESTIME_i$ but has a change in sign.

the ordinary least-squares models that have supply elements outperform the two-stage least-squares models in terms of R^2, statistical significance, and reasonableness of the elasticity estimates. The reduced-form elasticities are very sensible, but their R^2 values are lower than those for the ordinary least-squares equations, which are the preferred predictive models in this case in spite of their estimation bias. Contrasting these demand elasticities with those of other studies in Table 5, the elderly demand elasticities appear to be slightly underestimated considering that the elderly elasticities should have exceeded the general population elasticities, given the off-peak travel characteristics of the elderly.

CONCLUSIONS

The direct aggregate demand functions for transportation of the elderly presented in this paper show high R^2s and demand elasticities within the ranges estimated by previous investigators. The functions have been estimated from a national data base that includes observations from most of the states. We conclude that they are ready to be used in a variety of planning and design scenarios in both rural and urban settings.

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Cost and Productivity of Transportation for the Elderly and Handicapped: A Comparison of Alternative Provision Systems

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This paper reports on one part of a comprehensive study of 56 specialized transportation providers throughout the United States. Cost and productivity data for three different classes of providers (social service agencies, private contractors, and transit authorities) are presented. Such data were examined for their policy implications for systems currently in operation and proposed coordination and brokerage efforts. A distinction was made between "perceived" costs (items in the budget that require a monetary outlay) and "actual" costs (a more comprehensive account of the required resources for service provision). Such distinction helped explain seemingly irrational choices made by the providers studied and assisted in the determination of an "average" transportation budget for specialized services by major cost items. A comparison of the unit costs experienced by different providers revealed some uniformities: (a) the systems that have the highest productivities operate in dense areas and achieve a mix of group subscription and individual demand-responsive trips, (b) the separation of ambulatory from nonambulatory clients can lead to substantial economies, (c) it is not as clear that contractual agreements offer lower costs when hidden costs are accounted for, and (d) social service agencies are becoming increasingly more expert in the provision of transportation and in many cases have lowered their costs over time to a competitive level. On the basis of these findings, present and planned systems should stress the integration of group and individual trips and the separation of clients by level of service required in order to maximize efficiency.

It is difficult to analyze and evaluate the cost and productivity of transportation systems for the elderly and the handicapped (E&H) because the figures made available by the providers themselves are often incomplete, inaccurate, and scarcely reliable. Existing project reports, each referring to a specific geographic area and period of time, and each employing its own methodology in the definition of costs, do not allow for very meaningful comparisons of alternative provision systems from an economic viewpoint.

At the same time several policy hypotheses have been formulated on the basis of the results of local experiences. Among them are the alleged economic advantage of provision through contractual agreement over direct social service agency (SSA) provision, the opportunity for the heavier involvement of transit authorities in E&H transportation, and the desirability of mixing different client and trip types. Although supported by individual studies (and sometimes contradicted by others), many of these hypotheses have not been tested against comparable or consistent data sets.

In 1978-1979 the University of Texas at Austin undertook a national study of the cost and effectiveness of alternative E&H transportation systems sponsored by the U.S. Department of Transportation. The study attempted to provide a detailed nationwide data base whose cost and productivity measures were developed by using a consistent methodology and comparable terminology. [All data presented here appear in more detailed form in that project's final report (1).]

STUDY BACKGROUND

The purposes of the University of Texas study were manifold; they included

1. To look at the cost and productivity of different alternatives in order to isolate the characteristics of the most productive and more economic systems,
2. To examine the impact of different forms of assistance (for example, capital grants for purchase of equipment as opposed to operating subsidies) on the behavior of the recipients at the local level,
3. To develop a data base that would provide reference figures for a manual (2) addressed to the planning and evaluation needs of local E&H transportation providers, and
4. To formulate policy suggestions based on the observed uniformities and the relative advantages of particular provision alternatives.

Fifty-six providers were surveyed and were grouped into three major classes and further divided as shown below:

1. Social service agencies (17): 7 national and regional, 5 in urban setting, and 5 in rural setting;
2. Contract providers (28): 10 urban, not lift-equipped; 6 urban, lift-equipped; and 12 rural, lift-equipped; and
3. Transit-managed systems (11): urban, at least partly lift-equipped.

Two different definitions of cost were elaborated

(3): "perceived" costs, which represent disbursements made by the providers, and "actual" costs, which also include the costs not sustained by the provider but nevertheless essential for the execution of the service.

The distinction is relevant because the perspective of the observer will determine which of the two definitions will be used. An SSA or a direct provider will base its decisions on its perceived costs, since they are the ones that affect the resources it has available. Conversely, policymakers at an upper level will be interested in the total amount of resources used in a given project, and this perspective will bring them to look at actual cost figures. As a classic example, the use of a vehicle purchased on a grant and driven for a few hours a day by existing staff may be the most economical way for an SSA to provide transportation for its clients. The agency that funds the vehicle grant may wish to include the prorated cost of the vehicle (and the driver's wage). If that is done it may be evident that a direct subsidy given to the clients to use existing providers in the community (such as a taxi company) is on the whole a more cost-effective approach. Both views of the same system are rational, once the underlying assumptions and objectives are clear. Both definitions are therefore relevant for a meaningful analysis of any E&H system. In addition, however, the use of actual cost patterns allows the comparison of different types of providers from across the country.

This paper presents some of the most relevant study findings on the structure of the budget of E&H transportation providers, cost and productivity ranges and averages, and policy observations that were suggested by the experiences of the systems surveyed.

In the first section of this paper, the methodology followed in the reconstruction of cost items is briefly explained. The incidence of different cost items (equipment depreciation, overhead, fuel, maintenance, insurance, and operating salaries) in the budgets of E&H transportation providers is analyzed and compared. The second section of the paper maintains the distinction between perceived and actual figures, and identifies range and average costs per indices of operation (vehicle miles, passenger trips, and vehicle hours) for different categories of providers. The third section focuses on a comparison between SSA and contract provision.

The policy implications for both existing E&H transportation systems and the future of the recently introduced concepts of brokerage and coordination are summarized in the conclusions.

COMPOSITION OF THE E&H TRANSPORTATION BUDGET

Because available project data are usually vague or unreliable, it was important to accurately reconstruct the amount (and the cost) of the resources involved in alternative forms of provision of E&H transportation. Data were obtained from published research reports, unpublished materials and records, on-site visits, telephone interviews, or combinations of the above. These project-reported or supplied data were then "reconstructed" for all three classes of providers.

Reconstruction Methodology for SSAs and Transit Systems

A similar approach was followed for SSAs and transit systems; it was necessary to handle contract providers somewhat differently. For SSAs and transit systems, expenses were grouped into six major cost items: equipment depreciation, overhead, fuel, maintenance, insurance, and operating salaries. Perceived costs were those reported by the providers in their budgets. In order to reconstruct actual costs, an extensive checklist to evaluate the acquired data was developed, and the information available in written reports was supplemented by follow-up correspondence or telephone calls.

When cost data were not available for SSAs or transit system providers, information was gathered on the resources employed (e.g., number and type of vehicles or hours of volunteer work), and estimates were made on the basis of reasonable cost figures from comparable providers. Full equipment cost was depreciated over a four-year period (a reasonable lifetime for lift-equipped paratransit vehicles); volunteer labor was calculated at either going wages for the same type of work or at minimum wage rates. When existing staff members were dedicating part of their time to the project, a comparable part of their salaries and indirect costs (benefits, insurance, etc.) was imputed to the E&H transportation budget. If a specific cost item was clearly not reported at all, its value was estimated on the basis of that item's average incidence in the budgets of the same type of E&H transportation providers.

Reconstruction Methodology for Contract Providers

When E&H transportation was provided through contractual agreements (the third class of provider), the price charged by the contractor was considered to be the perceived cost since it represents the monetary outlay necessary if this option is chosen. Detailed breakdowns by cost items are not normally available from private contract providers, so that it was not possible to follow the format used for SSAs and transit systems. Three additional cost items had to be added to the price of contract service in order to reconstruct the actual cost: in-kind contributions, SSA equipment depreciation, and administrative costs. These items are often omitted by those evaluating contract provision, but their magnitude is sizable. Omitting such costs leads to an average 17 percent underestimation in the actual cost of service.

Each of these three items can be significant. First, private contracts for service often contemplate a discount on the total cost. If the agreement is with a taxi company and the price is based on meter reading, it is not unusual for a 5 or 10 percent discount to be granted at the time of payment. Such a discount can be viewed as in-kind contribution or subsidy given by the contractor, and was accounted for, just as in-kind contributions such as volunteer labor were quantified in dollar terms in the analysis of SSA budgets.

Second, some contractors manage and operate systems that use vehicles belonging to the public agency in whose name the service is provided. Typically, such vehicles are leased to the contractor for a nominal sum, and their depreciation is not accounted for by either party. In such cases this item has been reconstructed and included to determine the actual cost.

Finally, even when the system's operation is delegated to an outside contractor, an agency will still incur administrative costs that will vary according to the functions that have been retained by the agency. On the basis of information from the providers whose detailed data have been examined, administrative expenses range from 6 to 25 percent of total actual cost per trip; the average is 13 percent (1).

Table 1. Range and average distribution of cost items expressed as percentage of total system cost.

	SSA						Transit-Managed System					
	Perceived			Actual			Perceived			Actual		
Cost Item	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Equipment depreciation	0	19	5	5	16	12	1	21	9	5	23	14
Overhead	0	18	10	17	42	25	12	18	17	6	21	12
Fuel	6	16	12	6	14	10	5	12	8	2	11	6
Maintenance	3	17	10	3	13	8	2	13	9	2	22	8
Insurance	0	3	2	1	7	4	4	7	6	2	9	5
Operating salaries	49	72	61	33	48	41	47	62	51	42	72	55
Total			100			100			100			100

Note: Min = minimum percentage reported; Max = maximum percentage reported; Avg = average.

Missing Cost Items in Direct SSA and Transit System Provision

Social service agencies' data usually required adjustments in three cost items:

1. Equipment depreciation (vehicles, wheelchair lifts, and radiocommunications equipment): Very often such equipment is purchased entirely or nearly entirely through federal and/or state funds or else is donated by organizations or private citizens. As a result, most of the SSAs do not include a prorated cost of such equipment in their figures or at the most only depreciate the local share of such costs.
2. Overhead (general administrative functions such as certification of clients and eligibility screening, reservations intake, billing and accounting, elaboration of operating statistics, and program advertising and monitoring): Many SSAs do not carry transportation as a line item in their budgets since such programs have often developed over a period of time and no specific full-time positions have been created for the purpose. As a consequence, one or more agency staff members devote part of their time to the administration of the program, but the share of their salaries and other costs (such as utilities, supplies, and office space) is not isolated or clearly defined.
3. Maintenance and operating salaries (drivers and dispatchers): In-kind contributions of volunteer labor for any of these functions (especially driving) is the most common cause of the difference between the perceived and actual costs for this item.

In transit-managed systems, equipment depreciation is the most frequent cause of discrepancies. Besides simply considering the local share, some transit authorities depreciate the equipment cost over 15 years, which is considered the average life span for a transit bus but is too long for paratransit vehicles.

Comparison Between Transit Systems and SSAs

Table 1 gives the incidence, in percentages, of the six main cost items of the transportation budget of SSAs and transit systems derived from the 56 U.S. providers of E&H transportation previously mentioned. It allows a direct comparison between the two classes of providers by using either perceived or actual cost figures. [For a more extensive treatment of the data, see Hickman, Pio, and Rosenbloom (1, Chapter 2 and Tables 1.5 and 1.7).]

As mentioned previously, the average figures in this report have been obtained from a variety of sources throughout the United States. The range figures that accompany them show that variations caused by local factors and system characteristics are fairly large. These range figures, however, indicate the extreme values encountered; under normal conditions the spectrum would be narrower.

The data from Table 1 can also be used for a comparison between SSA and transit-managed systems. First, SSAs seem to have higher actual overhead costs than transit systems in the provision of E&H transportation (25 percent versus 12 percent). This can be explained both by their limited expertise in the field and by the mixture of agency-specific activities with the provision of transportation. Conversely, the incidence of perceived expenditure is lower for SSAs because they often use part of the time of agency staff members as well as other resources (such as office space and telephone) without attributing such costs to the transportation program.

Second, when actual costs are compared, operating salaries are a more relevant cost component for transit authorities (55 percent versus 41 percent for SSAs), mainly because of higher unit cost due to the unionization of the drivers. [Perceived cost figures are not significant because so many other cost items (equipment, overhead) are on the average underestimated by SSAs that labor automatically becomes the major perceived component.]

Finally, systems managed by transit authorities seem to be allocating less of their budget to fuel and oil consumption (6 percent versus 10 percent for SSAs). Although there is no clear evidence, it seems reasonable that such savings may be generated through mass purchase at a discount or through the use of more fuel-efficient and better-maintained vehicles.

Magnitude of the Differential Between Actual and Perceived Cost

The distinction between perceived and actual costs and the use of the reconstruction methodology described earlier have made it possible to identify the items most often neglected in the available E&H transportation budgets. When SSAs or transit authorities directly manage a system, the items usually underestimated are equipment depreciation, overhead, and operating salaries (because volunteer contributions or expenses paid for by higher levels of government are not accounted for). In the case of provision under contractual agreement, the omission of in-kind contributions from the contractor in the form of price discounts, SSA equipment depreciation, and overhead expenses normally explains the discrepancy between actual and perceived cost.

The magnitude of discrepancy between perceived and actual cost for the three major alternatives is shown below. These averages are derived from the average values of Table 2. The unit of measurement

Table 2. Unit cost data for classes of E&H transportation providers.

Type of Provider	Cost per Vehicle Mile ($)			Cost per Passenger Trip ($)			Cost per Vehicle Hour ($)		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
SSA area averages									
Actual	0.73	0.94	0.80	1.79	4.42	2.81	4.82	13.18	10.34
Perceived	0.46	0.79	0.67	1.50	4.19	2.54	4.05	12.49	8.91
SSA urban									
Actual	0.59	1.61	1.10	2.37	5.72	3.94	-	-	13.87[a]
Perceived	0.27	1.43	0.69	1.09	5.08	2.78	-	-	11.23[a]
SSA rural									
Actual	0.66	1.49	1.11	1.62	5.48	4.44	10.15	12.77	11.46
Perceived	0.57	1.19	0.74	1.29	4.77	2.91	5.27	11.11	8.19
Contract, urban non-lift-equipped									
Actual	0.53	1.55	1.08	1.48	10.80	3.70	-	-	-
Perceived	0.46	1.35	0.89	1.16	8.62	2.83	-	-	-
Contract, urban lift-equipped									
Actual	0.58	2.36	1.15	3.75	19.57	7.97	-	-	-
Perceived	0.38	2.10	0.96	3.75	17.39	6.68	-	-	-
Contract, rural lift-equipped									
Actual	-	-	-	-	-	-	-	-	-
Perceived	0.10	3.21	0.84	2.90	19.76	9.24	-	-	-
Transit system, urban lift-equipped									
Actual	0.65	2.76	1.64	1.12	10.84	6.16	9.84	27.54	17.86
Perceived	0.54	2.54	1.48	1.02	9.06	5.12	9.84	25.97	16.61

[a]Only figures available for this category.

does influence the absolute size of the discrepancy but not the relative standing of the three provision systems.

Unit Cost	Percentage of Actual Cost: Direct SSA Provision	Contractual Agreement	Transit Authority
Per mile	28	17	10
Per trip	24	17	17
Per hour	18	Not available	7

SSAs' perception of the cost of direct provision is the one farthest away from the actual cost. This misperception results from both a low degree of accuracy in record keeping and the fact that a significant amount of the resources used is provided by other entities (e.g., volunteers) or levels of government (e.g., grants for equipment purchase). As a consequence, SSAs that use their perceived costs as a reference figure will find direct provision preferable to other alternatives whose perceived costs are higher. This is in spite of the fact that comparison of actual costs would show other alternatives to be more economical.

This finding has often been used to prove that subsidized SSAs are unfairly competing against private contract providers. However, the above text table clearly shows that even contractual provision displays a significant difference between perceived and actual costs. Since at the local level the comparison takes place between the perceived cost of both alternatives and since in both cases the underestimation is significant, we should conclude that the argument has limited validity. In fact, as will be shown, in many cases direct SSA provision is an economically rational decision even when actual service costs are compared.

Finally, systems managed by transit authorities show the least discrepancy between actual and perceived costs not only because of their expertise in the field of transportation but also because of the more stringent reporting requirements imposed on them.

COST AND PRODUCTIVITY RANGES AND AVERAGES

Cost and productivity data for the three major classes of providers further subdivided into seven classes are presented next. In order to make them comparable, cost figures are presented in terms of unit costs (respectively per vehicle mile, per passenger trip, and per vehicle hour). All three measures have been computed to provide the reader with data in a variety of formats. In the following sections the analysis will be based mainly on cost per passenger trip.

The productivity data are presented per vehicle hour (total passenger trips divided by total vehicle hours), the indicator most commonly used in paratransit operations. Two additional measures are presented: passengers per vehicle mile (total passenger trips divided by total vehicle miles) and average operating speed (obtained by dividing the first indicator by the second).

Cost: Reported Values and Preliminary Observation

Table 2 presents the range of unit cost data for seven different classes of providers derived from the 56 U.S. providers mentioned above. Both actual and perceived costs are reported for each class. Minimum and maximum unit costs are, respectively, the lowest and highest costs reported by any provider within the class. Variations around the average and within the range are caused by the diversity of the local situations surveyed. They are reported here to underline the uniqueness of each system and to provide general reference points. [For more extensive treatment of the data, see Hickman, Pio, and Rosenbloom (1, Chapter 2 and Figures 2.1, 2.2, and 2.3).]

The difference between perceived and actual costs (in both ranges and averages) is clearly apparent. The effects of this difference are also easy to detect. If, for example, we look at the provision in urban areas, SSAs have no incentive to delegate transportation of their clients to lift- or to non-lift-equipped contractors, since the average perceived cost of direct provision ($2.78/trip) is lower than both alternatives ($6.68 and $2.83, respectively). This happens in spite of the fact that the actual cost of non-lift-equipped contract service ($3.70) would on the average be lower than the actual cost of SSA service ($3.94). SSAs' actual costs are lower than those of other lift-equipped providers, and we shall see later that this is achieved through a mix of demand-responsive and group subscription transportation.

Table 3. Productivity measures for E&H transportation.

Type of Provider	Passengers per Vehicle Hour			Passengers per Vehicle Mile			Average Operating Speed (miles/h)		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Social service agency	0.72	4.50	3.05	0.10	0.52	0.27	2.88	23.00	13.36
Contract provider	2.50	6.40	4.44	0.10	0.36	0.23	17.74	24.00	20.87
Transit authority	2.68	13.60	5.82	0.17	1.28	0.49	4.50	22.21	11.51

Transit provision appears to be the most costly alternative, both in terms of cost per mile and cost per hour, although not necessarily so in terms of cost per trip. Providers in rural areas experience a wide fluctuation in unit costs coupled with higher costs per trip. These can be explained in terms of the peculiarity of some contractual agreements and the generally higher average trip length.

Both urban lift-equipped contractors and transit systems have a higher average actual cost per trip than do non-lift-equipped contractors ($7.97 and $6.16, respectively, versus $3.70) because of differences in equipment costs, boarding time, etc. The perceived cost for rural lift-equipped contractors is also higher ($9.24).

If we were to choose reference figures to indicate the unit cost of operating an E&H transportation system, Table 2 can provide some general indications according to the system's characteristics. An attempt to further generalize across classes (with all the risks and limitations involved in such a generalization process) would produce the following approximate value ranges: (a) cost per vehicle mile = $1.10-1.50, (b) cost per passenger trip = $4.50-8.00, and (c) cost per vehicle hour = $11.00-18.00.

Productivity and Characteristics of Most Efficient Providers

Table 3 presents three productivity indicators (passengers per hour, passengers per mile, and average operating speed) for the three major classes of providers. This classification by type of provider is not necessarily the most analytically useful, but it is the only one possible with the data available. [The source of the data, which I have elaborated, derives from 11 SSAs, 2 contract providers, and 9 transit-managed systems. More extensive treatment may be found in Hickman, Pio, and Rosenbloom (1, Chapter 2 and Table 2.4).]

Average system productivity as expressed by the number of passengers per hour fluctuates between 3 and 6 across the whole sample. It seems to be higher, both in average and maximum values, for contract providers and even more so for transit-managed systems. The higher productivity of the latter offsets at least in part the greater average cost of operation ($17.86/h as opposed to the average of $10.98/h for the 11 SSAs that were examined).

A closer look at the distribution of values within each class shows that there are relatively few providers that have rather high productivity; they tend to raise the average for the class to which they belong. The common characteristics that these exceptions share can be summarized as follows:

1. Operation in urban areas or in settlements characterized by fairly high density (which allows for better routing and less deadheading),
2. Relatively few mobility-impaired riders who require special assistance (which shortens the time required for boarding and leaving the vehicles), and
3. Provision, among others, of a considerable amount of group subscription rides or route-deviation trips (thereby approaching the operational characteristics of a chartered vehicle or a transit system).

If these systems were excluded from the computation of the average productivity, the value for the remaining ones would be closer to 2.5-3 passengers/h, and no significant difference between providers could be detected.

Figures for passengers per vehicle mile are a traditional measure of productivity used by fixed-route bus operators. A more precise indicator could be constructed if passenger miles, rather than vehicle miles, were available but, because of the difficulty of collecting such data, very few systems offer this information. The range of values observed varies between 0.10 and 1.28. Systems with the highest values are normally characterized by the provision of group or subscription trips and/or the fairly high density of the areas in which they operate (such is the case, for example, of transit-managed systems). The rural providers considered in this study averaged only 0.04 passengers/mile, which is the equivalent of a considerable average trip length of 22.2 miles. If we exclude the relatively few providers that have a fairly high value, the most common range in urban areas seems to be around 0.15-0.30, and the average is close to 0.20.

Finally, it is possible to obtain average operating speed simply by dividing the first item (passengers per hour) by the second (passengers per vehicle mile). The data show that contract providers seem to operate at a considerably higher speed (though the figures should be taken with some caution, since they represent the average of the only two contractors for which data on the hours of operation were available). Other providers average about 12 miles/h, but the variations are significant among them, as the width of the range of values demonstrates.

PROGRAM AND POLICY IMPLICATIONS OF SYSTEM EXPERIENCE

An examination of the data presented in the previous section shows that on the average both unit costs and system productivity tend to become higher as we move from SSAs to contract provision to transit-managed systems. Average actual cost per trip grows from $3.75 to $5.80 and $6.16, respectively, and a similar pattern can be found in cost per mile ($1.00 to $1.10 to $1.65, respectively). Average passengers per vehicle hour increase from 3.05 to 4.44 to 5.82.

A closer look at the characteristics of the systems studied makes it possible to explain the reasons for such differences and to draw some significant policy inferences. Transit-managed systems will be considered first, and attention will be then concentrated on the difference between SSAs and contract providers.

Higher Cost of Transit Provision

Systems managed by transit authorities have the highest cost per mile and per hour. The higher wage rates paid by transit operations seem the primary cause of this phenomenon. At the same time, transit systems are generally available to the whole population of a locality and not just to a restricted client group. As a consequence, they tend to have longer operating hours and to maintain an excess capacity at times of day when demand is fairly low. Both factors tend to increase unit costs. The fact that they achieve a cost per trip lower than that of lift-equipped contract providers can be explained in part by the fact that transit systems exist only in urban areas where densities are higher and average trip lengths shorter than those encountered by the rural providers considered in the sample. As for the comparison with urban contractors, the transit systems that have significantly lowered their cost per trip seem to be those that have been able to provide both group rides and demand-responsive service. This aspect will be explored further when direct SSA provision and the use of contracted service are compared.

SSAs and Contract Provision

Incidence of Hidden Costs

It has been claimed that the apparently lower cost of direct SSA provision of E&H transportation can be explained by the omission of several cost items from the budget. In fact, this understatement is significant--between 18 and 28 percent of the actual cost (see text table above).

However, this study found that a similar phenomenon takes place when E&H transportation is managed by contract providers: Underestimation of cost, as the text table shows, is approximately 17 percent. Although approximately 3.5 percent represents in-kind contributions (discounts) from the contractors, the remaining 13.5 percent comes from the sponsoring agency's overhead expenditures and equipment depreciation.

When the omitted items are included, the actual cost of contract provision is increased to a more realistic level, and the argument for SSA inferiority in terms of cost-effectiveness loses some of its strength. Local providers engaged in comparing alternatives need to be aware of the necessity to include these considerations in their decision process.

Separation by Client Needs

The comparison between SSAs and contract providers becomes more meaningful if we break down the latter according to the type of vehicles used and if we limit ourselves to an urban setting.

The average actual cost per trip for urban contractors that use lift-equipped vehicles ($7.97) is significantly higher than for those that do not ($3.70); SSAs average $3.94 per trip. Table 2 also shows that, in general, cost per trip can reach considerably higher values for individual lift-equipped providers. The upper limit of the actual cost range observed was $19.57 per passenger trip, as opposed to $10.80 for trips on non-lift-equipped vehicles.

Several reasons can be given to account for the greater cost of providing demand-responsive trips to severely impaired passengers. Larger vehicles equipped with wheelchair lifts and tiedowns are needed; however, nonimpaired persons can be transported in normal cars, like those most taxi fleets use for their regular service. The higher cost of equipment (prorated through its depreciation) is therefore a first component. Such vehicles also require more fuel and, in many cases, are charged higher insurance premiums. Handicapped passengers also require more time and assistance in boarding the vehicles, and this causes the system's productivity (passenger trips per hour) to decrease.

A clear policy implication derives from this finding: Whenever possible it is highly advisable to separate mobility-impaired passengers from fully mobile clients and to adopt different modes of provision for the two. Even SSAs that use predominantly lift-equipped vehicles could achieve economies by tailoring their services to the special equipment and assistance needs of the clients.

Directly transporting the severely impaired traveler and allocating the overflow of mobile clients to a taxi company under a contractual agreement is a method already used with success in many localities. In Austin, Texas, the cost of direct provision in Special Transit Service vans ($10.84/trip) is significantly higher than the fare charged under agreement by a local taxi company ($5.00). A similar difference in cost ($9.75 versus $4.10/trip) can be found in the operation of San Antonio (Texas) Handi Lift. This situation shows the potential for a complementary, rather than competitive, use of alternative providers.

Mix of Trip Types

Range and average cost figures reported in earlier sections of this paper have shown that some SSAs have been able to bring their costs to a level that is quite competitive with that of other providers. The mixing of trip types has played an important role in this process.

The contract providers (both lift- and non-lift-equipped) considered in this study are typically involved in individual, demand-responsive trips from many origins to many destinations. A close examination of the service characteristics of the SSAs shows a mix of demand-responsive trips with other group trips of the one-origin-to-one-destination or many-origins-to-one-destination type.

Handicapped persons who go to work or rehabilitation courses typically need transportation in the early morning and late afternoon; senior citizens' meals normally take place at lunchtime. Individual demand-responsive trips (which are in greater demand during the middle hours of the morning and the afternoon) can be scheduled around this skeleton of subscription group transportation. Such an arrangement allows for the utilization of a system at levels close to full capacity. In reality, the integration of different kinds of trips does not always proceed as smoothly, since scheduling conflicts often develop and the resources available to a system may not be adequate to cope with utilization at full capacity. Vehicles may be idle but there may not be anybody available to drive them, or intense use of a vehicle can cause serious maintenance problems, just to mention a few recurring problems.

Across all types of providers the cost per group trip is much lower (from one-half to less than one-fourth) than the cost of demand-responsive service, as Table 4 [an elaboration of survey data (1)] clearly points out. The reasons for such differences are intuitive, since group trips concentrate the time-consuming boarding process, allow for reduction in miles traveled due to easier routing, and better utilize the capacity of the vehicles. The policy followed by SSAs of integrating group and demand-responsive trips that

Table 4. Cost comparison between demand-responsive and group subscription trips.

		Cost per Mile ($)		Cost per Trip ($)	
Type of Provider	System	Group	Demand-Responsive	Group	Demand-Responsive
SSA	Allied Services (Jackson, Mississippi)	1.33	1.29	0.89	3.91
Contractor	Variety Care Van (Dallas, Texas)	Not available	Not available	3.70	4.95-6.20
Contractor	Goodwill Rehabilitation Service (San Antonio, Texas)	0.67	0.78	3.75	5.39
Transit authority	Dial-A-Bat (Brockton, Massachusetts)	1.44	1.53	1.12	5.99

have different peak demand hours can be generalized to other providers; the policy seems particularly useful for systems that are attempting coordination or brokerage efforts.

In addition, the operation by private for-profit contractors of lift-equipped systems that employ dedicated vehicles and drivers does not present economic advantages over direct SSA provision. The two systems for which data are available (Dade County, Florida, and Fort Worth, Texas) show costs of $19.57 and $9.16/trip and $2.36 and $1.11/mile, respectively. Such costs are not any lower than those incurred by SSAs and are in fact higher than the average for lift-equipped contractors ($7.97/trip).

From an economic viewpoint, therefore, it seems that the role of contract provision should be in the complementary service to non-mobility-impaired clients rather than in the parallel development of systems that have dedicated vehicles and drivers.

CONCLUSIONS

In the course of this study, an extensive data base on the cost and productivity of E&H transportation has been reconstructed and analyzed. Both the perceived (direct outlay of the provider) and the actual cost (monetary equivalent of all the resources necessary) for the provision of the service under different arrangements have been determined.

The average budget for different types of providers has been compared, showing the significantly higher incidence of overhead expenditures for SSAs and of labor costs for transit-managed systems. All three classes of providers considered (SSA, contractor, and transit) show sizable discrepancies between their perceived and actual costs, although the reporting accuracy seems to increase as we go from the first to the last. The use of perceived cost as a decisive criterion at the local level explains some choices that would otherwise seem irrational from a broader policymaking perspective. One such choice is the direct SSA provision of transportation to clients who are not severely impaired and could be more efficiently and economically served by contract providers such as taxi carriers.

Both cost and productivity ranges and averages have been presented, maintaining as detailed a distinction between the alternative provision systems as the existing data allowed. These data, and the percentage budget composition illustrated earlier, can be cautiously used as reference figures in assessing a system's performance against that of the fairly large number of providers in the nation whose operating statistics have been organized by means of a uniform methodology.

Finally, a direct comparison of the different provision alternatives produced some interesting results in terms of policy implications. Transit-operated systems are consistently found to be the most costly, because of the higher incidence of excess capacity at some times of the day. If cost items such as equipment depreciation, overhead, and in-kind contributions that are normally omitted when contract provision is considered are allowed for, the often-proclaimed competitive edge over direct SSA provision is eroded.

Furthermore, it appears that, by providing a mix of demand-responsive and group trips that have different peak-demand times, SSAs have been able to lower their unit costs. Although such integration does reduce unit costs for the system on the average, the inevitable higher cost of providing individualized, demand-responsive, many-origins-to-many-destinations transportation must be acknowledged. It is, therefore, especially important to identify the actual needs of the client group served in terms of special assistance and equipment and, whenever possible, to differentiate between those clients who can use more conventional transportation modes and those who cannot. By providing the former with a less specialized, but still adequate, transportation service (typically a taxicab or non-lift-equipped provider), considerable money can be saved and can be used to improve service for the remaining segment of the client population.

The application of these concepts can be extended to the whole field of E&H transportation, regardless of the nature of the provider, and should be of special interest for the coordination projects now being implemented. Such projects are faced with a wide client population characterized by different needs, peak-demand times, and trip characteristics and have the possibility of using different modes of transportation in a creative combination that better exploits their characteristics and complementarity.

ACKNOWLEDGMENT

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Impacts of Allegheny County's Access Program

KEITH FORSTALL, ERVIN S. ROSZNER, AND THOMAS V. LETKY

Access is a countywide door-to-door transportation system for the elderly and handicapped in the Pittsburgh, Pennsylvania, area that is conducted under the Service and Methods Demonstrations Program of the Urban Mass Transportation Administration (UMTA). Access is managed for UMTA and the Port Authority of Allegheny County (PAT) by Multisystems, Inc., a private company that acts as central broker of transportation for human service agencies and for individual elderly and handicapped persons. The service is provided under contract through the use of vehicles operated by a mixture of existing private for-profit carriers and nonprofit agencies. Each provider is assigned a specific service area, and all requests for service in that area are normally handled by that provider. The broker can also arrange backup service whenever necessary. The Access program, including a description of the service, the delivery network, and implementation issues, is discussed. The fare system is described, including the zone structure, the use of scrip coupons to pay for service, the agency billing system, and the user-side subsidy program sponsored by PAT for those who cannot use the fixed-route transit system. The broker's role in managing funds to pay for service on a vehicle-hour basis is also described. Impacts on agencies, individuals, carriers, and the quality and cost of service are discussed. Service statistics for the first eight months of service are presented.

Access is a countywide transportation program in the Pittsburgh area that has been established to improve mobility for the elderly and handicapped and to provide benefits to social service agencies through coordination. It is funded as a two-year demonstration program under the Service and Methods Demonstration (SMD) program and is currently entering its second year.

Access is a door-to-door, advance-reservation, shared-ride service for persons 60 years of age or over and for persons who are handicapped regardless of age. The service is provided through the use of vehicles operated by existing private for-profit carriers and nonprofit agencies. Service costs are borne by social service agencies, by individual riders, and by the Port Authority of Allegheny County. Access services are managed by a "broker," Access Transportation Systems, Inc., a wholly owned subsidiary of Multisystems, Inc., which is charged with the responsibilities of organizing and managing service delivery and of coordinating the demands of individuals and agencies for this service.

Access offers a uniform system of fares that can be predetermined, a comprehensive countywide delivery network of lift-equipped and other paratransit vehicles, and a convenient, easily monitored scrip system that facilitates the application of user-side subsidies.

Access officially began offering service on March 14, 1979. By October 1979, monthly ridership exceeded 6000 passenger trips.

PROGRAM DESCRIPTION

This section provides brief descriptions of the key design and operating components of the Access system.

Coordination

In its original conception, Access was primarily geared toward coordination of human social service agencies. Because of the multiplicity of agencies that provide services directly or through contracts with for-profit carriers (mostly cab companies), a principal design feature of the Access system was a coordinated, nonduplicative delivery network. This had to be accomplished in an environment in which for-profit carriers had "turf" rights, firmly established by tradition and often (but not always) confirmed by regulatory approval.

Also, nonprofit agencies provided services directly to their clients in many portions of the county. Needless to say, this often met with a degree of resistance from the cab companies. To confuse matters, the authority to regulate service and similar issues was disputed between the state Public Utilities Commission (PUC) and the regional Port Authority of Allegheny County (PAT).

Delivery Network

In this environment, we decided to establish a comprehensive delivery network that produced the benefits of the competitive marketplace through a contract bidding process. At the same time, we decided that contract awards would give each of nine sections of the county [total area 1866 km^2 (729 $miles^2$)] exclusively to one carrier. This was intended to maximize the capability for ridesharing in any location despite potentially low demand densities.

The service is currently provided by a network of eight carriers, including four taxicab companies, one nonprofit chair carrier, and three nonprofit human service agencies. Despite the original intent to give exclusive responsibility for each area to only one carrier, cooperative arrangements were eventually negotiated in several areas to allow better distribution of resources.

Communication

Because of the unique correspondence of a single carrier to any given geographic area, there was no necessity for central dispatching. Each carrier could handle all calls for its area. Access installed a Centrex system that linked all contracted carriers with each other and with the central Access office. Thus, if consumers called the wrong number or needed to be referred to a different carrier or to the central office for any reason, they could be transferred without redialing. The Centrex system was part of a systematic effort to make the service as simple as possible to the user.

The direct scheduling through carriers also achieved this by maintaining the status quo for many individuals and agencies whose traditional carrier became part of the Access system.

To date most nonsponsored trips have been scheduled directly by the rider with the appropriate Access carrier, whereas all agency-sponsored trips have been scheduled through the central Access office. As a test for the efficacy of centralized scheduling, all Saturday trips are also being scheduled through the central office.

Fares

As part of the demonstration grant, contingency funds were made available to offset initial shortfalls in revenue and to permit some experimentation with fares and carrier payment mechanisms. Revenues were fixed on the basis of the Access fare system and charges accrued on the basis of hours or miles of service provided. The Access fare system is based on a zone fare schedule that incorporates 195 zones and a computer-calculated fare schedule that with some modification (for geographic barriers such as rivers) uses the airline distance between zone centroids as its basis.

Access estimated the carrier costs that would result from the bid process (in passengers per vehicle hour), and the typical trip length (in miles per passenger). From this an average revenue per passenger and per mile were determined and used to calibrate the fare schedule. The resulting fares were equivalent to approximately \$0.48/km of road distance (\$0.77/road mile). Although the savings varied depending on trip length, Access shared-ride fares were typically expected to be 20 percent lower than if the service were purchased from the certified carriers at their exclusive-ride rates.

Payment

The Access system allows payment for service in one of two ways. Individuals may buy scrip tickets by mail from Access, redeemable for service by giving the tickets to the driver. Agencies may set up billing accounts with Access for trips arranged by agency staff. Trips are then documented and billed to the agency at the end of the month.

In a program closely related to the SMD project, Access sells special scrip for which PAT subsidizes 75 percent of the face value. Eligibility to use this scrip is limited to those who are unable to board a PAT bus.

Service Hours

Access was originally offered from 6:30 a.m. to 10:30 p.m., Monday through Friday. After four months of service, Saturday service was offered during the same hours. The service nominally requires 24-h advance notice, but immediate requests will be handled in emergencies if possible. Return trips from medical appointments are scheduled on a demand-responsive basis.

Policy Formulation

Major project policy decisions are reviewed by the Southwestern Pennsylvania Regional Planning Commission's Handicapped and Elderly Transportation Advisory Committee at its monthly meetings and by a small technical advisory task force of consumers and other interested parties.

PROJECT RESULTS

In many ways the Access program has already proved highly successful. In other respects, the value of the project will take longer to assess, and in some ways the program has clearly left an opportunity to accomplish greater things in the second year of the project! The assessment of results to date will focus on five basic impact areas: impacts on consumers, impacts on agencies, impacts on service quality, impacts on carriers, and public subsidy costs.

Impacts on Consumers

Although the service is available to all elderly and handicapped persons, severely physically disabled persons who ride without agency sponsorship have been the primary beneficiaries because of a 75 percent fare subsidy provided by PAT. Individuals eligible for the PAT subsidy thus realize far greater economic savings than result from the shared-ride cost savings alone. The use of the Access system to meet PAT's accessibility requirements (prior to Section 504 regulation) was documented in the area's transportation improvement program (TIP).

Under the PAT program, users are certified through a simple yet definitive interview conducted by a physical therapist. A mock-up of a PAT bus entrance is provided and those who can climb the steps are not certified. In direct contrast to many programs, statements by the individual's own physician are given only marginal consideration. At the recommendation of consumers themselves, PAT maintains strict eligibility restrictions but sets no limits on travel within the Access system by those who are certified.

In the first eight months of operation, Access had certified more than 1100 persons for PAT's subsidy program. Of these, about 60 percent use wheelchairs. To put this in perspective, a 1976 study by the regional metropolitan planning organization (MPO) estimated that there were 6000 persons in Allegheny County who were unable to use a bus (and who were not homebound). By October, ridership among PAT-certified persons was running at 3200 passenger trips/month or 2.9 trips/person certified. Those eligible for the PAT subsidy incurred an average of out-of-pocket cost of \$0.88/trip, compared with the base PAT bus fare of \$0.50.

Ridership by ambulatory individuals who are not eligible for the PAT subsidy and who ride Access at their own expense has been disappointing, totaling only 400 rides in October. Apparently, the inconvenience of mail-order scrip purchase and 24-h notice outweigh the potential cost savings for these riders.

Impacts on Agencies

It was originally expected that the Adult Services/Area Agency on Aging (AS/AAA) would form the backbone of the Access program at about 5000 trips/month. In fact, many design features were incorporated with an eye to accommodating the largest single purchaser of special services in the county.

Fortunately or unfortunately, things did not work out as had been planned. At the time Access began operation, AS/AAA was just beginning to recover from a severe cutback in its transportation budget. For a variety of reasons, they decided it would not be expedient for them to joint the Access program at the outset. On the minus side, this lowered achievable productivities and resulted in lower total ridership figures than had been projected. On the plus side, this gave the Access program some breathing room to work out the bugs in its service and also forced the program to focus more on smaller agencies that stood to gain more from the economies of scale.

By October 1979, 25 agencies were purchasing service through Access. Their combined ridership was about 2600 trips/month, or 42 percent of total ridership. The general level of satisfaction among these agency participants has been encouraging. Many have cited the reduction in the administrative burden of trip scheduling and monitoring as the primary benefit. In addition, agencies are benefiting from the lower fares made possible by the increased ridesharing.

Impact on the Quality of Service

Access has initiated several programs to improve service quality for all system users. These include better insurance protection, better-trained drivers, safer vehicles, better service reliability standards, and an ombudsman service.

Prior to Access, many carriers carried the bare minimum of coverage required by the PUC ($25 000/person, $100 000/occurrence). Indeed, some carriers provided more, but a passenger could not be guaranteed of this. Access raised all its carriers' limits substantially and also purchased an excess liability policy that covered itself and the Port Authority well beyond the increased limits.

To make sure that the likelihood of passengers ever invoking those policies was minimized, Access supervised the development and administration of a half-day driver training program that all regular Access drivers were required to complete. The program puts heavy emphasis on understanding the nature of handicapped consumers' disabilities and on empathy training. Drivers are "handicapped" with blindfolds, crutches, and/or wheelchairs and are then forced to negotiate an obstacle course, to go out on a downtown street (where they typically report feeling extremely self-conscious), and to board and ride a van. Many drivers have commented very favorably on this course, regardless of the number of years of experience they have had in driving the handicapped.

A related program that Access has conducted is a vehicle inspection program. Access carrier contracts stipulate minimum standards for vehicles, and these standards are being enforced by on-site inspections and detailed follow-up efforts.

Access has developed what is undoubtedly the most comprehensive data-collection and analysis program of its kind in the country. The Access management information service (MIS) system is based on the premise that maximum information is obtained by recognizing the inherent data-collection limitations of private operators and by requesting no more than can reasonably be expected accurately and completely. The resulting information is analyzed to detect trends, weaknesses, and strengths of each carrier and of the Access system as a whole. This data base has provided valuable information for negotiating with carriers, both as a tool for constructive change and occasionally as a weapon against unsatisfactory performance.

Tied in to this is one of Access' strongest benefits. Of all the services that Access performs, one of the most important on a day-to-day basis for the individual consumer is the ombudsman role. The Access central phone receives many calls, particularly in the late afternoon, from persons who have been stranded because of a delay at the clinic, a "lost" return pickup by the carrier, or some other unforeseen circumstance. Access serves these persons in a way that no other entity could by articulating their needs to the appropriate carrier and by getting emergency backup service arranged as necessary. All who have handled the phone on such occasions can attest to the importance of such services for these persons.

Access has also assumed a broader role than originally anticipated in providing elderly and handicapped consumers with information about transportation (and other) services available to them in the community. For example, many callers are referred to agencies that provide transportation at no cost to their clients. From this activity has evolved a comprehensive guide to transportation services that are available to elderly and handicapped persons in the county.

Access has taken its responsibility to its clients very seriously. All service-related complaints are documented and followed up by telephone and/or in writing, both with the carrier involved and with the complainant, and pursued until there is a satisfactory resolution. In some cases, there is no satisfactory resolution in the short run (e.g., capacity constraint), but even this is communicated to the client.

Impact on Carriers

Clearly, one of the impacts on carriers has been that they have had to respond to a single, persistent voice nagging them to do better. Seat belts have been put in vehicles, circuitous routing has been minimized, and complaints have been cut back significantly despite the increasing volume of service.

As a growing business, Access has spurred new investments in vans and lift equipment. Despite a steadily declining budget within the major social service agency (AS/AAA), Access business has helped to keep the special services segment of the private for-profit sector healthy. After eight months of service, Access was spending more than $46 000/month on this sector alone and a total of more than $59 000/month among all certified carriers (including the nonprofit chair carrier). Thus, the Access program is clearly benefiting the traditional providers of service.

Of course, some of the Access carriers are nonprofit social service agencies. Although their contribution is invaluable in the specific areas in which they have been chosen, these carriers provide barely 10 percent of all Access trips.

Public Cost of Service

Access was originally intended to break even on provision of service; the SMD grant was to pay for development, startup, and administrative overhead costs. As explained earlier, several important assumptions were critical in meeting the objective that revenues should equal costs. In fact, several of these assumptions were incorrect:

1. Average trip lengths were longer than expected.
2. The heavy predominance of wheelchair patrons coupled with the failure to attract the AS/AAA business and the unattractiveness of the service for ambulatory individuals led to lower demand densities and lower vehicle productivities than expected.
3. Carrier costs rose quickly because of escalating gasoline costs and the general inflation.

As a result, the Access fare schedule, which had been developed by using cost and productivity estimates from recent contracts between cab companies and nonprofit agencies, produced inadequate revenue from the start. The deficit per passenger in October

Figure 1. Access system ridership.

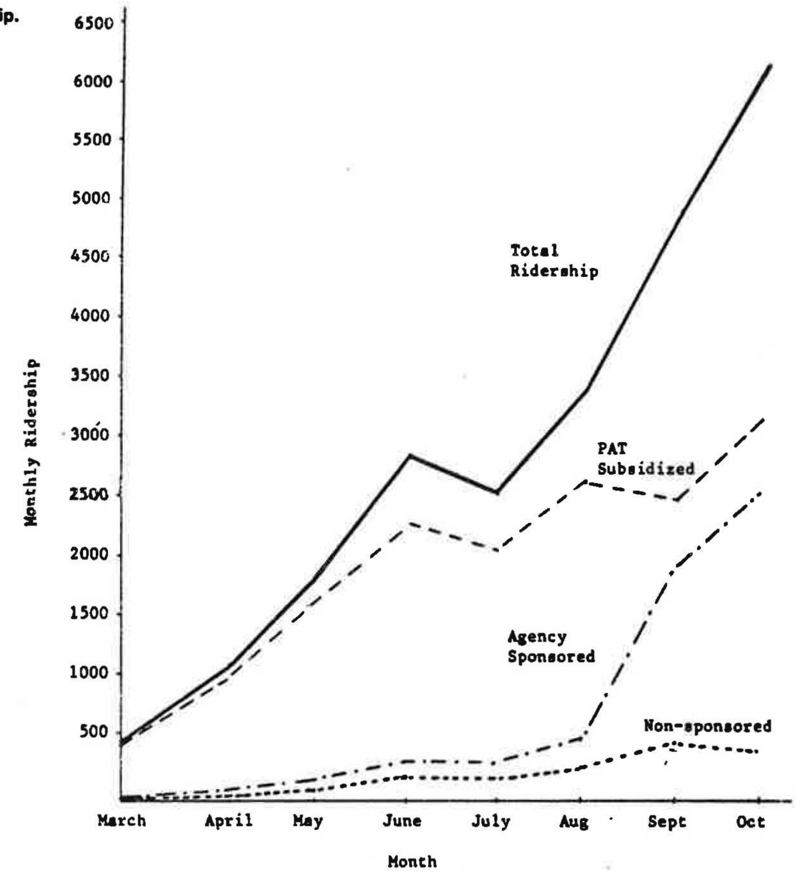
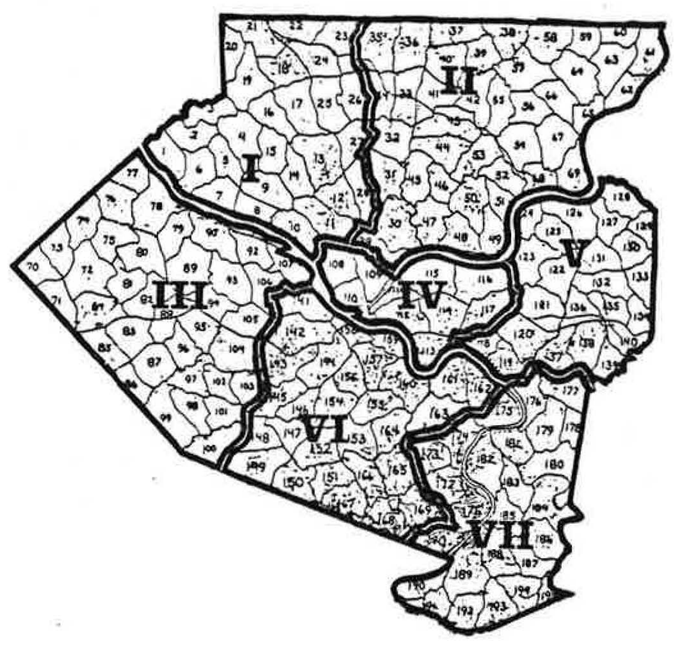


Table 1. Trip origin and destination patterns.

Trip Origin	Destination (%) Intra-area Trip	CBD	Other Areas	Total
Area I	1.0	0.8	0.5	2.3
Area II	0.0	1.1	0.2	1.3
Area III	5.2	0.2	0.3	5.7
Area IV (except CBD)	14.7	11.5	2.1	28.3
CBD	-	9.4	25.1	34.5
Area V	0.7	0.4	1.0	2.1
Area VI	12.6	10.5	1.7	24.8
Area VII	0.4	0.3	0.3	1.0
Total	34.6	34.2	31.2	100.0

Figure 2. Access service areas and fare zones.



1979 was $5.47. PAT supplied an additional $3.36/passenger trip in subsidy for certified individuals. All in all, subsidies on nonsponsored trips by persons unable to use the bus amounted to $8.83/person trip, and total subsidy provided for service to the nonambulatory for these nonsponsored trips is expected to total about $235 000 through the first year.

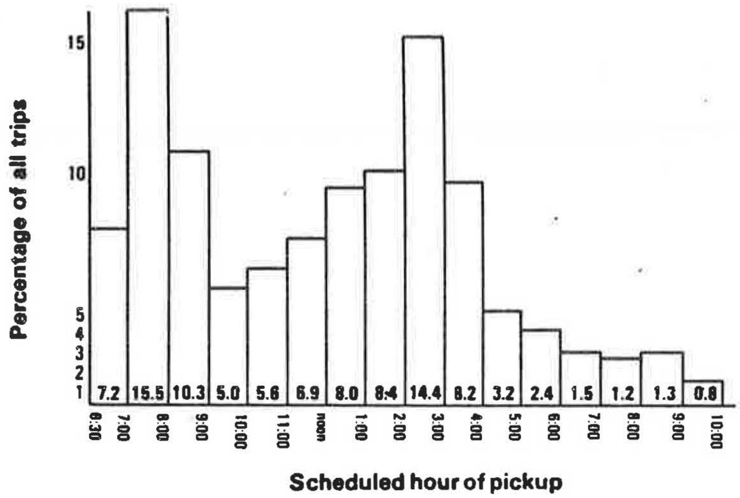
SERVICE STATISTICS

For those who want a slightly more detailed profile to the use of the Access service, the following exhibits and discussion may prove useful.

Ridership Growth

Figure 1 shows the early rate of growth of the Access service. Growth has been steady in all categories, although penetration of the scrip-users market is more advanced than penetration of the agency market. Eventually, agency ridership is expected to account for 65 to 70 percent of all trips. Escorts are tallied separately and account for roughly 4 percent of all passengers.

Figure 3. Ridership by time of day.



Trip Origins and Destinations

Table 1 shows the distribution of trip origins and destinations related to the areas delineated in Figure 2. Despite the numerous fare zones, much of the travel is concentrated in specific corridors. In particular, 24 percent of trips are destined for the two central business district (CBD) zones, 24 percent return from these two zones, and an additional 9 percent of all trips are taken within these two zones. Thus, almost 60 percent of all trips serve the major activity centers (business and medical centers) in the downtown, North Side, and Oakland areas of the city. Local trips in the eastern neighborhoods of the city or in the heavily populated South Hills suburbs constitute another 26 percent of all trips. Travel that originates in the more rural sections of the county remains extremely low. This reflects not only the smaller number of persons (90 percent of the population lives in 37 percent of the county's area) but also a habitual lack of travel by these more isolated persons.

It is estimated that 32 percent of trips are taken primarily for educational purposes, 30 percent are oriented to paid employment or other work-related activities, 21 percent are taken for medical reasons, and 17 percent are taken for social and recreational reasons.

Distribution of Trips by Time of Day

Figure 3 shows the distribution of trips by time of day. Times are based on scheduled pickup times. The graph displays the normal twin peaks of heavy work-trip patronage. Surprisingly, though, both morning and afternoon peaks are earlier than for the general public. The morning peak may be explained by the concern of riders of a shared-ride service that they not be late for work. However, it is less clear why the afternoon peak is over by 4:00 p.m.

Productivities

By October 1979, vehicle productivities, excluding metered cabs, had reached 1.3 passengers/vehicle-h. Although this figure is lower than that hoped for, it is within range of the vehicle productivity figures of Orange County, California, and Boston, Massachusetts, where similar services are running in the range of 1.5-2.0 passengers/vehicle-h.

CONCLUSIONS

After the first eight months of service, Access has already established itself as a major influence on the mobility of the handicapped. As a mechanism for providing accessibility to the nonambulatory at comparable fares, Access has proved an immediate success to a large number of persons. As a consumer ombudsman and as a powerful market influence on vehicle, driver, and insurance standards, Access has demonstrated that it is a powerful voice for the consumer.

Access has had moderate success in providing coordination benefits to agencies. Its greatest increases in ridership over the coming months are expected to come from this market. For the ambulatory individual, Access has had the least success because of its use of a scrip system and its day-before advance-notice requirement. Finding creative ways of attracting nonhandicapped elderly persons to Access will be a major challenge.

To date, Access has failed to realize the level of productivity gains originally envisioned. Now that the service has been established, this will be a major focus as the program moves into its second year.

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Local Responses to Meeting the Transportation Needs of the Handicapped: The Experiences of Six Texas Cities

SANDRA ROSENBLOOM

The attempts of six Texas cities to meet the transportation needs of handicapped citizens by making extensive use of existing community transportation providers are described. An analysis of these experiences reveals that intuitive solutions to providing cost-effective services for handicapped riders are often simplistic. In particular the analysis found that (a) contracting with an existing provider is only cost-effective if the provider is asked to perform traditional services and not innovative ones, (b) contracting with an existing provider can only generate cost savings if a city is willing to trade off direct control and supervision for lower unit costs, (c) dedicated services (vehicles and drivers) can provide a high level of service but often at high unit costs, (d) segregating riders who require minimal assistance from those who require extensive assistance can reduce costs if different providers are used for each group, and (e) every limitation on rider eligibility and contract service provision generates the need for additional administrative staff, which can significantly increase unit costs. The experiences of the six Texas cities suggest that solutions to the problem of devising transportation services for special groups depends on careful analysis of the capabilities of existing community providers; a firm understanding of the trade-offs between levels of service, cost, and control; and some hard decisions about what level of transportation service a community expects and to which special groups it should be delivered.

Many U.S. cities are responding to the transportation needs of elderly and handicapped (E&H) citizens and to their interpretations of Section 504 regulations administered by the Urban Mass Transportation Administration (UMTA) in a variety of ways. Because UMTA's final regulations were so long in coming, many localities felt free to devise their own arrangements and their own organizational solutions to the problems of these citizens. This paper presents information on how six Texas cities whose populations ranged from 313 000 to 1 455 000 people (estimated 1976) have responded in different ways to the transportation needs of elderly or handicapped citizens. All six cities are notable because they made extensive use of existing community resources and expertise in providing transportation services. The paper discusses the relevance of these experiences for other American cities.

The six Texas cities and their basic characteristics are shown in Table 1. Each city is served by a publicly owned transit system; the systems in Houston and San Antonio are owned by areawide metropolitan transit districts, both fairly recently formed. All cities have bus-only fleets that now have no "accessible" vehicles in fixed-route service. All provide reduced fares on their regular transit service to E&H citizens.

Each of these six cities will be briefly discussed and the organizational strategies that each used to provide transportation services for the E&H will be described. Basic cost, performance, and productivity measures for each service will be discussed and compared.

BACKGROUND

Austin

The city's publicly owned transit system currently provides a special 24-h advance-notice service to handicapped citizens of Austin at $0.50/one-way trip. Eligible riders must have some form of physical handicap that prevents them from using the city's regular fixed-route service. Eligible riders must register with the transit system before their

Table 1. Basic characteristics of E&H transportation in six Texas cities.

City	Population	Type of Service	Eligible Riders	Eligibility Screener	One-Way Fare to Riders	Actual Service Provider	Type of Vehicle Used	Average Daily Ridership (one-way trips)
Austin	313 000	24-h notice	Handicapped only, citywide	City	$0.50	Transit system	Wheelchair-equipped vans	112
						Yellow-Checker Cab Company	Regular taxis	138
Dallas	849 000	24-h notice	Handicapped only, limited service area	Social service agencies, private doctors	$2.00	Highland Hills Transit Service (private company)	Wheelchair-equipped vans	240
El Paso	391 000	24-h notice	Handicapped only, citywide	Social service agencies, private doctors	Free	Red Cross, El Paso chapter	Wheelchair-equipped vans	81
Ft. Worth	368 000	24-h notice	Handicapped only, citywide	City	Income test ($0.50-1.00 billed to rider)	Yellow Cab and Baggage Company	Wheelchair-equipped vans	280
Houston	1 455 000	24-h notice	Handicapped only, limited service area	Transit property	$0.50	Yellow Cab, NCDCA, (nonprofit), St. Joseph's Hospital (nonprofit)	Wheelchair-equipped vans	567
San Antonio	784 000	24-h notice	Handicapped only, citywide	Goodwill, transit property (after 8/79)	$0.50	Goodwill (nonprofit)	Wheelchair-equipped vans	
						Yellow and Checker Cab Companies	Regular taxis	1273
						Transit system (to begin 8/79)	Lift-equipped vans	

first trip; currently 1800 people are registered to use the system.

The city provides service in five specially equipped vans that can carry up to five wheelchair occupants at one time; generally only four vans are on the road at any point. Requests for trips are received by 3:00 p.m. of the day preceding the day of travel; the city system takes all wheelchair requests and then allocates any overflow nonwheelchair riders to Austin Yellow-Checker Cab on a contractual basis. The city usually directly carries about 40-45 percent of all requested trips; the rest are allocated to the taxi operator, who receives those trip requests by 5:00 p.m. of the day preceding the rider's travel. The cab company's contract currently calls for the repayment at $5.00 (including the rider's $0.50) per one-way trip regardless of the trip length (note that the transit system does all client intake and eligibility screening).

Although there have been a few problems, the city is fairly happy with the taxi contract. The taxi system is often more prompt than the city service; the city service is often delayed by the variable time required to provide assistance to wheelchair passengers and to other severely handicapped individuals. The transit system was able to obtain a Section 13c clearance on the arrangement by agreeing that the number of drivers who provide the direct city special service would never fall below the existing number of drivers--nine. Because the taxi operator often mixes riders in the same taxi, a special city ordinance against group riding had to be modified.

The combined city-taxi special transit service currently provides an average of 250 trips/day; this usually involves between 100 and 150 riders. Over an average week, the special transit service probably carries 500-600 riders on a fairly regular basis. Of the 1800 people eligible to ride the special vehicles, the city estimates that about 100 would be able to use conventional transit service if all vehicles providing fixed-route service had (or were retrofitted with) full accessibility features.

The city began the special transit service in 1974 when it bid successfully on a regional Department of Human Resources (DHR) (then Public Welfare) contract to provide service to Medicaid and Medicare users unable to use conventional transit services. The city bid included the purchase of the original two specially equipped vehicles. Later the city purchased additional vehicles and began to mix DHR clients with "ordinary" citizens of Austin who required such special services. Although many DHR clients lived in Austin, the city system was required to provide service in and to rural Travis County DHR clients. However, within the city limits an interesting anomaly arose; non-DHR Austin residents paid a fare of $0.50 for a service identical to that provided DHR clients (who were also Austin citizens) for which DHR paid the city almost 15 times that amount. Both the DHR and the transit system feel they were losers in this arrangement; however, DHR did not end it until 1977. The city system also originally had a contract to allow able-bodied DHR Medicaid and Medicare recipients to ride conventional fixed-route transit by simply showing proper identification; the city then billed DHR for a sum that generally represented total monthly estimated ridership. Currently the transit system simply sells DHR books of tickets ($3.00 for 10 riders at full fare during peak hours) that that agency gives to its clients in any manner it chooses.

Dallas

A flexible service to the E&H in Dallas is provided by CareCar, a curb-to-curb demand-responsive service managed by Highland Hill Transportation Service (a private company) under contract to the Dallas Transit System (DTS).

E&H people who are unable to use regular transit vehicles can apply for a photo identification card that is proof of their eligibility to use the service. Applications must be certified by a physician or by one of the authorized social service agencies before being presented to DTS; 572 persons were certified through July 1, 1979.

CareCar operates 12 vans, small buses equipped to carry eight persons and two wheelchairs. The vehicles were acquired under an UMTA Section 5 capital grant at the cost of $15 500 each and are leased to the contractor for the nominal sum of $1.00/year per van. The system was started in December 1978 and has been operating in a limited area (within highway loop 12 in Dallas) from 7:00 a.m. to 6:00 p.m. Monday through Saturday. It requires 24-h advance notice.

Except for accepting applications, advertising, and some monitoring, DTS involvement with the system has been up to now very limited. The vans are leased to the contractor, who receives the calls, provides for the dispatching and operation, and collects fares. Fares were $1.00/one-way trip, but were $2.00 starting on July 16, 1979, when assistance for the amount of $30 000 was negotiated for the following 2.5 months; on October 1 the whole contract will be renegotiated.

Cost to the users is rather high, especially after the increase to $2.00/one-way trip. Many of the regular users ride twice a day, five days a week, which means they pay some $80.00/month. Service characteristics create some problems; the bus operator only waits 2 min at the curb after scheduled pickup time, so that some people miss the bus. The curb-to-curb service obviously provides less comfort than a door-to-door service.

The city transit system wants to limit its direct involvement in providing the service; plans are under way to expand the geographic service area if new vehicles can be acquired through grants, and an operation subsidy will probably be provided in the future. At present DTS does not show much awareness of or interest in operating statistics (number of miles, trips, etc.) of the service.

El Paso

The city of El Paso provides a special transportation service, HandySCAT, to handicapped citizens of the city through contract with the El Paso chapter of the Red Cross. HandySCAT operates Monday through Friday between 7:00 a.m. and 6:00 p.m. Riders whose eligibility has already been certified directly call the Red Cross to obtain transportation.

The city has found that ridership on the Red Cross service tends to follow citywide transit trends. In March 1979 (a typically high-use transit month) the special service carried 1937 one-way passenger trips; in May of the same year the service carried 1713 one-way passenger trips.

El Paso (which only began operating the transit system in 1977) began providing the HandySCAT service in January 1978 after carefully considering a number of alternatives that included contracting with a local taxi operator. At the time the city began its deliberations, the El Paso chapter of the Red Cross was providing a limited Help-on-Wheels service and was under contract to the regional office of the Texas DHR to provide transportation services for their Medicare and Medicaid clients (a situation similar to that in Austin). In order to provide a better service, the Red Cross had obtained an UMTA 16b(2) grant to buy seven wheelchair-equipped vehicles. However, by the time the vehicles arrived, DHR had cancelled the contract with Red Cross (over allegations of overcharging and financial problems that have not yet been settled). Red Cross refused to accept delivery of the vehicles because they did not have the funds to operate or maintain them. The city decided that the most cost-effective solution to their need to provide specialized services citywide was to contract with the Red Cross to use those vehicles, as well as the agency's previous expertise in transportation.

At the current time, the city is involved in a study of future alternative options. El Paso is probably the largest city in the United States that provides citywide service by means of volunteer drivers, and there is a question as to whether that situation can continue.

Ft. Worth

Mobility Impaired Transportation Service (MITS) started operating in the city limits of Ft. Worth on June 1, 1979. Operation is contracted by the city to the Yellow Cab and Baggage Company of Ft. Worth, which has set up a special section to handle MITS. A MITS section was created within the city's transportation department, parallel to, but independent of, Citrans, the municipal transit authority.

Once clients have been certified for eligibility, they call MITS-Yellow Cab directly to receive service. Curb-to-curb service is provided Monday through Friday between 6:00 a.m. and 6:00 p.m., and reservations must be made 24 h in advance. Yellow Cab handles the scheduling and dispatching; the city elaborates the raw data on ridership provided by the taxi company and bills the clients at a rate of $1.00/passenger trip ($0.50 for persons below a set income threshold).

Yellow Cab operates seven modified B300 Dodge vans that are equipped with wheelchair lifts; each van has a capacity of two wheelchairs and four adults who have walking aids. The vans were purchased by the city with an UMTA Section 5 capital grant (80 percent UMTA, 13 percent state, and 7 percent city funds) at the cost of $120 000 and are leased to the taxi company for the nominal sum of $1.00/year.

The screening and eligibility determination for the applicants is handled by the city. At present, eligibility is restricted to persons who are confined to wheelchairs or to those who have severe physical, mental, or emotional problems that prevent them from using Citrans' fixed-route service. Application forms have been distributed to 14 local social service agencies, which directly handle the certification for their clients at no cost. The contract between the city and Yellow Cab is designed so that the company receives a minimum guaranteed monthly payment in exchange for a given level of service (up to 120 operator-h/week); additional service is billed at an hourly rate.

Houston

The Metropolitan Transit Authority (MTA) that serves Houston and Harris County operates a 24-h-notice appointment service called Metrolift for the eligible E&H in a geographic subarea of MTA's jurisdiction. The current Metrolift service, which began in April 1979, grew out of an earlier, far more limited, service that was begun in April 1978.

MTA is attempting to develop a genuine brokerage system in the Houston area and so has attempted to draw a number of agencies into the service, either as providers or as purchasers of service. Thus, the Metrolift program is open to eligible E&H individual citizens of Houston living within the prescribed area and to clients of participating agencies.

Currently, three agencies are under contract to MTA to provide drivers and wheelchair-equipped vehicles--Neighborhood Centers' Day Care Association (NCDCA), Yellow Cab, and St. Joseph's Catholic Church. Yellow Cab is the major service provider that operates dedicated vehicles; the other two providers are called when demand exceeds Yellow Cab's capacity. Receiving client calls and dispatching is handled for all three providers by Yellow Cab under a separate contract with MTA. Yellow Cab is paid $64 000/year for dispatching. MTA currently pays Yellow Cab $12.00/vehicle-h for the transportation service; NCDCA and St. Joseph's are paid $14.00/vehicle-h when their vans are used. The $12.00/h rate is for dedicated vehicles; $14.00/h is paid to providers who guarantee their vehicles. MTA justifies the differential payment schemes on the grounds that the latter two providers are only used on demand for backup services.

In addition to MTA's own citizen riders, MTA currently contracts with other agencies to provide services to their clients. One funding source is the Center for the Retarded. Another agency is the Texas DHR, which must provide transportation for its Medicaid and Medicare clients. DHR has a separate contract with Yellow Cab to provide that service in regular nondedicated taxis, but the arrangement has not worked well. The current DHR arrangement is that whenever possible or necessary Yellow Cab will place DHR clients on board the vehicles dedicated to MTA service rather than place them in conventional taxis. MTA is negotiating to provide service to eligible riders who live in designated neighborhoods in the Houston Community Development Program. No service has yet been provided in this program; contractual details have not yet been settled.

The charges incurred (or to be incurred) by each of the three agencies currently participating in the MTA brokerage differs. MTA currently guarantees the Center for the Retarded a ceiling price of $2.00/one-way passenger trip (regardless of length). The Houston Community Development Program will be guaranteed a $3.00/trip ceiling price; DHR pays $5.00/one-way passenger trip. These large variations are officially justified because the characteristics of the three agencies are dissimilar. Actually, it appears that, since the charges to all three participating agencies are significantly below MTA's cost to provide service, each agency was billed for what it would bear without seeking other alternatives. MTA staff members justify this approach to their governing board by noting that all of the participating agencies' clients would have to be carried for only $0.50 if the clients called Metrolift directly.

MTA is currently negotiating with the Area Administration on Aging (AAA) (now located in the city government) to carry their clients also. AAA's clients are generally elderly persons carried daily at midday from their home to congregate meal sites. AAA, which operates a fleet of vans, believes that it currently serves those clients for approximately $1.01/trip. MTA would have to meet or beat that cost for AAA to become involved with the brokerage. Beginning in September 1980, MTA will provide a temporary experimental service for AAA clients at one congregate meal site; this will allow AAA to determine whether MTA can deliver the quality of service AAA desires.

San Antonio

Via, the metropolitan transit authority that serves San Antonio and Bexar County, originally contracted for Handi-Lift, a special transportation service for the handicapped, with Goodwill Rehabilitation Service. Goodwill Industries is a nonprofit agency that has been expanding its activity in the field of special transportation. Handi-Lift was started as a pilot project in 1977 to provide transportation to mobility-impaired persons who were unable to use public transportation effectively. At present, the service is in a stage of transition; Via has just begun to directly provide service.

Under the original contract, Goodwill used its 13 lift-equipped vans and its own drivers to carry nonambulatory passengers. The transportation of ambulatory passengers in excess of capacity was subcontracted to a taxi operator.

Operating hours were 6:00 a.m. to 10:00 p.m. Monday through Saturday. Clients needed to register and submit to Goodwill proof of eligibility as certified either by a physician or by selected social service agencies. Requests for pickup had to be made 24 h in advance. There were no restrictions on trip purposes.

Under the old contract, Goodwill administered the whole program, from eligibility screening to reception of calls, scheduling, and operation and maintenance of vehicles, and it was reimbursed by Via on the basis of documented expenses. Vehicle depreciation was not included as a cost item, since the vans had been purchased with UMTA 16b(2) funds. The cost per trip for the client overflow subcontracted to the taxi operator was negotiated on a daily basis, according to the trip characteristics of the advance reservations, and was a flat fare per trip. Under the previous arrangement, Via reimbursed Goodwill for the expenses incurred in the provision of the service and had little direct involvement.

As previously stated, the system is now in transition. In July 1979, Via took over the handling of ambulatory passengers and is contracting directly with Yellow Cab and Checker Cab for the provision of this service at a flat fare per trip of $3.35 ($2.85 paid by the city and $0.50 by the passenger); no data on ridership or mileage are yet available.

In August 1979, the contract for the transportation of nonambulatory passengers was also terminated. Via will start operating its own system, called Via-Trans, with 25 lift vans (capacity three wheelchairs and three adults) obtained under UMTA Section 5 capital grants (cost $16 500/van).

Handi-Lift clients have been asked to register for eligibility to use the new system, which will operate seven days a week between 6:00 a.m. and 11:00 p.m. and will require at least 2-h advance reservation. The annual operating budget will total $492 000, and a system cost of $5.00/one-way trip has been estimated.

Via-Trans will be available to provide transportation for social service agencies under contract, charging the full cost. A problem situation might develop whereby social service agencies would encourage their clients to request transportation from Via-Trans privately, since the clients would be entitled to ride for a $0.50 fare like all other eligible San Antonio citizens. Once there is a Via-Trans manager, the new system should be much more efficient and cost-effective than Handi-Lift, because it would use, among other things, an innovative scheduling system. The first data to make a comparison will be available around the end of October 1980.

COMMON DIFFICULTIES

Eligibility

All six of the cities discussed have limited special services to those with physical handicaps regardless of age; this is consistent with the regulations issued pursuant to Section 504 of the Rehabilitation Act of 1973. Such limitation is not particularly responsive to UMTA's concern for the elderly in general nor to the advocates of such groups, which suggests that these systems may come under increasing pressure to expand their eligibility requirements and to provide service to the able-bodied elderly as well.

Determining the eligibility of handicapped people has also proved difficult for all six cities. El Paso will not accept mentally retarded individuals, although this may not be consistent with the Section 504 regulations. Almost all cities described have trouble in defining the eligibility of the blind; several systems that are nearing capacity are considering refusing service to the blind. Again, this may not be consistent either with the Section 504 regulations or with the political demands of advocates.

Some systems are refusing to consider the mere presence of a physical ailment or disease to indicate eligibility; they demand that doctors or social service agencies certifying clients actually state that the client cannot, for example, lift his or her foot above a certain level or perform some physical maneuver necessary to use conventional transit. These requirements appear to develop when the system comes close to capacity, at least during certain times of the day, and the administrative staff is pressed to limit ridership. The development of such detailed eligibility requirements creates a number of problems; staff must spend a great deal of time checking on doctors and riders and becoming familiar with the symptoms of a myriad of diseases. Riders, doctors, and participating social service agencies find such requirements to be discriminatory and bureaucratic (which of course they are). Lastly, the development of complicated and complex eligibility requirements may discourage riders in real need of assistance from seeking it.

El Paso and Houston have set up citizen and agency boards to deal with appeals from clients or citizens denied eligibility.

Capacity

Most of the systems that have been described above have arrived at full capacity at least during certain times of the day. Houston and Austin are completely scheduled during the morning and evening peaks; El Paso is near full capacity at midday. Each system is attempting to deal with the problem in different ways. Some systems have instituted classes of priorities for trips, often after the service has begun. Some systems are simply refusing to accept new clients at all. Both approaches create difficulties; it is not clear that the first approach meets Section 504 requirements, and the second approach clearly does not. Such restrictions, particularly those that are initiated after the service has been in effect for some time, create real informational problems for riders and for participating social service agencies.

Such peaking demands and capacity situations also appear to create real operational difficulties,

Table 2. Cost and performance measures for E&H service in six Texas cities.

System	Initial Cost per Passenger Trip ($)	Cost per Passenger Trip as of January 1980 ($)	Passengers per Vehicle Hour	Cost per Vehicle Hour ($)	Cost per Vehicle Mile ($)	Average Trip Length (vehicle miles)
Austin						
Special transit services	NA	10.84	NA	NA	1.29	8.4
Yellow-Checker Cab (regular taxi)	5.00	5.00	NA	NA	NA	NA
Dallas, Carecar	NA	5.10	3.81	12.09	0.54	5.83
Reconstructed costs[a]		5.86		14.45	0.63	
El Paso, Handy-SCAT[b]	15.05	4.47	NA	NA	0.42	10.7
Ft. Worth, MITS	28.82	8.43	2.27	19.34	0.86	6.9
Reconstructed costs[a]	34.02	10.03				
Houston[c]						
Metrolift	14.11	9.13	1.7	24.00	NA	NA
Billing to Center for the Retarded	17.26	14.00	1.2	29.00	NA	NA
San Antonio						
Via	9.05	8.00	NA	NA	1.22	7.43
Reconstructed costs[a]		8.80			1.32	
Yellow and Checker Cab	3.85	3.85	NA	NA	NA	NA

[a]Costs reconstructed to include administration and overhead.
[b]El Paso figures do not include insurance, capital costs, or depreciation.
[c]Houston figures do not include dispatching costs. Costs are from May 24-June 24, 1979.

Table 3. Costs per passenger trip over time.

City	Cost per Passenger Trip ($)				
	Initial	June 1979	July 1979	August 1979	January 1980
Dallas	NA			3.17	5.10
Reconstructed[a]				3.79	5.86
Ft. Worth	19.73			14.02	8.43
Reconstructed[a]					10.03
Houston[b]	12.77	11.52	10.35		9.13

[a]Cost reconstructed to include administration and overhead.
[b]Does not include administrative, overhead, or dispatching costs.

particularly when different clients require different amounts of assistance and different amounts of time to board and alight. Reliability on many of these services has been reported as very poor by client groups, particularly for nonregular or nonscheduled trips.

COSTS AND PERFORMANCE MEASURES

Table 2 summarizes major cost and performance characteristics for the six cities examined. It is obvious that costs range widely, partly in response to unique local conditions such as trip lengths. They also vary, however, in response to the way the service is actually provided. The following discussion will illustrate how different modes of delivery affect costs (1).

Reduction in Costs As System Gains Experience

Table 3 shows that over time most systems significantly reduced their costs per passenger trip. In Ft. Worth the average operating cost for the first seven weeks that the MITS system was in operation was $19.73/passenger trip (initial cost was $28.82/one-way passenger trip). During the seventh week alone (when ridership was up 54 percent from the average of the previous six weeks, from 181 to 280 passenger trips per week) the cost fell to $14.02/passenger trip. Table 3 also shows that Houston's total Metrolift costs on a monthly basis fell for each of the three months that followed introduction of service.

The Dallas CareCar program has experienced increasing per-unit costs, but initial cost data are not available. It is possible that Dallas follows the same downward pattern from its initial costs.

Increase in Administrative Expenses to Meet Funds Available

Both Ft. Worth and El Paso show particularly high administrative cost patterns for different and interesting reasons. Ft. Worth's MITS system involves not only totally dedicated vehicles and driver personnel but also a rather large dedicated administrative staff. If we include both the city staff and Yellow Cab overhead costs, they represent about 44 percent of the total cost of the project. Two explanations can be given for this. First, comparable overhead figures normally collected are probably understated. Second, the administrative staff for the project is quite sizable, and this can be explained by the expected future expansion of the system, which has now been operating for less than two months. In the initial period, these costs will weigh rather heavily on the limited number of trips provided; in fact, in the first seven weeks the overhead costs alone averaged $9.00/passenger trip.

Figures in El Paso are comparable; although firm data are not available, it appears that administrative expenses account for well over 50 percent of operating expenses. Again, the El Paso Red Cross has a large administrative staff dedicated to the contract transportation services alone. Thus, although the Red Cross uses volunteer drivers, administrative salaries help to bring the cost per passenger trip (while low) close to that offered by taxis in other cities.

Dedicated Service and Defining Classes of Client Handicaps

Dedicated service, even if provided by private entrepreneurs who have expertise in transportation, at least initially appears to be extremely costly. Using taxi operators to provide dedicated service, as in Houston and Ft. Worth, does not seem to tap the lower costs that taxi operators in normal operation can offer (as they do in Austin and San Antonio). Of course, as the ridership of the first two systems grows, costs per passenger trip may decline, but it is hard to see how they could fall to the level offered by taxis in ordinary meter operation. At least initially it appears that it is the high utilization of equipment and labor in normal private taxi operations that generates lower unit cost and not lower labor or other costs.

This factor, however, overlaps with another: Those cities that separate severely handicapped people who require significant assistance and time to enter and leave a vehicle from those people who do not require such aid can significantly lower their average costs per passenger trip. In fact, some systems can lower per passenger costs for both classes of passengers as well.

The Austin and San Antonio transit systems have been able to realize considerable cost savings by directly carrying only those passengers who require extensive assistance and lengthy boarding time; they carry the less severely handicapped only when they have excess capacity on that service. The rest of the trips of the ambulatory handicapped are contracted out to the local private taxi provider, who integrates those travelers into the regular taxi service offered to the community. In addition to keeping costs per passenger trip lower, both cities have found that the taxi operator provides a more reliable and on-time service; the dedicated service for the severely handicapped is less reliable because the time required to assist and transport those clients can vary so significantly.

Thus, two overlapping service features appear to significantly increase costs: (a) dedicating vehicles and drivers and (b) mixing clients who require different levels of service and assistance. It should be noted that not only do dedicated systems tend to keep overall vehicle productivity low (at least initially), but they also tend to create the need for an extensive administrative staff. This increase of administrative staff occurs in both nonprofit and profit-making providers, as the contrasting cases of Ft. Worth and El Paso show.

The staffs of several of the cities are not unaware of the problem described here. Even where the city is aware of the problems of dedicated service and mixing clients who have different needs for assistance, it still may consciously choose this option for one of the following reasons. First, the actual or expected trip volume for any type of rider may be too high for the regular taxi (or other) provider to accommodate or integrate into regular citywide service: In Houston, a large social service agency chose to join the MTA brokerage (a dedicated service) because the regular taxi service they received under contract was so poor.

Second, many cities are simply unable to predict their ridership at all and certainly not segmented by the degree of assistance any group of riders will require. They assume, not unnaturally, that one way to increase vehicle productivity for whatever service they do provide for whatever number of riders is to mix as many riders as possible on board at the same time. This approach is consistent with an emerging national view that stresses mixing clients of different agencies to reduce unit costs. Unfortunately, when clients are extremely dissimilar in their personal characteristics and trip patterns, mixing them may increase per-unit costs. Obviously it would be useful to know at what point productivity is reduced by mixing clients, but this information is not currently available.

Third, some cities have chosen dedicated services because they wish to exercise a great deal of control over the provider and the transportation services delivered. This may explain why some of the Texas cities studied also felt the need to develop a specific city unit to oversee the operation of the provider. It is ironic that in some cases the city has chosen to contract with an existing nonprofit or private transportation provider because it wishes to minimize its involvement in direct transportation provision but then feels the need to establish administrative staffs to compensate for the lack of control, a control that direct provision would bring.

A fourth reason is directly related to the third; some cities have chosen to contract with existing providers and/or to provide dedicated services because they do not wish to integrate those services into the regular transit services of the city. Some cities are providing such services because they have been forced to (by, for example, local handicapped groups) or as an interim step until all the confusion over UMTA's Section 504 regulations have been cleared up. Some cities do not wish to continue such services or are afraid that they will be unable to do so; in either case it will be easier to cancel a contract or to cut off an operation that is not fully integrated into regular transit operations.

IMPLICATIONS FOR OTHER CITIES

These six Texas cities are interesting because several of them have tried innovative or highly touted ways to provide transportation services to special user groups. Their experiences have given some insight into which operational characteristics actually can lead to higher performance and which cannot. As in any examination of intuitive solutions to urban problems, there have been some surprising and enlightening results.

1. Contracting with an existing transportation provider can be highly effective if the provider is asked to provide the same type of service previously rendered in relatively the same manner. Asking a provider such as a taxi operator to provide a different class of service may produce higher costs than expected.

2. Contracting with an existing provider can offer total cost savings if the city or transit property is willing to give up some control and direction over the services provided in exchange for lower unit costs. If the city simply substitutes the administrative overhead generated by supervisory staff for direct costs of operation, total costs per passenger trip will rise, sometimes significantly.

3. Dedicated services for the handicapped can provide a relatively high level of service to most riders, but often at high cost. Dedicated services appear to have a more limited capacity for increased productivity than commonly thought; productivity seems to be negatively correlated to the number of riders requiring extensive assistance and boarding time. Moreover, as the number of such severely handicapped riders increases, the high level of service sought by the dedicated system may decline sharply. (If demend-responsive and mixed service is continued, scheduling will become increasingly more difficult and the service will become unreliable and involve lengthy on-board, home, and nonhome waits for pickup.)

4. Segregating riders who require only minimal assistance to use door-to-door services from those who require more extensive service appears to offer some significant opportunities for cost savings if different providers are used to respond to the transportation needs of these groups. However, if the demand becomes too great for conventional contract providers, the quality of service available to either group may fall significantly.

5. Almost every limitation on rider eligibility and every condition imposed on contract service providers appears to create the need for administrative staff on the part of the certifying agency, the contracting agency, and the operating

agency. In short, whenever possible, and not actively prevented, administrative expenses can increase sharply for all participating agencies.

In summary, the experience of the six Texas cities suggests that solutions to the problem of devising an efficient way to provide transportation services to the handicapped depend on a careful analysis of the abilities and capabilities of existing transportation providers in the community; a clear understanding of the trade-offs between quality, control, and cost; and some hard decisions about what level of service a community and its E&H citizens expect and are willing to pay for.

ACKNOWLEDGMENT

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Comparison of Findings from Projects That Employ User-Side Subsidies for Taxi and Bus Travel

DON KENDALL

Experiments with user-side subsidies began about four years ago. The Urban Mass Transportation Administration Service and Methods Demonstration program has funded a series of projects and monitored others already in operation to determine the workability of user-sider subsidies in different settings as they are applied to different forms of public transportation. Results from 13 applications of user-side subsidies as a means of improving the mobility of transit-dependent persons are presented. Examples of public and private providers, paratransit and fixed-route services, small to medium-sized cities, and limited (target market) eligibility, including a variety of subsidy levels, payment mechanisms, and fare policies, are discussed and examined. Generalizations are made, where possible, about administrative policies, fare-discount strategies, and project impacts.

There has been a great deal of interest in the concept of user-side subsidies since the early experiments began about four years ago. The Urban Mass Transportation Administration (UMTA) Service and Methods Demonstration (SMD) program has funded a series of projects (1,2) aimed at determining the workability of user-side subsidies in different settings and as applied to different forms of public transportation. In the meantime, there has been a growing number of locally initiated user-subsidized services; some of these have been monitored by the SMD program (3,4). Given the substantial amount of accumulated experience and the high level of current interest on the part of the planners, cross comparisons of existing results were made in an effort to develop transferable findings that will be useful in planning other projects.

Subsidies for public transportation have traditionally been provider-side subsidies made available directly to the transportation provider as compensation for offering certain specified services at fares that do not generate sufficient total revenues to cover the cost of providing the service. The user-side subsidy offers an alternative method of subsidizing transportation services (5,6). In this method, a provider accepts tickets or vouchers (or any mechanism used to provide evidence of trips delivered) from users and redeems them from the subsidizing agency for a value established in advance. This value usually represents the difference between the fare paid by the rider and the total cost of the trip. However, it may also be applied in such a way as to permit subsidization of the difference between a discounted fare and the full fare in cases in which a transit operator receives a provider subsidy as well.

This paper presents results from 13 applications of user-side subsidies, in most cases as a means of improving the mobility of transit-dependent persons. Examples of public and private providers, paratransit and fixed-route services, small to medium-sized cities, and limited (target market) eligibility and subsidization of all trips, including a variety of subsidy levels, payment mechanisms, and fare policies, are examined and discussed. Where possible, generalizations are made about administrative policies, fare-discount strategies, and project impacts.

The analysis of the available data from these projects has focused primarily on six areas:

1. Characteristics of the market segments that elect to participate and the penetration of the eligible market,
2. Trip-making frequency and mode share of project trips,
3. Findings related to trade-offs among alternative administrative policies,
4. Costs of user-side subsidy projects,
5. Benefits to project users, and
6. Impacts of user-side subsidies on taxi operators.

VARIATIONS IN THE DESIGN OF PROJECT STUDIES

Table 1 contains a summary of the basic features of each of the four on-going demonstration projects in Danville, Illinois; Montgomery, Alabama; Kinston, North Carolina; and Lawrence, Massachusetts. A user-side subsidy demonstration project in 1978 in Milton Township, a suburb of Chicago, is also included.

In addition to the above demonstration projects, the SMD program monitored locally initiated user-side subsidy programs in Kansas City (4), the San Francisco Bay area (3), Los Angeles, and the state of West Virginia (7). Summary information on

Table 1. Summary of user-side subsidy projects.

Item	SMD Demonstration Projects					Non-SMD Projects			
	Danville	Montgomery	Kinston	Lawrence	Milton	Kansas City	San Francisco Bay Area[a]	Los Angeles Harbor Area	West Virginia TRIP
Date project began operation	12/75	8/77	9/77	7/78	8/78	5/77	1974-76	9/78	6/74
Population	42 600	133 400	22 300	66 900	61 600	500 000	NA	120 000	1 810 000
Area (miles^2)	12.9	46.4	6.1	6.8	36	NA	NA	23	24 181
Population density (persons/mile^2)	3300	2900	3800	9800	1955	1600	NA	5217	75
Population over 65 (%)	13	9.3	9.8	14.9	6.2	12	NA	NA	NA
Total eligible population	7500	18 600	2860	12 500	6500	75 000	1250-21 000	NA	122 000
Project modes	Taxi (1975-78), bus (1978)	Taxi, bus	Taxi	Taxi, bus	Taxi	Taxi, agency vans[b]	Taxi	Taxi	Taxi, bus
Number of taxi companies in service area	2	16	10	10	NA	NA	NA	NA	NA
Number of participating taxi firms	2	3	8	8	2	2	-	1	NA
Number of participating taxi vehicles	24	47	33	63	14	90	-	35	NA
Project taxi coverage (vehicles/mile^2)	2.0	1.0	5.5	9.3	0.4	0.3[c]	1-2	0.66	NA
Taxi fare structure	Zone	Zone[d]	Zone	Zone	NA	Zone[d]	Meter	Meter	Meter
Shared-ride service available	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No
Taxi subsidy mechanism	Vouchers	Vouchers	Tickets	Tickets	Tickets	Tickets	Scrip, tickets, vouchers	Tickets	Tickets
Fare discount (%)	50[e]	50	50	50	NA	75	50-100	>90	88
Avg user fare ($)	0.62	1.30	0.76	0.75	0.50[f]	0.50	0.0-0.63	0.15[f]	0.38[g]
Monthly travel limit (total undiscounted fares, $)	20	30	25	20	None	NA	NA	None	8
Avg vehicle trip length (miles)	2.0	2.5[c]	1.3	2.0	2.0	NA	1.7-5.4	1.7	NA
Fixed-route transit									
Standard fare ($)	40	0.30, 0.15[h]	-	0.15	-	-	-	-	NA
Project fare/trip ($)	20	0.15, 0.0[h]	-	0.01	-	-	-	-	NA
Results									
Persons registered	3500	5500	700	3200	-	10 710	140-2000	NA	NA
Percentage of eligibles registered	47	30	25	26	-	14	4-32	NA	NA
Project taxi ridership (monthly)	4500[i]	3290[j]	3200[j]	7000[j]	NA	10 000	413-1650	3500	NA
Project transit ridership (monthly)	10 660[k]	21 100[j]	-	15 000[j]	-	-	-	-	NA

Note: NA = data not available.
[a]Six programs in six regions of San Francisco; range of values for the programs is shown.
[b]Eight agency vans; three city-owned vans.
[c]Estimated.
[d]Zone fares for project trips only.
[e]Fare discount was 73 percent during first year of project.
[f]Flat fare.
[g]Estimated average total fare is $3.00.
[h]Peak and off-peak fares, respectively.
[i]Ridership level after introduction of bus service.
[j]Average over a stable six-month period 1978-1979.
[k]Handicapped and elderly ridership only; transit discounts are also available to youth (under 18 years of age).

these projects is also included in Table 1.

Although the user-side subsidy was originally tested by the SMD program as a means of providing low-cost taxi service for transportation-handicapped persons, the concept has since been applied to fixed-route transit service and is being tested in a variety of contexts. Because the subsidy is offered only for trips delivered, it offers the potential for selectively subsidizing different markets and even varying the fare discount for each eligible target market. For instance, in Danville, taxi service for eligible (registered) transportation-handicapped persons was discounted about 75 percent for the first year (December 1975 to December 1976) and 50 percent for the remainder of the taxi portion of the demonstration (January 1977 to June 1978), while bus service, which began in December 1977, was discounted 50 percent for all persons over 65 or under 18 years of age. Persons eligible to receive discounted service on both modes could make travel choices depending on the accessibility of each mode to their destination, the desired level of service, and the cost differential involved.

In most cases, user-side subsidies are being applied to existing transportation systems. An administrative staff is required to register eligible persons, issue identification or some proof of eligibility, redeem tickets or vouchers submitted by the provider, conduct marketing and promotional activities, and perform other necessary management and accounting functions. The agency that administers the program and subsidizes providers is usually part of the local government and is not directly involved with the provision of service or a part of the institutional structure of any single transit authority. This gives it the flexibility to select existing public and private providers, negotiate service agreements, and even encourage new services by offering a guaranteed minimum total subsidy or by producing evidence of an untapped demand.

With this flexibility, it is possible to coordinate among a mix of potential carriers, including social service agencies, nonprofit providers, and taxi operators. The Share-A-Fare transportation brokerage project in Kansas City (4) coordinates travel for elderly and handicapped citizens by enlisting providers, scheduling trips, and administering user-side subsidies. The transportation suppliers include two taxi companies, three social service agencies that have vehicles, an ambulette service, and three city-owned and city-operated vans. Agency clients can travel in taxis or a lift-equipped van (either a city or ambulette vehicle). Taxi and agency carriers are reimbursed on the basis of a fixed cost per trip, and users pay a 50-cent flat fare. Subsidy funds come from revenues generated by a 0.5 percent city sales tax allocated to public transportation purposes.

FARE POLICIES AND PAYMENT MECHANISMS

User-side subsidy projects have used either tickets or vouchers as instruments for fare and subsidy transactions. In voucher use, the rider presents an identification card at the time of the trip, and the driver completes a standard form with the user's name, information about the trip, and the total fare. Then the user signs the voucher and pays his or her share of the fare, and the voucher is subsequently submitted to the project for reimbursement of the difference between the user's share and the total fare. The essential difference between tickets and vouchers is that tickets are purchased in advance and the user pays a discounted fraction of their face value. No cash transaction is required at the time of the trip, since tickets are accepted at their face value for the full fare and redeemed at a later date by the provider.

The decision as to whether to use tickets or vouchers would seem to depend on the application. Tickets require less processing at the time of the trip and hence are being used for the public bus services to minimize the time the driver spends in fare-collection activities. Other advantages of tickets are that (a) when tickets are purchased in advance, the city benefits from a cash flow that represents the total discounted value of unredeemed tickets; (b) the number of discount trips taken by an individual can be limited by the number of tickets sold to him or her during a given time period; and (c) the redemption process is straightforward and permits prompt reimbursement. These advantages must be weighed against the necessity of establishing a ticket-distribution system (through one or more outlets) and the potential for misuse and fraud that result from the transferability of tickets. This latter problem is minimized if an identification card must be shown when tickets are used.

Vouchers are a somewhat more complex mechanism in terms of administrative requirements. Drivers must fill them out and have them signed by the passenger, and mistakes are not infrequent. Vouchers must be checked and verified by the project staff, resulting in delayed reimbursement, which was a major factor in the decision of some taxi drivers in Montgomery to withdraw from the project.

These disadvantages of the voucher mechanisms are offset to a degree by the following: (a) no ticket sales and distribution systems are required, (b) vouchers permit third-party billing to agencies that sponsor client travel, and (c) trip information available from vouchers is useful for project monitoring and agency accounting.

The potential for fraud, misuse, or overuse (users who exceed their monthly budget) has been noted in connection with user-side subsidies. So far, there is no evidence of widespread misuse of tickets by ineligible persons; however, the budgets have not been strictly enforced in cases where registered taxi users have exceeded their monthly limit for essential travel purposes. Apparently, fraud, misuse, and overuse do not constitute a major problem if proper monitoring procedures are followed and measures are taken to counteract any unacceptable practice when it occurs.

TAXI SERVICE POLICIES

Shared-ride policies generally permit a taxi operator to collect one fare for each passenger, regardless of whether the riders are part of a group traveling to the same destination or have different origins and/or destinations. This is difficult to implement in cities that have meter-based rather than zone-fare policies. Changes in city ordinances were introduced in Kinston and Lawrence that allowed shared riding for all taxi trips, project or otherwise. Montgomery has decided to revise its taxi ordinances to permit shared riding. (This seems to be an important impact of user-side subsidy projects.) Consequently, all of the sites studied that permit shared riding have zone-fare structures, except for the Los Angeles Harbor Area project. In Los Angeles, successive riders in a shared-ride trip do not get charged for the "flag drop"; however, the meter cost of deviations necessitated by pickups and drop-offs is included in their fare.

Group riding is a different policy than shared-ride taxi service. If two to five people are traveling to the same destination, under a group-ride policy they would all be allowed to travel for one fare. This provides an incentive for the riders to travel together, thus increasing the efficiency of subsidized service. It is employed where meter fares are used and shared riding would necessitate a complicated method of determining each individual's portion of the total meter fare. No more dispatching effort is required than if a person were traveling alone, and the taxi operator is only reimbursed for one trip (in most cases). This policy has been adopted in all projects that do not employ shared riding, e.g., San Francisco Bay Area programs and the Transportation Remuneration and Incentive Program (TRIP) in West Virginia.

USER-SIDE SUBSIDIES FOR FIXED-ROUTE TRANSIT

Three SMD projects are testing the potential of user-side subsidies for fixed-route transit. In Montgomery and Lawrence, project subsidies are available for trips taken by taxi or on the public transit system. Danville, which pioneered the user-side subsidies for taxis, has replaced the Reduced Taxi Rate (RTR) program with a demonstration of fixed-route bus service. It began in December 1977, six months before termination of the RTR program.

Danville had no public transit; the city decided to employ the user-side subsidies as a means of compensating a private carrier for all trips provided and thus test the market for fixed-route transit without purchasing vehicles and operating a transit system. The transit provider operates under a renewable contract with the city. The city sells books of 40-cent tickets to the general public and half-fare tickets to the elderly, handicapped, and young. Tickets are sold in a number of banks and stores in Danville. Every week the tickets collected are redeemed by the transit operator for a value specified by the contract. Passenger who do not have tickets pay a cash fare of 50 cents for which the provider receives a match to cover the remainder of the specified cost of a trip.

In contrast to Danville, user-side subsidies for the public transit system in Lawrence and Montgomery are limited to registered elderly and handicapped persons. The fixed-route transit system is publicly operated in Montgomery and privately owned and operated in Lawrence; both systems receive provider-side subsidies to cover operating deficits. Tickets are issued to project participants and redeemed by the transit operator for the face value, which is the standard fare charged to elderly and handicapped persons. In essence, the city is subsidizing project riders for the fare they would have paid without the project.

PROJECT DEMAND

Registration

Project registration is usually required before eligible persons can begin to take trips at a discounted fare. The percentage of the estimated eligible market that has registered is 47 percent in Danville and 25-30 percent for the other three demonstration sites. For the nondemonstration projects, registration rates vary widely, from 4 to 32 percent; most programs experience a 15-30 percent penetration of the eligible market.

A comparison of socioeconomic characteristics of registrants in general reveals that they are predominantly over 65 years of age, unemployed, have very low incomes, and live in households that do not own automobiles. Only 10-18 percent of the registrants are under 65 years of age, and 5-10 percent work full or part time. The size of the nonelderly handicapped, elderly handicapped, and able-bodied elderly segments of the registered population are also similar across projects. About 30-50 percent of registrants require some form of mobility aid (crutches, cane, walker, or wheelchair) to get around.

Eligible persons who do not register seem to be more self-sufficient; they have higher incomes and acceptable transportation alternatives. In this respect, there is a distinct difference between registered and nonregistered eligible persons. These differences are an important indication that the subsidies are being used by those who need them most.

Frequency of Taxi Use

Trip rates reported here for different projects represent frequency of use by registrants who make one or more trips per month. This group will be referred to as project users, or simply users, in the discussion of trip making that follows. A comparison of trip rates of all registrants is less enlightening, because the varying proportion of nonusers at the different sites tends to mask variations in trip rates among users.

A frequency distribution of project taxi trips per month shows that about 66, 40, and 85 percent of registrants in Danville, Kinston, and Montgomery, respectively, do not use taxis during a given month. The registered nonuser segment in Danville and Kinston is composed primarily of persons who already have adequate alternatives and who registered in order to have transportation on occasions when their usual modes are unavailable. The much lower percentage of registered persons taking project trips in Montgomery probably reflects lower taxi coverage there.

The demographic profiles of Danville and Kinston registrants who travel by project mode during a month are similar to those of persons who do not. However, project trip frequency (in trips per month) for those who do use the service is clearly related to age and health. Trip rates decrease with age; handicapped but ambulatory persons 45 years and under averaged almost twice as many project trips per month as those between 45 and 65 years of age.

The mean trip rates for those who use the project at least once in a month are 5.5, 5.1, and 7.9 for Danville, Montgomery, and Kinston, respectively. (These rates represent conditions before Danville public bus service was introduced in December 1977 and after user-side subsidies were applied to the Montgomery public transit system in November 1978.) About 25-30 percent of users in Danville and Montgomery took more than 5 trips/month, and the fraction who reach or exceed their monthly limit (which corresponds to about 12-14 trips) is usually less than 10 percent. The higher rate of project trip making in Kinston compared with Danville and Montgomery may reflect better taxi availability and coverage and a more taxi-dependent market. Kinston has no public transit, and automobile availability is much lower than in Danville and Montgomery; less than 10 percent of Kinston registrants have ready access to a car.

Total vehicular trip-making rates reported for elderly and handicapped persons range from one to two one-way trips per day. Total project trip frequencies discussed above indicate that most users are relying on the project mode for less than one-fifth of all their trips, in spite of the general shortage of alternative modes reported in the registration interviews. The small percentage of registrants who take more than a few trips per month indicates that, for most participants, the projects provide a backup mode of transportation. However, there is a small group of registrants at each site that relies heavily on the system.

Fare Elasticity of Demand for Project Taxi Trips

Judging from the predominantly low income of project registrants, cost per trip should be an important factor in the decision as to which mode to use. This sensitivity to cost is expressed as fare elasticity of demand. An opportunity to measure this elasticity occurred in Danville (8) when the fare discount was reduced from an average of 73 to 51 percent, coincident with a general taxi fare increase of 12 percent. Project demand dropped substantially, and the resulting average fare increase of about 100 percent caused a 28 percent decrease in use. The aggregate price elasticity of demand was therefore -0.28, which is in the range of the demand elasticity exhibited for the transit industry in general (-0.2 to -0.4). The gradual climb in project ridership during the year that followed the fare increase is attributable to continued growth in the population of registrants, which buffered the long-term aggregate impact of the price change.

Although the average taxi fare currently paid by users of demonstration project service falls within a fairly narrow range ($0.70-$1.25/trip), an example of the influence of much lower fare levels on taxi use is available from the Los Angeles Harbor Area project. The user fare is only $0.15, regardless of trip length, up to a meter fare of $3.00 (riders pay the excess meter fare above $3.00, which corresponds to about a 2.5-mile trip length). In a sample month, 507 persons who took project trips averaged 8.2 trips each, which is only slightly higher than the average rate for Kinston users. However, this trip frequency might be greater without a $3.00 limit on the subsidy per trip. Only 20 percent of all trips in one month were greater than 2.5 miles, and 11 percent were greater than 3 miles.

Mode Share of Project Taxi and Bus Trips

Fixed-route bus service was introduced in Danville seven months before the RTR program ended. Since both modes were available, the user could trade off cost and level of service in deciding which mode to use. Fixed-route buses cost $0.20/trip and operated at 30- and 60-min headways. Immediate-request door-to-door travel by RTR taxis costs an average of $0.62/person trip.

Total ridership on the Danville fixed-route transit system has grown from 450 passengers/day at the start to a current level of around 950. Trips by riders eligible for half-fare tickets (youth, elderly, and handicapped) constitute about 69 percent of the total trips. Demand from this market has steadily increased, while full-fare ridership has stabilized at about 300/day.

An analysis of mode shifts and the overall impact of the Runaround (fixed-route system) on RTR demand during the seven-month period when both modes were available (9) has revealed a number of interesting findings:

1. Total RTR demand decreased by more than 30 percent as a result of the bus service.
2. Most of the registered people who began riding buses continued to ride taxis as well. Very few, if any, switched all trips from RTR to the Runaround.
3. Two-thirds of RTR riders did not use the bus because of their health, age, or inaccessibility to bus routes. Only 12 percent of RTR trips surveyed would have been made by bus if there were no taxi discount--some riders would have had to find another way to travel or else forgo the trip. About one-half reported they would still take a cab at full fare.
4. After the RTR program was discontinued, bus ridership by persons eligible for RTR continued to increase but at about the same rate as before the termination of taxi discounts.
5. Attitudes regarding the choice between Runaround and RTR indicated that the cost, general convenience, distance to the bus route, and the physical condition of the traveler were more important determinants of mode choice than the difference in level of service (wait time and travel time) between the two modes.

Demand for the bus trips grew steadily in Lawrence and Montgomery during the first year of the discounts. Project registrants in Montgomery account for more than twice the number of bus trips that were taken by the total handicapped and elderly population before the project. Records of ticket sales will provide a means of linking registrant's identification numbers with serial numbers of tickets, thus permitting analysis of bus trip rates, mode shares of bus and taxi use by market segment, and disaggregate modeling of bus and taxi demand.

Registrants averaged 4.7 and 4.3 bus trips/month in Lawrence and Montgomery, respectively (registration is not required to ride buses in Danville, and the number of persons taking half-fare trips is unknown). A frequency distribution of project bus trips in Lawrence for the month of January 1979 indicates that users took a mean of 9.3 trips and a median value of 5 trips. During that month, about 44 percent of all registrants took bus trips.

When both taxi and bus discounts were available in Danville, the ratio of project bus trips to taxi trips was 2.4. This ratio was about 2.1 for Lawrence and 7.0 for Montgomery. The much higher ratio of bus to taxi trips in Montgomery reflects the higher average cost of taxi trips and the limited project taxi coverage. These aggregate ratios should not be taken as an indicator of mode choice, however, since some registrants may use one mode almost exclusively.

The introduction of discounts for bus service in Montgomery did not precipitate a decrease in project taxi ridership; in fact, monthly taxi ridership grew from 2600 to 3200 over the six-month period that followed initiation of the bus discounts. An important distinction to make in comparing this experience with Danville, where taxi demand decreased, is that there was already bus service in Montgomery and the project discount only reduced the cost of transit trips, whereas in Danville a new public transit mode was introduced.

PROJECT COSTS

For user-side subsidy projects, the total cost to the public includes subsidies paid to the provider plus the cost of administering the program. There are two categories of administrative costs: (a) initial planning and implementation and (b) monthly management and administration. Monthly costs can be further broken down into direct costs, which are related to voucher or ticket processing; registration and reimbursement; and indirect expenses for marketing, coordinating, and project management.

Cost breakdowns were analyzed for taxi service in Kinston, Montgomery, and Danville. The total annual project cost for Danville was $76 000, representing a total of 74 520 trips delivered. This cost is based on the average monthly ridership during a stable period prior to introduction of the bus service. For Kinston and Montgomery, total annual costs of $52 600 and $77 400, respectively, were projected from the monthly ridership levels.

Monthly administrative costs do not increase in direct proportion to ridership, at least up to the capacity of the administrative staff to process additional vouchers or tickets. Hence, as ridership increases, monthly administrative costs are spread over more trips. Project start-up costs, which include system design, initial planning and registration, advertising, and office supplies, were $14 000 in Danville and $2914 in Kinston. Start-up cost is not included in the total annual cost or cost per trip.

Danville was the first user-side subsidy demonstration project; consequently, a major portion of the start-up cost was spent on the design and development of administrative mechanisms and policies. The difference between Danville and Kinston project start-up costs implies a similar savings for other cities that are able to use this experience and adopt the administrative systems already in use.

The administrative costs per trip for Kinston and Montgomery, $0.61 and $0.67, respectively, are much higher than that for Danville ($0.24/trip). A large part of this difference is explained by the higher ridership in Danville. The total annual administrative costs are $18 000, $23 400, and $26 400 for Danville, Kinston, and Montgomery, respectively. Inflation undoubtedly accounts for some of the difference, since the Danville data reflect conditions over two years prior to the period in which costs for Kinston and Montgomery were examined. Furthermore, the fact that the Danville taxi program was dealing primarily with only one taxi company must have greatly reduced the time required for reimbursements, coordinating policies with drivers and owners, etc. (Three firms participated, but one went out of business early in the demonstration, and another provided less than 5 percent of all trips.)

A comparison of direct costs for Kinston (tickets) and Montgomery (vouchers) reveals that Montgomery's cost is about $600/month higher. Part of the difference stems from the time required for certification and registration; these activities account for 25 percent of the direct costs in the Montgomery project, which has more than seven times as many registrants as Kinston. It appears that direct costs are otherwise fairly comparable (monthly ridership is about equal), suggesting that the cost of ticket sales was offset by voucher processing costs. Therefore, the main determinant of potential cost advantages of tickets over vouchers depends on the labor required for ticket sales. In a city as large as Montgomery this could be much more costly than in Kinston, unless ticket sales were centralized or tickets were sold by employees of stores, banks, or other outlets.

Administrative costs stabilized early in the Kinston project but have been decreasing steadily in Montgomery as a result of improvements in procedures and the implementation of a computerized voucher and bus-ticket processing system. Costs associated with distributing bus tickets, processing them, and reimbursing the transit operator amount to only $0.02/bus trip or about 19 percent of the total administrative costs of the bus and taxi program. This does not, however, reflect marketing and promotion of the bus discounts or costs associated with registering persons who are only using the bus service (registration has increased more than 20 percent since the introduction of discounts for bus service). Nevertheless, it is evident that providing subsidies for bus travel involves a marginal increase of perhaps 20-25 percent in the administrative cost of operating a taxi discount program.

FACTORS THAT INFLUENCE COST

At fare levels and trip distances similar to those of Danville and Kinston, a user-side subsidy program that delivers 100 000 taxi trips/year would cost the city about $1.00/trip (including administrative costs). This compares favorably with the cost of publicly provided demand-responsive services in similar-sized cities. User and project costs per trip will generally increase with city size because cities that have larger areas and populations also have higher average trip lengths and, very possibly, higher labor rates. For instance, in Montgomery, which has an area four times that of Danville, the average fare is about $2.60, reflecting a 25 percent greater average trip length and a 30 percent higher cost per mile for taxi service.

With user-side subsidies, the inherent flexibility of taxi supply can be exploited. This is a distinct cost advantage with respect to alternatives that involve a fixed capacity, such as a publicly operated fleet of minibuses or a contract with a private operator to provide a fixed or guaranteed minimum number of vehicle hours of service. Since demand varies over a day and total demand is difficult to estimate a priori, the per-trip reimbursement approach protects the program from insufficient or excess capacity that could result from purchase of a given number of vehicle hours per day.

BENEFITS TO PROJECT USERS

It has already been shown that the regular users of discount taxi services are the more transit-dependent (and economically disadvantaged) segment of the eligible market. When the cost of taxi travel is reduced, people who have to rely on taxis because of the lack of other suitable alternatives can take more trips or can spend a smaller portion of their income on transportation.

The analysis of project trip-making rates discussed above reveals that most project registrants benefitted primarily from a reduction in their expenditures for bus and taxi travel. There has not been an overall increase in the frequency of taxi trips or a greater reliance on taxis, except where the fare reduction was sufficient to make the cost of taxi travel comparable to that of bus or private automobile. Where this is the case, the most prominent change in travel behavior has been a mode shift from walk to taxi for short trips.

Bus ridership has increased as a result of the program discounts of about $0.15/trip, although data are not yet available to determine whether this increase is primarily a result of more bus users, increased reliance on buses, or a combination of both.

A 50 percent reduction in taxi fares is certainly a help for people on limited incomes. However, at user round-trip fares of $1.00-$2.50, cost is still a significant constraint on the extent to which these projects can enable increases in trip making that lead to improved health, quality of life, etc. At mean taxi trip frequencies of 5-8 trips/month, demonstration project users are saving between $4.00 and $6.00/month. Apparently, the cost of taking more taxi trips, even at a 50 percent discount, has deterred most participants from approaching their monthly maximum taxi budget, which corresponds to 12-18 trips, based on the average fare per trip and maximum dollar amount of accumulated fares.

Other findings about benefits to project users are qualitative in nature and come primarily from surveys of users who were asked questions about whether and how the project affected their travel habits. In Danville, follow-up surveys of registrants were conducted to investigate impacts of the taxi discount project on travel behavior (1); 41 percent claimed they traveled more often because of the project, 43 percent said they were able to take trips they could not take before, 58 percent said they were less dependent on others for transportation, and 30 percent reported that they were able to take more trips during a particular part of the day.

A survey of users of TRIP tickets in West Virginia (7) revealed that taxis have become the primary mode for 45 percent of users, compared with 20 percent before the program. Buses (tickets can be used for buses or taxis) continued to be the primary mode for about 35 percent of TRIP users. About 87 percent of participants in the TRIP program claimed that their mobility had increased. When asked what additional trips were being taken, the purposes most frequently mentioned were visits to a doctor's office or clinic, shopping, and visits with family and friends.

IMPACTS ON TAXI OPERATORS

It has been postulated that competition among providers for project trips will stimulate better service. However, this assumes that providers have an incentive to increase their share of the project-based demand. Any such interest on the part of taxi operators would depend on the economics of serving project trips, that is, whether project trips increase total revenues, permit more efficient utilization of vehicles and drivers by spreading the demand over the day, or are at least as profitable as other business.

Impact on Taxi Revenues

Whether taxi revenues have increased as a result of the demand created by project discounts is difficult to establish in most projects because of the lack of reliable taxi operating data and the tendency of exogenous factors that affect supply and demand to mask the impact of project trips on total taxi revenues. Nevertheless, some project data and estimates based on observed changes in travel behavior merit discussion here. Taxi ridership data from Danville indicate that the maximum increase in taxi demand attributable to the subsidized taxi service (at a time when the fare discount was 73 percent) was about 4000 trips/month, representing about a 15 percent increase from preproject conditions (1). This growth, which was not sustained after the discount was reduced to 50 percent, reflects increased use of taxis and new customers who were not riding taxis before the project.

The impact of increases in demand by the target market depends, of course, on the share of the total taxi business represented by these users. Trips made by elderly and handicapped persons account for about 10 percent of the ridership of the operators in Lawrence and Montgomery that are serving the bulk of the project trips. Project demand constituted 24 percent of all trips in Danville, where only one provider was involved, although three firms participated, as noted above. Increases in taxi demand generated by project discounts will, therefore, have less of an impact in Lawrence and Montgomery than in Danville.

Relative Profitability of Project Trips

Of comparable importance to the question of whether total taxi demand increased as a result of project subsidies is whether project trips are as profitable as nonproject trips. In other words, is the revenue per taxi mile greater than, the same as, or less than it would be for regular service? The characteristics of project trips may differ in such a way as to affect labor and vehicle productivities. For instance, operators assert that shorter trips are less economical because of increased deadheading and dispatching costs. If the fare structure is the same for project and nonproject trips, then such factors as the average trip length, extent of shared riding, and dwell time will affect the efficiency and hence the relative profitability of the project service on a per-trip basis.

An analysis of waybill data from a sample of cabs in the Los Angeles Harbor Area project (10) supports the contention that shorter trips are less efficient. The ratio of paid to total miles, which is a measure of operating efficiency, increases with average trip length for both exclusive and shared-ride trips. Because the 15-cent flat-fare policy in the Los Angeles Harbor Area project is low enough to enable people to shift a portion of their walk trips to taxi, project passenger trip lengths average 1.5 miles compared with an average of 2.3 miles for nonproject trips. As a result, the shorter project trips appear to generate less revenue per taxicab mile.

Another factor that influences the profitability of project trips is the extent of shared riding. If more shared riding takes place, the revenue per revenue mile and the ratio of revenue miles to total miles will increase.

Since project riders in Los Angeles cannot share a cab with nonproject persons (presumably because of different fare policies), the extent of shared riding is constrained. Only about 16 percent of subsidized trips were shared, compared with an average of 29 percent of all taxi trips before the project. In Danville, 36 percent of all project trips were shared with another trip (project or nonproject), compared with 28 percent of all nonproject trips. Project trip lengths in Danville were only about 15 percent shorter because the zone-fare policy results in a minimum fare of at least $0.38, even for very short trips. Hence, the greater extent of shared riding for project trips offset the reduced efficiency of slightly shorter trip lengths, and the revenue per total cab mile was about equal for project and nonproject trips.

Another factor that can affect the extent of shared riding in both project and nonproject trips is the taxi supply. Dispatchers are unlikely to schedule shared rides if there is an excess supply and other cabs in the vicinity are vacant. This has been reported by the project administrator in Kinston to be the explanation for the low incidence of shared riding. An on-board taxi survey there revealed that only 13 percent of project users (and about the same proportion of nonproject trips sampled) were part of a shared-ride trip.

In sum, project fare levels that encourage the use of taxis for very short trips will result in a lower ratio of paid miles to total miles and require more dispatching time in relation to fewer, longer trips. Similarly, policies that limit the potential for shared riding, especially those that prohibit sharing among project and nonproject trips, will further constrain the revenue per taxicab mile.

If project trips are generally less profitable than other trips, taxi operators will be reluctant to serve project users at times when the demand approaches fleet capacity, which will result in a decreased level of service compared with nonproject trips.

A positive impact of project trips on the economics of taxi operations is the potential for spreading the demand more uniformly over the day. If project trips occur during periods of low total demand, the excess taxi capacity can be utilized and, since nonproject trips are not forgone, the operator may be less concerned about the relative profitability of subsidized trips. Some taxi operators, e.g., Kansas City and the San Francisco Bay Area, have reported that this has occurred (3,4). However, for the three cities (Kinston, Lawrence, and Montgomery) for which data exist to permit a comparison of demand profiles over the day between target and nontarget riders, Lawrence is the only site where the target population is making significantly fewer trips during the peak period than other taxi riders.

Attitudes of Taxi Operators Regarding User-Side Subsidies

Taxi operators' attitudes toward user-side subsidies are reflected in their willingness to participate in the program. For all demonstration projects except Montgomery, most or all of the local taxi firms elected to serve project users. In Montgomery, only 3 of the 16 local taxi companies are participating; 2 firms withdrew from the project during the first year. Reasons given for not participating include (a) the complexity of the grid-fare structure (Montgomery is the only demonstration city where the nonproject fares are based on meters and mileage; all other sites have zone-fare structures for all taxi trips), (b) time required for preparing and submitting vouchers, (c) delays in reimbursement of vouchers submitted, and (d) the burden of increased paperwork.

In the other three demonstration sites, more than 80 percent of the taxi firms have become project providers, and there are no instances of providers in these cities droppimg out of the program (except for reasons independent of the project). In both Kinston and Danville, participating taxi operators have generally favorable attitudes toward the project.

Providers in West Virginia have had a strong positive attitude toward TRIP, although none of them believed that TRIP revenues would ever be sufficient to propel the industry into long-term financial stability. More than 97 percent of providers (taxi and bus) surveyed are participating, and the only common complaint of taxi operators has to do with delays in reimbursement (7).

CONCLUSIONS

The following conclusions can be drawn from the findings discussed here about the transferability of user-side subsidies and specific issues relevant to other applications:

1. The user-side subsidy is a workable means of providing transportation for a selected market that involves public and/or private providers. It is easy to administer and does not require the purchase and operation of vehicles.
2. Project registrants are distinguished by lower income and lower automobile availability than in the target market as a whole.
3. Where taxi supply is adequate, more than 40 percent of all registrants take at least 1 project trip per month by taxi. The mean project trip rate for users at sites studied has been between 4 and 8 trips/month and tends to remain stable, with only slight fluctuations over time. Handicapped non-elderly persons are the most frequent users, averaging 6-12 project trips/month.
4. The aggregate price elasticity of demand for taxi trips is in the range of price elasticity values reported for the transit industry.
5. User-side subsidies for taxi travel are a cost-effective alternative to publicly operated demand-responsive service.
6. There is no evidence as yet to indicate that competition among providers will tend to improve service quality; however, it is preferable to involve as many providers as possible to ensure adequate coverage and a stable supply of taxis for project trips.
7. Taxi operators may have reservations about participating and require some assurance that reimbursement delays will not be intolerable. Small taxi firms are less likely to be willing to participate, because of the burden of increased paperwork.
8. Project fare levels that encourage the use of taxis for very short trips will reduce the ratio of paid miles to total miles and require more dispatching time for fewer, longer trips.
9. The compatibility of project and nonproject fare structures is essential to maximize the extent of shared riding.
10. Implementation of user-side subsidies for taxi service with meter-based fare structures is more complicated, especially if shared riding is permitted. However, introducing zone fares for project trips only is not an attractive solution from the point of view of taxi operators. There are two potential problems: (a) the complexity of having different fare structures for project and nonproject trips and (b) the likelihood that drivers will assert that zone fares for some trips are less than meter fares.
11. Fraud and abuse do not constitute a major problem when appropriate administrative procedures are followed to monitor users and providers.
12. Providing subsidies for bus and taxi modes extends the penetration of the target population, primarily because able-bodied elderly persons who rarely travel by taxi will continue to choose the bus.
13. More than twice as many bus trips as taxi trips are taken by project registrants if user-side subsidies are available for both modes. However, conventional buses are not an acceptable alternative for many people who use taxis, even at much lower fare levels.

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