Duplication Between Demand-Responsive Systems and Fixed-Route Systems

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The purpose of this study was to determine the degree to which a specialized door-to-door transit service for the elderly duplicated existing fixed-route service in Cedar Rapids, Iowa. The analysis measures the proportion of elderly who could use the existing fixed-route system for their trip making and therefore do not need the door-to-door system. The study proposes alternatives that can be implemented to increase service and to ensure service to those who need it.

In response to growing demands by elderly persons for door-to-door transit service and to federal guidelines, the city of Cedar Rapids, Iowa, implemented a door-to-door demand-responsive service for the elderly April 15, 1974. The Regional Transit Corporation (RTC) operates the city's fixed-route system, which has 20 (47-passenger) buses and 11 routes. Service is provided from 5:45 a.m. to 5:45 p.m. Monday through Saturday. The fare is 30 cents for adults and 20 cents for senior citizens with a senior citizen card. Six of the 11 bus routes operate on 30-min headways. The maximum headway is 70 min (for one route only).

RTC also operates the Senior Citizen Transit Service (SCTS), which only serves the elderly and handicapped. This service consistes of two new 31-passenger buses equipped with radio units but not with wheelchair lifts. The hours of service are from 9:00 a.m. to 8:00 p.m. Monday through Friday. The fare is 20 cents for persons with senior citizen cards or who are handicapped. All other senior citizens must pay a 30-cent fare. Reservations are requested at least 24 h in advance. This demand-responsive service operates only in the city of Cedar Rapids.

TARGET POPULATION

All Cedar Rapids residents over the age of 62 are eligible to use the SCTS regardless of socioeconomic status. The elderly population is concentrated in and around the central business district. This distribution is similar to that in other urban areas (1). Even though many elderly live in the downtown area near activities they still need public transit. Many elderly are physically unable to walk short distances especially in the winter. Moreover, they do not live near needed supplies and services, which are often located at the periphery of the city. For many elderly public transportation is a necessity.

PERFORMANCE MEASUREMENTS AND PROBLEMS

The SCTS, like other demand-responsive services, is able to provide service for about 36 passenger trips/vehicle/d. Scheduling problems, roadway repair and congestion, and service from many origins to many destinations greatly limit the ability of the system to serve more elderly. Two major problems have arisen since implementation. The first is that the demand surpassed the ability of the SCTS to provide service. The service is booked by 1:00 p.m. the day before. Thus, some elderly or handicapped must either postpone their trip or use another mode.

The second major problem is that the service is more expensive to operate than originally anticipated and budgeted. There were 3.3 passenger trips/vehicle/h at \$2.77/passenger trip through August 1974. Other urban demand-responsive systems (2, 3) averaged 7 trips/vehicle/h at a cost of \$0.40 to \$1.20/passenger trip.

Although the economic performance measures suggest that the SCTS operates below a norm, the observed performance may be partially explained by three factors. First, unlike the SCTS, the average given above is based on systems whose target population is the general public, not just the elderly. The elderly, a large proportion of whom are also handicapped, require more time entering and exiting vehicles. This results in lower vehicle productivity. Second, extensive construction in the downtown Cedar Rapids area during the study period necessitated vehicle rerouting and detours. Third, the study was conducted shortly after the service was begun and before it had yet reached its potential (Table 1). The negative influence of these three factors may not fully account for the performance of the system, and a more

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complete analysis is suggested.

STUDY

The purpose of the SCTS is to meet the transportation needs of the elderly in the urban area. The extent to which the service actually serves the people who need it is an important consideration in measurement of the service performance. An operational definition of need has been developed for this study based on access and time.

This study is concerned with measuring the extent of duplication between the public fixed-route service and the SCTS. Duplication is defined as that proportion of trips made on the demand-responsive system that could have been made on the existing fixed-route system.

One of the acknowledged limits of the conclusions and study design is that the measures defining need are not sensitive to unseen physical problems such as asthma, heart condition, arthritis, and climatic conditions. Therefore, the extent of service duplication is probably overestimated.

The data used in this study were taken from the daily logs of the SCTS for August 1974. Trip records provided the name of the trip maker, origin address, destination address, the number of the fixed routes nearest the origin and the destination, and any difficulties the trip maker had walking or boarding. A trip was defined as a one-way journey from an origin to a destination.

The number of trips that did not satisfy one of the following conditions could have been taken on the fixed-route system and represents the extent of duplication.

1. The trip by fixed route would have involved a travel time of more than 30 min. (Travel time by transit was not given in the available data; therefore, we assumed that, if a transfer was involved, the bus trip took more than 30 min.)
2. The user had an obvious physical handicap that impeded his or her walking, access, or riding ability.
3. The user had to walk more than two blocks to reach a bus stop or walk more than two blocks from a bus stop to a destination.

Conversely, the number of trips that did satisfy one of the conditions represents the degree to which the system was used by those who needed door-to-door service.

As mentioned previously, the number of handicapped in the study was underestimated because the study included only those persons with an obvious ambulatory handicap. Any handicap that was not visually apparent to the driver could have been overlooked. The study also did not include nonambulatory persons because the fixed-route vehicles were not equipped for wheelchair users.

Initially we assumed that each of the three conditions was mutually exclusive and calculated the number of trips that met each condition separately. In the final analysis, we considered the three conditions simultaneously to avoid double counting.

ANALYSIS

During the 18-d study period there were 1270 passenger trips, or an average of 71 trips/d, and an average of 36 passenger trips/d for each of the two vehicles.

Figure 1 shows that demand for the system varied considerably from day to day over the study period. Using a 3-d moving average to smooth fluctuations in daily ridership, an upward trend in ridership is observed. (This is reasonable considering the system was only 3 months old at the time of the study.)

Figure 2 shows that the fluctuations in ridership varied consistently. Ridership was lowest on Monday, increased during the week, and peaked on Friday. This fluctuation is partially explained by the fact that users were requested to make reservations 24 h in advance. Thus, trip requests for Monday had to be made on Friday of the previous week.

An interesting feature of the service was that it was used almost exclusively by females, as shown below:

Sex	Trips Number	Percent	Adjusted Percent
Male	100	7.9	10.0
Female	896	70.5	90.0
Unknown	274	21.6	Allocated
Total	1270	100.0	100.00

Of the total trips taken on the SCTS 44 percent would have required a transfer if the fixed-route system had been used. Based on the first condition, duplication is 56 percent. Of those elderly using the SCTS, 20 percent had a physical impairment (observed by the drivers) that limited the rider's mobility. Therefore, based on the second condition, the extent of duplication between the systems would be about 80 percent. Figure 3 shows the distribution of walking distance from trip origins and destinations to the nearest fixed route; 15 percent of the trips would have required a walk of more than two blocks from the origin and 13 percent of the trips would have required a walk of more than two blocks to the destination. Accordingly, 72 percent of the trips would have required a walk of less than two blocks to or from the route.

In the final analysis the conditions were analyzed collectively to avoid double counting. The following table indicates that 30 percent of the trips made on the SCTS could have been made on the existing fixed-route system.

Item	Trips Number	Percent
Need SCTS	890	70.1
Do not need SCTS	380	29.9
Total	1270	100.0

This estimate may be too high because the criteria were not sensitive to weather conditions and less obvious handicaps.

Even an adjusted estimate does not indicate that the Cedar Rapids SCTS is inefficient or ineffective. The SCTS was implemented to serve all elderly, and the service is scheduled to capacity daily. Therefore, the service is effective. Service can possibly be provided more efficiently, but an in-depth analysis of operations is beyond the scope of this study. However, the following alternatives might lead to increased supply and efficiency.

SCTS ALTERNATIVES

The alternatives can be divided into three categories: supply, demand, and funding.

The supply of service could be increased by changing the number of vehicles, hours of service, or level of service. This could be accomplished by purchasing more vehicles or by using backup systems and volunteers. Extra vehicles might be rented from charter bus companies for use during peak periods. Other services have relied on volunteers, subsidized local taxi systems, or paid employees to use their own cars

Table 1. Service changes between 1974 and 1975.

Date	Revenue ($)	Net Operating Cost ($)	Passenger Trips	Vehicle Distance (km)	Operating Cost per Passenger Trip ($)	Operating Cost per Kilometer ($)
August 1974	356.00	3460	1781	4736	1.94	0.73
August 1975	467.00	3608	2333	4532	1.55	0.80
Change, %	+31	+4.3	+31	-4.4	-20.1	+9.6

Note: 1 km = 0.62 mile.

Figure 1. Daily ridership.

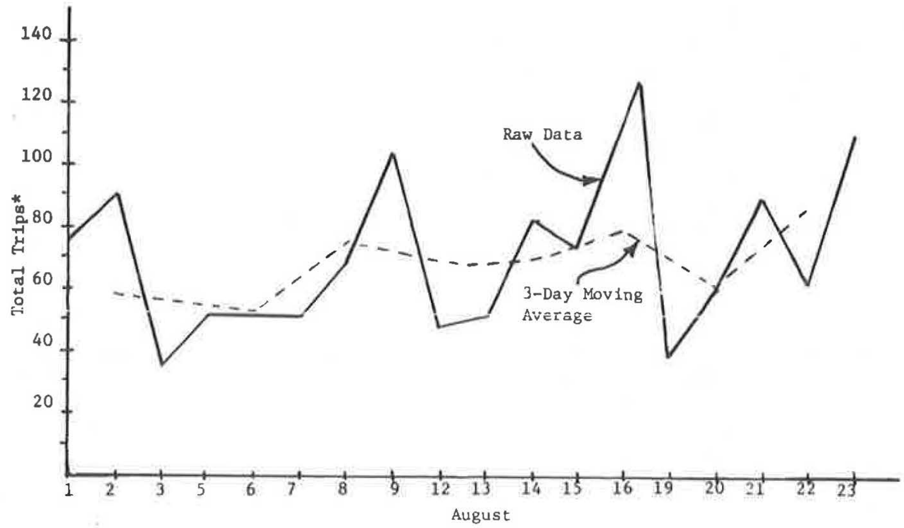


Figure 2. Distribution of weekly ridership.

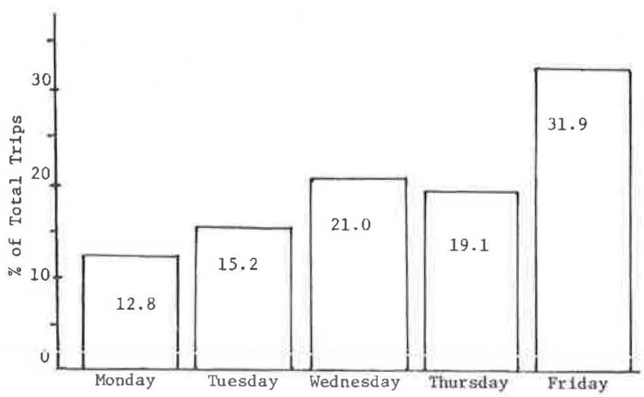
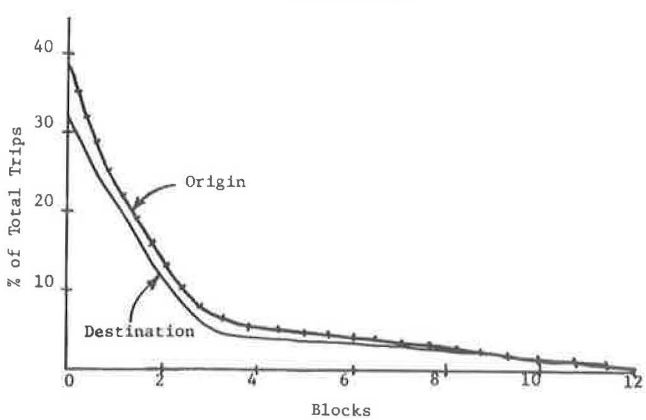


Figure 3. Distribution of distance to bus stop.



to provide service during peak periods. Service could be extended to include weekends. This would have the advantage of being able to satisfy some of the unmet demand and the disadvantage of increasing total and marginal costs.

A change in the level of service might be implemented in a number of ways or in combination. Users might be required to call 48 h in advance to facilitate better planning of more efficient routes and arrangement of scheduled pickups. Limiting the amount of time the driver must wait for a rider would increase productivity, but might defeat the objective of the service.

Each vehicle could also be restricted to a certain area or zone of the city. A transfer between vehicles would then be required for interzonal trips. Service might also be increased by facilitating transfers to the fixed-route system for those persons who are capable.

Other methods for influencing efficiency include controlling demand through eligibility and service-level restrictions. However, the demand alternatives should be considered only if the system cannot be expanded and if it were decided that only a portion of the elderly would be served. A reduction in demand is the antithesis of the goals of most transit systems and the U.S. Department of Transportation. If controlling demand is necessary, the number of users could be restricted by limiting service to specified areas on particular days. For example, Monday service might be provided to only those people in the northwest quadrant of the city. A user living in any other part of the city would not be able to use the system on that day. Similarly, service might be restricted to certain trip purposes on particular days. Friday might be limited to only shopping trips; Thursday might be limited to medical and dental trips. Destinations might also be constrained. For example, on a particular day users might have access only to the central business district or designated shopping centers.

The number of trips a person might take over a certain time period might also be restricted. For example, users might be permitted access to the system only twice a week. This restriction in turn would increase the number of potential users who would have the system available to them.

Another alternative would be to set up a priority system by trip purpose. Categories of trip purpose would be ranked according to necessity and importance. High-priority trips would receive service before ones of lower priority, regardless of trip requested first.

Major changes require substantial funds and the flexibility to use those funds. This study focuses on funding sources and not flexibility. A transit system requires support from all geographic and political levels—local, state, and federal. Funding sources exist at all levels and include public and private community agencies. Membership fees might also be initiated. Such fees might entitle the user to reduced fares or unlimited rides. Memberships might be purchased by agencies for clients.

State social service agencies might be asked to pay the actual operating costs of a trip for a certified user. The state departments of transportation might also have funds available for special transportation services in the form of matching capital or operating assistance. The sources of funding from federal agencies are numerous (3).

CONCLUSION

The results of this study suggest that at most 30 percent of the users of the Cedar Rapids SCTS might have been able to use the fixed-route service. However, many decisions based on this finding depend on an improved measurement of need and on the goals of the service. If the primary goal is to provide service to anyone who qualifies as an elderly person, then the service is effective. On the other hand, if the goal is to provide service to the elderly and handicapped who have no other means of transportation, such systems should be expanded to guarantee service.

The findings are preliminary. The analysis was performed without prior knowledge of Cedar Rapids SCTS goals and without data from users of the service on the real and perceived barriers to using the fixed-route system. A more conclusive judgment of duplication between fixed-route and SCTS could be reached only after a more comprehensive analysis in other cities.

ACKNOWLEDGMENT

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