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Activity Flexibilities of Rural Households: Implications for Ridesharing

CHRISTIAN F. DAVIS

The research described in this paper deals with activity patterns and their relationship to travel needs in a rural area in eastern Connecticut during a typical weekday. It was part of a larger effort to determine the potential for dynamic ridesharing in a low-density area. Various types of activity flexibilities are examined based on the results of a home interview survey of 601 households in the 330-mile^2 Windham Planning Region. Activity flexibility in time was found to be very great except for work or school. With the exception of these two, it was found that 75 percent of all activities were judged to be not fixed in starting time. In fact, 37 percent of all activities could have occurred on a completely different day. Demands on the responsiveness of a ridesharing program should not be excessive since most activities are known well in advance. In the case of the sample households, only 5 percent of the recorded activities occurred with no advance notice and 75 percent were known 24 h in advance. The results indicate that an effective program to encourage ridesharing should recognize that activities occur with great regularity and hence can be scheduled far in advance or are quite flexible in time and can thus be rescheduled to be compatible with ridesharing.

There would appear to be little doubt that ridesharing is an effective strategy for conserving energy, increasing mobility, or achieving some favorable combination of the two.

For the most part, previous studies have focused on satisfying existing travel patterns that in turn are partly the result of habits gained during a period of cheap energy. The possibility of taking advantage of the underlying flexibility of the activities that give rise to the travel patterns has received little attention. It is suggested here that, within limits, not only can the transportation system adapt to travel patterns, but travel patterns can be adapted to the transportation system and that this adaptation can take place within the constraints established by our pattern of daily activities.

The research described in this report deals with activity patterns and their relation to travel needs in a rural area in eastern Connecticut. Of specific interest is the commonality in tripmaking and the flexibility of activity patterns in both spatial and temporal terms. The work was part of a larger effort (1) aimed at examining the range of benefits that could derive from making use of the excess capacity of the private automobile and the inherent flexibility of activity patterns through ride-sharing. It should be noted that, although the work trip was considered, it was not the major focus of the study.

GEOGRAPHIC AREA

The geographic area studied was the 10-town Windham Planning Region in eastern Connecticut. The Planning Region covers an area of approximately 330 $miles^2$ with an estimated 1977 population of 71 000, which gives a population density of 195 persons/$mile^2$. Density varies from 45 persons/$mile^2$ in Hampton to 3200 persons/$mile^2$ in the City of Willimantic (2).

The region is largely undeveloped and relatively rural and only 6 percent of its land area is built up (as opposed to being vacant) (2). Significant determinants of the character of the region in addition to its low density are the City of Willimantic (1977 population, 11 857) and the University of Connecticut at Storrs, which has a student enrollment of more than 17 000 and 4145 employees.

SURVEY DESIGN

The basic input data for all the analyses described in this report are the results of a home interview survey of 601 households in the Planning Region. Questions on the survey, taken during the period from November 1979 through May 1980, are restricted to a typical working day (Monday through Thursday), and only trips by residents of the area are reflected. The survey instrument consists of socio-demographic data pertaining to the household, activity patterns of household members during the day preceding the interview, flexibility of activities, and a series of questions dealing with attitudes toward ridesharing.

After consideration of several alternative sampling designs, the method of simple random sampling was chosen as the most appropriate in terms of data limitations precluding a stratified sampling model. The ultimate unit of analysis was the occupied housing unit from which data were collected via at-home interviews.

ACTIVITIES AND FLEXIBILITY

The time-geography model as described by Burns (3), among others, is helpful in visualizing the activity flexibilities and constraints examined in this study.

Without loss of generality, we consider motion in only one spatial dimension in a time-space coordinate system, as depicted in Figure 1. The path P represents the individual's trajectory through time and space and is not a trajectory in physical space since that trajectory remains a straight line. The slope of the trajectory is, of course, simply the inverse of the speed of the individual at any given point.

Note that if an individual wishes to engage in activity A_1, represented by a short, broad line, it would be impossible to also engage in activity A_3, since one can be at only one place at any given time, say t_3. In fact, all the shaded area between t_1 and $t_1 + L_1$ would be inaccessible to the individual. Moreover, if the maximum speed attainable were v (for simplicity, neglect acceleration and deceleration), it can be seen that all activities such as A_4 falling within the area abhcd would also be inaccessible. By similar arguments, if the individual wishes to engage in both activities A_1 and A_2, he or she is left with only the unshaded space-time prism (efgh) available.

Now consider the possible types of flexibility that might attach to an activity. For convenience we designate these as follows:

1. Translation, which allows the entire activity to be shifted in the temporal direction [for example, activity A_3 in the preceding discussion might be shifted to the position shown as activity A_3*, which allows participation (if the constraint imposed by activity A_2 is also removed)];
2. Extensional flexibility, which might allow for participation in activity A_4 if in fact the activity could begin at any time between t_4 and $t_4 + \Delta t_4$;
3. Substitution, which is simply the substitution of one activity for another, for example, activity A_5 for activity A_3 (note that the most obvious occurrence of this would be in the substitution of one geographic location for another);
4. Permutation, which involves both translation and substitution by switching the sequence of activities; and
5. Complete elimination of the activity from the daily pattern, probably the most extreme form of flexibility.

With this brief background, the technique can be used to help demonstrate the various degrees of freedom that give rise to flexibility. Figure 2 shows a hypothetical distribution of activities in time and one-dimensional space. In Figure 2 we denote an activity by A_{ij}, where i signifies the activity group according to the following classification:

Activity Category	i,j
Work	1
Participatory sport	4
Medical appointment	5
Convenience shopping	6

In our study there are 16 activity types (plus return home), which are grouped into categories by similarity. In general, there are a number of potential sites for each activity and a specific site is identified by the j-index. Thus in the simple example shown in Figure 2, there are three potential work sites (A_{11}, A_{12}, A_{13}), one potential site for participatory sports (A_{41}), three potential sites for convenience shopping (A_{61}, A_{62}, A_{63}), and one potential site for medical appointments (A_{51}). Note that unless flextime is being practiced, most work-type activities are fixed between, say, 8:00 a.m. and 5:00 p.m. In general, the time for a participatory sport is fixed by the participants and is constrained only by the availability of the facility. Thus, we have assumed in this example that the facilities would be available from 8:00 a.m. until 12:00 midnight. A similar situation holds in the case of a medical appointment, and very great flexibility exists for convenience shopping.

We now consider three individuals denoted by I, K, and M. Assuming that these individuals have the ability to travel at a speed v, we see that they have space-time prisms abcd, pqrs, and efgh, respectively. Thus, for example, it would be impossible

Figure 1. Space-time prism and activity.

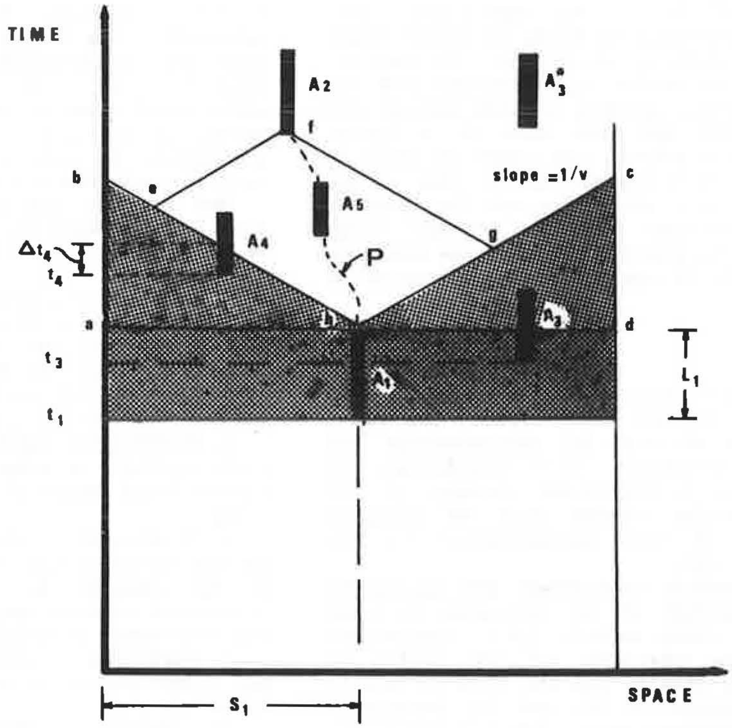
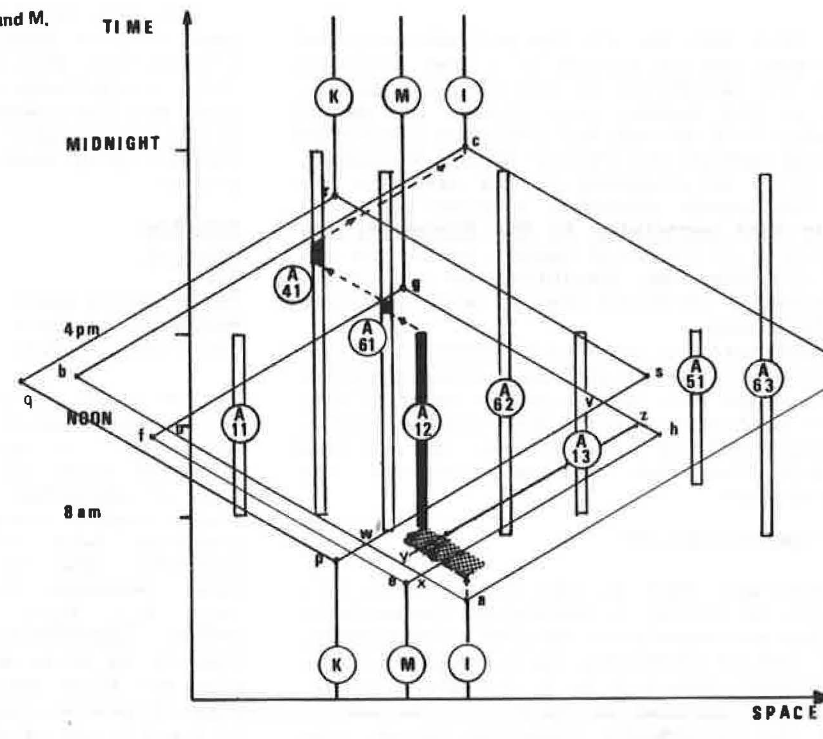


Figure 2. Feasible ridesharing strategy for I, K, and M.



for individual I to work at the location denoted by A_{11} without either relaxing his or her terminal constraints or not putting in a full day's work. He or she could, however, shop at the location shown by A_{63} between about noon and 4:00 p.m. Suppose for the moment that individual K had no transportation available and thus the potential space-time prism pqrs has been eliminated. However, we note that I's prism overlaps most of K's potential prism and it is this overlap that can be used to advantage in ridesharing. Assume now that activity sequences $\{A_{12}, A_{61}, A_{41}\}$, $\{A_{61}\}$, and $\{A_{12}\}$ have been established for I, K, and M, respectively. We note that I has established a specific time (6:00-7:00 p.m.) when he or she will be using the sports facility but that no further constraints have been applied to his or her convenience shopping (other than the fact that it will take about 0.5 h to complete).

RIDESHARING

To examine feasible ridesharing strategies, we can immediately observe that the prism wugv in Figure 2 is common to all three individuals but that neither A_{12} nor A_{41} is entirely within this prism, so there is no feasible strategy involving all three individuals for an entire tour. However, I and M have the prism xugh in common, and moreover this prism completely contains A_{12}. Since A_{12} is contained in the desired activity sequence of both I and M, ridesharing between these two individuals to this activity is feasible. Activity A_{61} could also be included since the duration is only 1 h. By continuing the above line of reasoning, a feasible ridesharing strategy involving all three individuals at one time or another can be developed, and the result is shown in Figure 2. In this strategy, I leaves home at 5:30 a.m. and picks up M at 7:00 a.m. and they share a ride to work; they arrive there at 7:30 a.m. After work, I drives M home, drops him or her off, and continues on to grocery shopping. I shops for 0.5 h and drives on to a sports event, for which he or she picks up K on the way. I and K leave the sports event at 8:00 p.m. and I drops K off at K's home and continues on; I reaches home at about 11:30. Note that in this example neither K nor M was required to provide his or her own transportation. Thus, M's effective space-time prism (if M does not have transportation available) becomes some fraction of yugz; the exact boundaries depend on I and K.

Several of the elements of temporal flexibility were mentioned earlier (e.g., convenience shopping can take place any time between 7:00 a.m. and 11:00 p.m. and is constrained only by its duration). Another element can be demonstrated by supposing that M's workday is 1 h shorter than I's. The additional 0.5 h, say, at each end could be thought of as an additional sacrifice in activity space or it could be viewed as a flexibility in the coupling constraint. In the latter context it becomes quite important in assessing feasibility of individual matches. We note in passing that the shaded area represents the activity space I has sacrificed to engage in ridesharing. In this particular case it is completely a result of route deviation, although, in the more general case, it could include space due to time incompatibility.

RESULTS

A total of 2943 activities (defined as an action by any member of a household that took place more than 0.5 mile away from the household) were reported in the survey. This amounts to 1.8 trips per person per day and 4.9 trips per household per day. The somewhat low values recorded for these rates probably reflect the large student population, the low income of the region, the fact that the respondent was unlikely to be aware of all the activities of the members of his or her household, and the definition of an activity.

Figure 3 shows the frequency distribution of the 16 activity types after excluding the return trip and grouping them into nine categories with reasonably similar characteristics. As might be expected, work is the single most frequently occurring activity (28 percent), followed closely by shopping (23 percent). The activities classified as school and after-school account for 14 percent and these are followed in order by serve passenger (11 percent), recreation (9 percent), community activities (4 percent), restaurant (4 percent), "other" (primarily personal business) (4 percent), and medical or dental (3 percent).

One section of the survey questionnaire attempted to quantify the types of flexibility described above. It is important to note that, with the exception of permutation, the flexibilities attach to the activities themselves and the constraints under examination are determined by requirements at the activity and not by some perceived time required to reach the next activity.

Table 1 presents the distribution of times given by the respondents in answer to the question, "What was the earliest time you could leave home for this activity?" Of the total of 1211 activities reported by the respondents, the 478 shown in Table 1 include only those where home is the starting point and those activities for which the respondent gave the information. Work activities showed the expected time constraints; the two hours between 6:00 a.m. and 8:00 a.m. included 58 percent of the earliest times the respondents could leave home for work. Small-item shopping exhibited a distribution later in the day; 35 percent of the respondents reported the earliest time they could have left home for these activities as between 12:00 a.m. and 12:00 p.m. At first glance, it would seem that the earliest one could leave home would be independent of activity type. The differences between types probably resulted from (a) difficulty in making clear to the respondent that the constraint lay at the home end and (b) the fact that a different subgroup of the total population was responding to the question for each activity. Keeping these facts in mind, the pattern is what might be expected for small-item shopping that originated from the home.

Other activities in Table 1 generally were concentrated in the afternoon hours in terms of the earliest time the respondent could leave home. For example, theater, spectator sports, participatory sports, after-school activities, public meetings, and restaurants were all more than 80 percent in the period between 12:00 noon and midnight in terms of earliest time and most of these were centered around 4:00-7:00 p.m. When the time constraints on all respondent activities originating from the home are considered, ignoring type, there is much less concentration in any one time period. Again, this would suggest that several different subgroups of the population are reflected. In response to a similar question dealing with the return home, the respondents indicated that all but 26 percent of their 362 returns could have occurred after 2:00 p.m. The most common time period for the latest return home was 4:00-6:00 p.m.; 33 percent of the respondents' trips occurred during this time. Interestingly, only a total of 16 percent of the respondents reported that they could return home between 8:00 and 12:00 p.m. at the latest. This seems to indicate that about 7:00 p.m. is the practical limit for returning home for the respondents.

Figure 4 shows, for the respondent, the proportion of activities of each type that had a fixed starting time. A closer examination of the data indicates that for work activities with a fixed starting time, 30 percent of respondents reported 7:00-8:00 a.m. as the starting time, followed by 29 percent who reported 8:00-9:00 a.m. as the fixed time. As expected, school-related activities with a fixed starting time were concentrated in the period 7:00-8:00 a.m. The other activities with a fixed starting time were scattered throughout the day. It should be noted that relatively few of the respondents' activities had a fixed starting time where the location of the previous activity was not home. This suggests considerable flexibility in starting

Figure 3. Distribution of activities in sample households by type (excluding return trip).

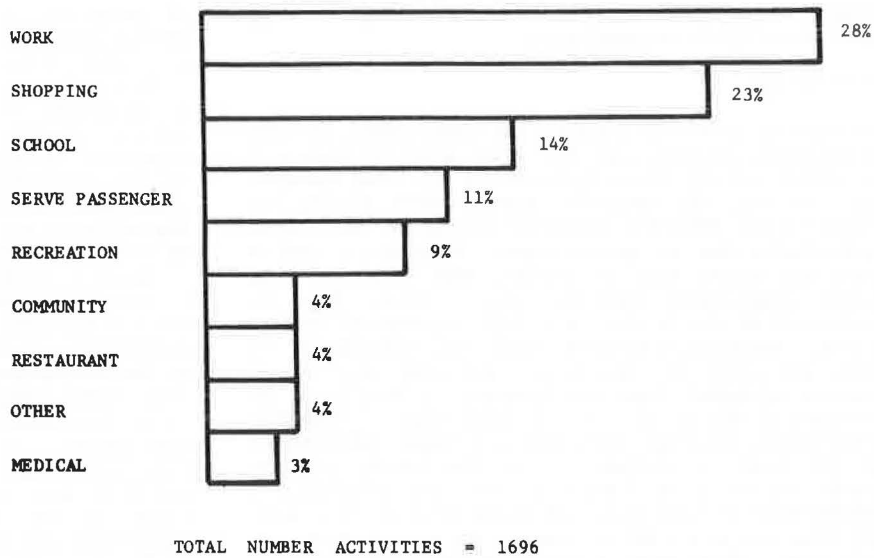


Table 1. Earliest time respondent could leave home by activity type.

	Percent of Total							
	Earliest You Could Leave Home?[a]							
Activity Type	1:00 a.m.-5:00 a.m.	5:00 a.m.-6:00 a.m.	6:00 a.m.-7:00 a.m.	7:00 a.m.-8:00 a.m.	8:00 a.m.-9:00 a.m.	9:00 a.m.-12:00 a.m.	12:00 a.m.-12:00 p.m.	No. of Activities
Work	6.0	9.0	27.1	30.8	8.3	0.7	18.1	133
Theater	-	-	-	-	-	-	100.0	4
Spectator sport	-	-	-	-	-	-	100.0	3
Participatory sport	-	-	-	-	-	16.7	83.3	12
Other recreation	-	-	6.7	-	23.3	13.3	56.7	30
Small-item shopping	1.0	1.0	1.0	10.3	26.8	24.6	35.3	97
Clothes/appliance shopping	-	-	-	20.0	-	10.0	70.0	10
Other shopping	-	-	-	28.6	14.3	14.3	42.8	7
Church	-	-	-	-	25.0	25.0	50.0	4
School	-	1.0	14.8	33.3	18.5	7.5	25.9	27
After-school activity	-	-	-	-	-	-	100.0	3
Voluntary association	5.3	-	5.3	5.3	5.3	10.6	68.2	19
Public meeting	-	-	7.1	-	-	12.5	80.4	8
Restaurant	-	-	-	-	-	15.8	84.2	19
Medical/dental/legal	-	-	-	10.5	26.3	10.6	52.6	19
Other[b]	-	3.6	9.6	14.5	9.6	24.0	38.7	83
Total	2.3	3.1	10.0	16.5	12.9	12.6	42.6	478

[a]Only for those activities where home is the starting point and for which respondent gave information.
[b]Approximately 41 percent serve passenger, 25 percent personal business, and 16 percent social or recreational; only 6 percent fixed in time.

times for most activities of the respondents.

Responses to a similar question regarding fixity of ending times showed a pattern similar to that for starting times, but the proportions fixed are generally somewhat smaller. As in the previous case, these data show relatively few activities for which there is a fixed ending time and where the location of the preceding activity is not home. This again suggests considerable flexibility of ending times for most respondent activities.

Figure 5 presents responses to the question dealing with coupling constraints: "If a ride were provided for you, how long would you be willing to wait at the location of the activity before starting that activity?" Excluded are activities for which the respondent did not give a waiting time and of course return-home activities. A large proportion of all the applicable activities (31 percent) involved no willingness of the respondent to wait. However, for 44 percent of the activities, the respondents said they would be willing to wait 15-30 min at that location before starting the activity. Longer waiting times of 30-60 min and more than 1 h were agreed to by only a small number (5 percent) of the respondents. This pattern suggests that for those respondents who indicate a willingness to wait before starting an activity, 15-30 min is the upper limit. Respondents' willingness to wait after completing an activity showed a pattern similar to that observed in Figure 5; 30 percent of all applicable activities fell in the no-wait category and 42 percent in the 15-30-min category. Small-item shopping was evenly divided: 35 percent of the respondents indicated no waiting time and 37 percent said 15-30 min. Willingness to wait longer than 30 min at the location of the activity after completing it was indicated for only 5 percent of all activities. The overall conclusion from these data is that, although for many activities respondents are not willing to wait at the location after completing the activity, many are willing to wait up to 30 min.

Questions shown below reflect an attempt to examine the possibilities of substituting or eliminating activities and to determine frequency and

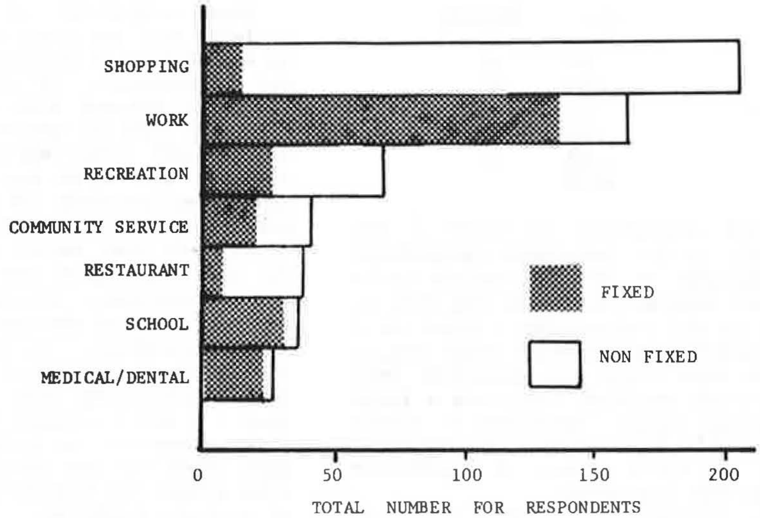


Figure 4. Fixed and nonfixed starting times by activity type.

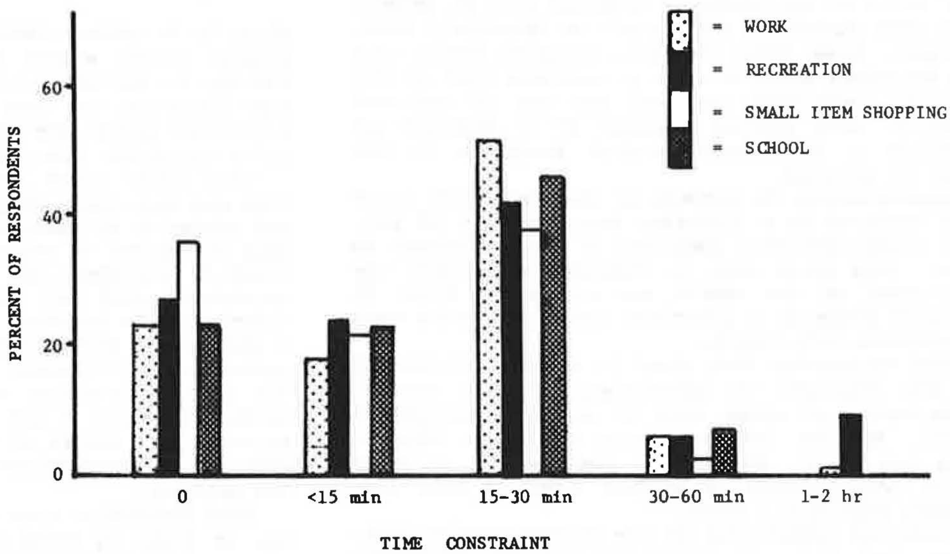


Figure 5. Time respondent willing to wait before activity by type.

advance knowledge of the activity. These questions were included not only to assist in the general analysis of the results, but to give maximum utility to the data for use in various matching algorithms.

1. How important do you think this activity is for the well-being of your household?

Response	No.	Percent
Very important	810	56
Important	312	22
Relatively unimportant	161	11
Unimportant	142	10
Do not know	12	1
Total	1437	

2. Would it have been possible for this activity to have occurred on a different day?

Response	No.	Percent
Yes	524	37
No	902	63
Do not know	6	<1
Total	1432	

3. Would it have been possible to complete this activity at a place closer to home?

Response	No.	Percent
Yes	203	14
No	1214	85
Do not know	8	1
Total	1425	

4. What is the usual frequency of this activity?

Response	No.	Percent
Daily	1100	46
Once/week	733	31
Once/month	253	11
Infrequently	281	12
Total	2367	

5. How far ahead of time did (you/they) know that this activity would occur?

Response	No.	Percent
No advance knowledge of time	75	5
<1 h	107	8
1-2 h	51	4

Response	No.	Percent
2-4 h	32	2
Same day but >4 h	85	6
24-48 h	209	15
>48 h but < one week	93	6
> one week	758	53
Do not know	10	1
Total	1420	

Note that statistics represented in Table 1 and Figures 4 and 5 apply to the individual respondents themselves; the remainder of the tabulations apply to all persons in the sampled households for whom it was possible to obtain the information. (Question 4 totals exclude 576 activities for which there was no answer.) Note also that since the questions were not asked for the return activity, there are a large number of inapplicable cases. (Question 5 totals exclude 1235 inapplicable activities.) The percentages are based on the total number of applicable cases for which data were available.

With regard to elimination of the activity, respondents felt that 78 percent of the recorded activities were important or very important for the well being of the household compared with 21 percent that were viewed as unimportant or relatively unimportant. Given these findings, it seems likely that the household would attempt to continue most of the recorded activities even if the use of personal vehicles were limited because of a shortage of gasoline or there were drastic increases in the price of gasoline.

Approximately 37 percent of the activities could have occurred on a different day, but only 14 percent could have been completed at a place closer to home. This would seem to indicate that either the activities of the sample are relatively fixed in terms of place or a conscious attempt is being made to minimize trip length.

The respondents were asked to provide information on the frequency of activities, and the general distribution of these data is shown in question 4 above. For the 2367 activities for which information was given, 46 percent occurred on a daily basis, whereas only 12 percent occurred less frequently than once a month.

Detailed examination of the survey results indicates that work and school are the two activities that make up the majority of the daily activities when return home is not considered, whereas shopping for groceries and other small items makes up a sizable proportion of the weekly activities. Shopping for small items also makes up the largest proportion of once-monthly activities and the second largest proportion of those activities that occur less frequently than once a month. The other categories, including banking, tended to make up an increasing proportion of the activities as the time interval between activities increased. The percentage distribution of the frequency of the activity for each of the types indicates that work and school are predominantly daily activities. Shopping, sports, recreation, and voluntary associations occur more often on a weekly basis, whereas theater, public meetings, and medical, dental, and legal activities occur less often. It is evident from the data that the frequency of the various types of activities varies considerably.

The data on how far ahead of time the persons in the sample knew they were going to participate in a given activity are shown in question 5. Only a relatively small proportion of the activities occurred without any advance notice (5 percent). In the vast majority of the cases (75 percent), the individuals knew at least 24 h ahead of time that they were going to participate in a given activity.

Some indication of the relationship between activity type and prior knowledge can be gained from an examination of activity patterns for the individual respondents. Of course, work activities included 78 percent that were known one week ahead, but more than 60 percent of participatory sports, school and after-school activities, and public meetings were known more than one week ahead. For small-item shopping, 28 percent of these activities were known 24-48 h in advance by the respondents. In fact, this time period was the second most common for the respondents and included 10 percent of all their activities. The respondents knew 24 h or more ahead of time of the occurrence of 39 percent of all their activities. In terms of short prior knowledge, only 6 percent of all the individual respondents' activities fell into the category of less than 1 h and 2 percent into the category of 1-2 h. Thus, comparing the percentages for the respondents with those for the sample as a whole suggests that role within the household influences prior knowledge of activity schedules.

CONCLUSIONS

If it is to achieve maximum success, any ridesharing program cannot afford to attempt to tailor ridesharing to randomly occurring requests; rather it must recognize and take advantage of the fact that activities either are regular or can be rescheduled to be compatible with ridesharing.

This study found that activity flexibility in time was very great except for work and school. With the exception of these two activities, it was found that 75 percent of activities were judged to be not fixed in starting time. In fact 37 percent of all activities could have occurred on a completely different day. In addition to these time flexibilities, a significant proportion of respondents (44 percent) indicated a willingness to wait for 15-30 min from the time of arriving at the site of an activity before the start of the activity if such a wait was required as a result of ridesharing. Similar figures apply to the respondents' willingness to wait after the activity.

Thus activities seem to be either quite inflexible in time, in which case they are known well in advance and occur in a narrow time band common to many persons, or quite flexible in time so that to a large extent schedules could be adjusted to be compatible with ridesharing.

Demands on the responsiveness of a ridesharing program should not be excessive, since most activities are known well in advance. In the case of the sample households, only 5 percent of the recorded activities occurred with no advance notice, and 75 percent were known 24 h in advance.

Flexibility in space is another matter. Only 14 percent of the recorded activities were perceived as not being performed as close to home as possible. More than one-third of those traveling farther than necessary for an activity cited tradition and personal desires as the reason.

Finally, although activities, with the exceptions noted, were found to be quite flexible in time, very few (21 percent) were perceived as unimportant or relatively unimportant for the well-being of the household. Thus total elimination of activities would generally have a significant impact on lifestyle.

Since activities are either regular with a high level of commonality in starting times (work, school) or very flexible (shopping) and are ordinarily known well in advance, it would appear that a matching program of modest sophistication could be quite effective for all trip types.

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Comparative Commuting Costs: Vanpooling, Carpooling, and Driving Alone

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The costs of alternative commuting modes are compared by developing and using models that recognize both time and travel costs. Vanpool survey data from the Baltimore region are used to calculate costs and find an equal-cost commuting distance beyond which vanpooling is cheaper than carpooling or driving alone. The distance is found to be approximately 18.5 miles for leased vanpools that provide front-door service and 30 miles for leased vanpools that pick up passengers at a few central places. However, front-door vanpools seem less workable for commuting distances beyond 30 miles. Equal-cost distance is shown to decrease, which makes vanpooling cost-effective for smaller commuting distances, as the result of various changes. These include increased fuel cost, an increase in the perceived cost of operating an automobile, employer subsidy, provision of tax rebates or free loans for purchases of vans, and elimination of free commuter parking. High-occupancy-vehicle lanes would encourage vanpooling but no more than other, less costly strategies. Lighter 7-passenger vans do not appear to be as cost-effective as do 13-passenger vans. The decrease in equal-cost commuting distance with perceived value of time suggests that vanpooling should be attractive to lower-income workers if they were given an opportunity to join a vanpool.

As part of a project to estimate the market for vanpooling in the Baltimore region, models have been developed to compare the costs of participating in a vanpool with the costs of other modes that could be used for commuting long distances to work. Five modes are considered: driving alone, carpooling, front-door-service vanpools, central-pickup vanpools, and subscription bus. The commuting distance is assumed to be beyond that of regular bus transit, so mode is not included in the cost comparisons.

The cost models build on an equation developed by Johnson and Sen (1). They include perceived value of time as well as travel costs; thus inconvenience factors are recognized as well as money spent. The models are then applied to the Baltimore region by using data obtained locally, particularly from a vanpool survey conducted by the Mass Transit Administration (MTA) of the Maryland Department of Transportation (MDOT) in 1980 (2).

The relative perceived costs of the modes as given by the models depend on commuting distance. For each pair of commuting modes there is a commuting distance called the equal-cost commuting distance beyond which one of them (vanpooling in particular) is less costly. Insofar as cost is a factor in mode choice, the models can be used to find the commuting distance over which a particular mode would be most attractive. Recent work has emphasized the importance of social factors in the decision to join a vanpool, but cost savings remain important (3-5).

COMMUTING-COST MODELS

Drive Alone

Equation 1 shows the round-trip cost of commuting as perceived by a person driving alone a distance L between home and work. The first part of the expression represents the perceived time costs of making the trip and the second part, the perceived cost of operating the automobile. Clearly, the less aware a driver is of the real costs of operating an automobile, the cheaper the drive-alone trip becomes.

$$\text{Round-trip commuting cost (drive alone)} = 2L[(T/S) + C_{oa}] \quad (1)$$

where

- L = one-way direct commuting distance from home to work,
- T = perceived value of time ($/h),
- S = average speed during drive-alone trip to work or during line-haul portion of carpool or vanpool trip to work, and
- C_{oa} = cost of operating an automobile as perceived by person driving alone ($/mile).

Carpool

Equation 2 estimates the round-trip cost of commuting as perceived by a member of a carpool. The carpool is assumed to meet at a central place that is an average distance (d) from the homes of the poolers and then travel a distance [L - (d/2)] from the pickup place to work. (After joining the pool, members must travel an extra distance d/2 each morning and afternoon.) The first term represents the time and travel costs of the daily trip to the pickup place and back. The second term represents the trip between pickup and work. Note that carpoolers' perceived cost of operating an automobile, C'_{oa}, may be different from that of a person driving