

ANALYSIS OF ACTIVITY-TRAVEL BEHAVIOUR IN THE CONTEXT OF DEVELOPING COUNTRIES

SUBBARAO, SSV; Research Scholar, IIT Bombay, India

KRISHNA RAO, KV; Professor in Civil Engineering Department, IIT Bombay, India

ABSTRACT

From the past few decades, concentration on activity based modelling has increased due to inconsistencies and disadvantages of four step traditional trip based modelling. Behaviourally oriented activity based modelling approach has the ability to model individual activity behaviour and interactions within households. This approach to travel demand analysis views travel as a derived demand. The purpose of activity based model is to predict which activities will be conducted, where, when, for how long, with whom, and with which transport mode. Activity based approach requires a survey instrument that can collect detailed time-use data and other details of activities for estimation and analysis of the models. Activity diaries in place of the traditional questionnaires are necessary in this regard. Developed countries have been using sophisticated activity diaries and innovative administration methods over the past few decades for analyzing behavioural activity patterns of the people. But researchers hardly concentrated on designing an activity diary and analysis of activity and travel changing behaviour of people from developing countries.

This study focuses on designing of new survey instrument called activity diary and drawing distributions and summaries of activity-travel patterns for developing countries context. Mumbai and Pune metropolitan regions from India are selected as the study areas. A pilot survey is conducted to assess the suitability of the instrument. Main survey will be carried out after necessary modifications have been done in the instrument. Data obtained from the instrument is to be used for analyzing activity patterns of the people and the distributions obtained from the analysis will be useful for understanding the differences between activity changing behaviour of people in developing and developed countries. Further, the developed survey instrument and activity patterns will be tested and validated. The final aim of doing this study is to development of a prototype of activity based model for developing countries context.

Keywords: *Developing countries - Activity based modelling - Activity diary - Activity patterns*

1. INTRODUCTION

The environment in which transport analysis and infrastructure planning takes place has changed dramatically during the last few decades. Traditionally, transport models were largely used to predict and assess the transport demand and characteristics of transport system. Due to increasing number of urban areas considering transportation control

measures, trip based travel demand models can not able to address these effects. Urban sprawl also has been recognized as a problem that faces the developing world. Between 1950 and 2008 the global urban population has more than tripled to reach 3.3 billion. By 2030 this is expected to swell almost by 5 billion. While urbanization has considerably slowed down in developed countries, the developing world is where cities are growing the most. By 2030, the towns and cities of the developing world will make up 81 per cent of urban humanity. The big cities in developing countries are constantly facing pressures for meeting the social, economic and infrastructure needs of increasing population due to heavy immigration. Most of such cities show a high growth of private mode of transportation coupled with the mass transport systems like bus, rail services for meeting mobility needs. As a result, during peak hours, the system reaches crashing point, leads to delays, traffic congestion, and heavy air and noise pollution. Hence this issue has become major concern for planners, policy makers and environmentalists etc.

Issues related with urbanization in developing countries are dynamic and are different from those in which developed countries urbanized. Therefore by taking into these differences for specific situations, solutions must be proposed. Due to the dynamic behaviour, only short term solutions can be proposed. These solutions lead to unsustainable patterns of growth. They should be economically viable and in line with the broader goals of the country. Hence they should deal with the lifestyle and attitudes of the people. Traditional models cannot help in this regard. Hence these have to be replaced by a more behaviourally oriented activity based travel demand models. In developing countries like India, the efforts made for developing a prototype of these models are minimal. Hence, this study starts from the base level i.e. literature review, designing of survey instrument and ends with a prototype of activity based travel demand model which can be implemented in developing countries like India. This paper highlights the first part of this study, discusses about the newly developed survey instrument, experiences faced in survey instrument design and pilot survey, and brief results about the pilot survey followed by the future scope of work.

2. REVIEW ON ANALYSIS OF ACTIVITY-TRAVEL BEHAVIOUR

Due to dissatisfaction with the forecasting accuracy of the traditional travel demand models, from the past few decades researchers concentrated more on behavioural aspect of people which is resulted to activity based travel demand models. An activity can be defined as a physical engagement of an individual in something that satisfies his or family needs. Activities are motivated by economical, physiological and sociological needs of an individual. The purpose of full activity based model is to predict which activities to be conducted, with whom, where, when, how long and with which transport mode. The activity-based approach to travel demand analysis views travel as a derived demand; derived from the need to pursue activities distributed in space (Jones et al., 1990). In an activity-based approach, a day is usually considered as the basic unit of analysis of the travel/activity pattern. The activity pattern is defined as the revealed pattern of behaviour represented by travel and activities over a specified time period. These travel/activity patterns are referred to as household activity patterns and arise from the scheduling and execution of household activity programs. Although much research has aimed at improving the conceptual understanding of this

phenomenon or developing models for capturing certain components of activity scheduling behaviour, a very few are developed completely. In developing countries like India, ongoing research in this particular area is minimal. Inadequate, insufficient, inaccurate, and biased data can lead researchers away from the target, even if they are working with the most sophisticated tools available. It all depends upon the decisions taken regarding the data collection technique, survey instrument design, pilot survey for estimating the accuracy of the instrument, enumerator's capability and sample design. An inappropriate format of the survey instrument may produce incomplete information.

Data needs

Activity-based models thus differ widely in terms of their theoretical underpinnings, their modelling approaches and their complexity. The data required for activity-based model can be grouped into four dimensions 1) activities 2) location of activities 3) time 4) transport mode (Arentz and Timmerman, 1998). The data requirement for activity based behaviour is well explained by Axhausen (1995b). Hagerstrand (1970) focused attention on constraints which limit activity options available to individuals. These include coupling constraints, authority constraints and capability constraints. Hirway (2001) gives a very detailed discussion about the different classification of activities involved in Indian as well as in some other countries. Lawton (1995) suggested that data has to be collected by considering the following issues in activity-travel forecasting. Issues include activities to be served, arrangement of those activities in daily and weekly pattern, tradeoffs between in-home and out-of-home activities and locations of an activity and interaction between household members.

Survey instrument

Data collection can be done by using Diaries, Computer based electronic instruments like GPS, Mobile trackers, ICT etc. The information compiled during travel surveys is susceptible to various types of errors due to the difficulties in incorporating the behavioural aspect (Stopher and Sheskin, 1982). The time-space diary design adopted by Cambridge Systematic Inc. (1995) is comprehensive and considers minute details of each activity; like starting and ending time of activity, details of each mode in each leg if the activity is travel, details of the person travelling along with the respondent, parking and other facility at the destination, etc. However, each activity and its details were marked in different sheets in the same booklet, which raise consistency problem between activities. Diaries can be broadly classified into two types – travel diaries and activity diaries. Travel diaries focus on trip and trip related information, with limited attention paid to the activities. In particular, there is significant evidence that travel surveys under-report trips, especially off-peak and non-home based trips of short duration. Hence, the information compiled during travel surveys is susceptible to various types of errors due to the difficulties in incorporating the behavioural aspect (Armoogum and Madre, 2000). Growing dissatisfaction with four step travel demand models and increasing interest in developing activity based models has stimulated research on the design of activity diaries. Stopher (1992) has discussed about the use of an activity based diary to collect household information. In which the two alternative methods were pilot tested. One is telephone interview method and another is mail back method. Arentz et al.

(2001) has tried with three formats, namely stage, day-planner, and combined stage and day planner format. Stopher and Wilmot (2000) developed a time use diary, which collects data on both in home and out of home activities, treats travel as another activity. A computerized activity scheduling survey was also conducted by Doherty and Miller (2000). This survey was implemented in Toronto, Canada. However, these techniques may not be suitable for developing countries due to lack of technological advancement. Martin (2006) suggested that Information and communication technologies (ICT) enabled activity and travel surveys can give more response rate. Stopher (1992) and Stopher (2000) suggests that the use of activity-based time-use diaries is resulting in higher rates of trips than did the use of trip-based diaries and introduced an activity diary that was implemented in the Boston area. Its introduction was fostered by the conviction that most travel is a derived demand, and hence, it is necessary to identify and understand the activities that give rise to travel. The development of diary instruments in household travel surveys is well documented by Axhausen (1995), Stopher (1996), and Stecher et al. (1996). Gershuny (1992) argued that a one-day diary gives a good estimate of the prevalence of the activity of the population as a whole, but leaves open the question of differential participation rates. If we observe that a certain proportion of the sample engages in a particular activity on the diary day, we do not know if they engage in the same activity on the non-diary days or not. Thus, one-day diaries seriously limit the kind of analyses one can conduct, and may even lead to misleading interpretations and conclusions

Method of administration

In any survey, diaries to be administered by mail, personal face-to-face interview, telephone or Intelligence and communication technologies (ICT). Meyburg and Brög (1981) found that face-to-face interviews yielded lower estimates of travel time compared to mail questionnaires. Moreover, the diaries recorded in the presence of the interviewer yielded 15 percent fewer trips. Stopher (1992) compared the completion rates between mail-back and telephone and found a better result for the mail-back retrieval. Ampt (1989) compared a self administered and a personal interview for the collection of 24-hour travel diaries in Australia and found that the personal interview provides higher response rates. In another study, the form of administration may also impact response rates. Ampt and Richardson (1994) compared six diary instruments that differed in terms of form of administration. One involved the telephone to establish initial contact, four established initial contact by mail, and the final instrument was based on personal initial contact and a personal interview to retrieve the diary data. Before carrying out the final data collection with the survey tool designed, it is recommended to conduct a pilot survey to ascertain the sufficiency, adequacy, correctness and usefulness of the data collection technique and survey tool. Along with the training of survey enumerators, this is supposed to increase the response rate by 8-10 percent. From the experience of various methods of survey administration, researchers are now concentrating on developing a mixed format taking the advantages of the best features of various methods of administration (Patten and Goulias, 2003). Technological advancement leads to the development of new data collection techniques like computer assisted telephone interview, computer assisted personal interview, computer assisted self interview (Kalfs and Saris 1997), and the emerging technologies, like, geographical information systems (GIS)

and global positioning systems (GPS) (Murakami and Wagner, 1999). A computerized activity scheduling survey was also conducted by Doherty and Miller (2000). However, these techniques may not be suitable for developing countries due to lack of technological advancement. Hawkins and Stopher (2004) discussed about the collecting data with GPS and non-response in the household data survey using GPS. Axhausen (1994) developed environmentally aware travel diaries. Kochan et.al. (2004) discussed about dynamic activity-travel diary data collection using a GPS-enabled personal digital assistant. In this a data collection tool, which is able to capture dynamic activity scheduling behaviour was presented.

Non-response problem

Data collection by using activity-travel diaries faces some problems like non-response (Armoogum and Madre 2000) and data quality problem (de Heer and Moritz 2000). Clarke et. al. (1981) found that no respondent had any apparent difficulty in recalling yesterday's trips in the trip diary format, although some acknowledged difficulty with trips made the day before. Omissions were either of all trips in one trip-purpose category, or short-duration trips. Some activities involving local travel, notably walking to local shops, tended not to be popularly construed as trips. Harlesden (1999) has given valid explanation about the design of time-use diary for developed and developing countries. A final operational decision concerns which instrument (paper-and-pencil or computer) to use to collect diary data. Most diaries to date have used the paper-and-pencil format. If respondents are asked to keep a log of their activities and/or trips, a booklet form is probably the most convenient way of keeping track of events, although recently introduced palmtop time-management systems may also be considered. For decreasing non-response, Stopher and Ampt (2006) identified that mixed method data collection surveys are to be useful. This study concludes that which type of mixed mode surveys would improve trip estimates and cost efficiency of the Sydney household travel survey.

Interactions among household members

Interactions among household members can be captured by using the data obtained from activity diaries. For example, in a family with a child of school age, one of the parents has to adjust her/his schedule in order to be able to drop off the child in the morning to school. Another example can be a joint dinner of both parents. Both must adjust their schedules in order to meet at the same time and at the same restaurant. These examples show the importance of study on interactions among household members. Pribyl and Goulias (2005) proposed a model that can simulate activities which are conducted alone as well as those that are conducted jointly with other household members. Golob and McNally (1997) discussed about the application of structural equations to capture the behavior of male heads and female heads of household simultaneously in terms of their activity participation and travel. Kato and Matsumoto (2006) developed a joint activity based time allocation model. Based on results coming from this model, authors described about the intra-household interaction analysis among a husband, a wife and a child. Kato and Matsumoto (2009) discussed about the intra-household interaction in a nuclear family based on utility maximizing approach.

The final consideration for designing any diary is based on the user friendliness, Respondent's burden, and the quality and quantity of the required data. A standardized procedure for question formulation and survey instrument design has not been developed for developing countries context. Hence a new survey instrument is developed in this study and data collection capability of instrument is well explained in the analysis of pilot survey.

3. STUDY AREA AND DATA COLLECTION

Ideal requirement of a study area for the application of the instrument is that it should carry maximum activities within the selected area. The people living in this area should use all the major modes of transportation and there should be sufficient segregation in their socio-economic status. Pilot survey was carried out in different places of Greater Mumbai region. Total population of this region is 11.9 million based on the census 2001 and expected to reach 14 million by the end of 2011 (WFSL, 2005). The population density is around 27000 persons per square kilometre. The transportation system of Greater Mumbai is dominated mainly by the public transportation mode. About 78% of the trips (considering trips only by train and bus) are carried by public transport modes and remaining trips are carried by the private vehicles (Car and Two wheelers) and IPT modes (Auto rickshaw and taxi's) (CTS, 2008). Figure 1 shows existing rail and road network in the study area. Based on the experiences of various researchers and giving due consideration to the different socioeconomic characteristics of the study area as compared to cities in developed countries, it was decided that drop off and pick up method is the best suitable data collection technique.



Figure 1 – Study area (Greater Mumbai, India)

4. DESIGN OF SURVEY INSTRUMENT

The data required for the activity based model development is Socio-demographic information, travel information and a full day activities carried out by the respondents in a continuous time frame. This data can be considered as the revealed preference data. Suitable stated preference survey should also be designed if required, especially for some policy analysis. For getting more and accurate information, a new survey instrument called an activity diary is developed for getting information about both activities and travel. The survey instrument is planned to design in such a way that it will overcome the limitations of travel diary (which collects trip based data). The new survey instrument design allows to collect travel data and activity data in disaggregate level, which assures good quantity and quality of demand data. Even though, incorporating more things in the diary increases complexity, but limitations of travel diary motivated to preparing this activity diary. First, travel diary does not provide continuous time frame of different activities. Second, travel diaries do not allow the respondents to report information about multiple activities which were carried out successively at same location. Third, comparing to travel diaries, activity diaries occupy less number of sheets. Due to this respondent burden will be decreased and response rate will be increased. Fourth, travel diaries cannot able to address the various combined activities carried out in the same household at the same time. The new survey instrument collects detailed information about the travel and activities carried out by the individual persons and households. The survey instrument used for the data collection is described in detail in the subsequent sections. The questionnaire used in the survey was checked out several times with academic experts to check its suitability to developing countries like India. Choices given in the questionnaire is fully based on our domestic conditions. Information to be collected is divided into household characteristics, personal characteristics and continuous 24 hour activity diary information for a period of 15 days.

Household characteristics

First part of questionnaire contains household characteristics, which includes household contact details, type of residence and ownership, no. of persons living in household (includes information about workers, non-workers, children etc.), and household vehicle ownership, parking space available at residence, household monthly income and number of licensed drivers in the household. Contact telephone number is also collected for the purpose of future contact. Household monthly income has been collected for checking out with personal income and number of workers in the household. A sample sheet of the household questionnaire is shown in Figure 2.

Household information

Household Location

Building Number / Name	
Street Name	
Locality / Area Name	
Land Mark	
City / Village	
PIN Code	_ _ _ _ _ _ _
Name of Head of Household	
Contact Telephone No.	

Household Number	
Date of Interview	

Interview status:

	Refused	Partial	Full
Household data sheet			
Person Information			
Activity diary			

Total no. of members in household Male Female <5 years

School/College Workers Retired Others

Type of Residence	Ownership				No. of Rooms
	Owned	Rented	Govt. Quarters	Employer Provided	
Apartment/Flat					
Independent House					
Chawl					
Slum					
Others					

Household Income (in Rupees):

<5000	<input style="width: 30px;" type="text"/>
5000 - 10000	<input style="width: 30px;" type="text"/>
10001 - 20000	<input style="width: 30px;" type="text"/>
20001 - 30000	<input style="width: 30px;" type="text"/>
30001 - 40000	<input style="width: 30px;" type="text"/>
40001 - 50000	<input style="width: 30px;" type="text"/>
>50000	<input style="width: 30px;" type="text"/>

Vehicle Ownership:

	Owned by household	Owned by others
Cars/Vans		
Two wheelers		
Bicycles		
Others		

Parking available at Household:

	Private spaces	Park on-street
Cars/Vans		
Two wheelers		
Others		

Number of Licensed Drivers in the household:

Figure 2 – Household information sheet

Person Characteristics

The second part of the questionnaire collects information at the person level including name, age, sex, relationship with household head, education level, driving license status, occupation, type and cost of travel pass if any, general modes of everyday travel and type of workplace. Government generally gives fare-concession to the regular commuters and these were asked in the pass-holder details. Household income can be cross checked with occupational status of individual person in the household. A sample sheet of the person information is provided in Figure 3.

Person Information

Details of each member of Household (5 years and above)		Household Number	<input style="width: 40px; height: 20px;" type="text"/>			
Name	<input style="width: 240px; height: 20px;" type="text"/>	Age (Years)	<input style="width: 40px; height: 20px;" type="text"/>	Sex		
				<table border="1" style="display: inline-table; border-collapse: collapse;"> <tr> <td style="width: 30px; height: 20px; text-align: center;">Male</td> <td style="width: 30px; height: 20px; text-align: center;">Female</td> </tr> </table>	Male	Female
Male	Female					
Relationship with Household Head:		Education Level:				
Self	<input style="width: 30px; height: 20px;" type="text"/>	Illiterate	<input style="width: 30px; height: 20px;" type="text"/>			
Son/Daughter	<input style="width: 30px; height: 20px;" type="text"/>	Primary (5th Pass)	<input style="width: 30px; height: 20px;" type="text"/>			
Father/Mother	<input style="width: 30px; height: 20px;" type="text"/>	Secondary (10th Pass)	<input style="width: 30px; height: 20px;" type="text"/>			
Other Relative	<input style="width: 30px; height: 20px;" type="text"/>	Higher Secondary (12 th Pass)	<input style="width: 30px; height: 20px;" type="text"/>			
Not Related	<input style="width: 30px; height: 20px;" type="text"/>	Graduation	<input style="width: 30px; height: 20px;" type="text"/>			
		Post Graduation and Above	<input style="width: 30px; height: 20px;" type="text"/>			
Mode of travel:		Driving License Status:				
Walk	<input style="width: 30px; height: 20px;" type="text"/>	Auto/Car/Jeep/Van	<input style="width: 30px; height: 20px;" type="text"/>			
Bicycle	<input style="width: 30px; height: 20px;" type="text"/>	Two wheeler	<input style="width: 30px; height: 20px;" type="text"/>			
Taxi	<input style="width: 30px; height: 20px;" type="text"/>	Both	<input style="width: 30px; height: 20px;" type="text"/>			
Auto rickshaw	<input style="width: 30px; height: 20px;" type="text"/>	Heavy vehicle	<input style="width: 30px; height: 20px;" type="text"/>			
2 wheeler	<input style="width: 30px; height: 20px;" type="text"/>	Others	<input style="width: 30px; height: 20px;" type="text"/>			
Car /van (driver)	<input style="width: 30px; height: 20px;" type="text"/>	Type of Travel pass:				
Car /van (passenger)	<input style="width: 30px; height: 20px;" type="text"/>	No pass	<input style="width: 30px; height: 20px;" type="text"/>			
Bus (public)	<input style="width: 30px; height: 20px;" type="text"/>	Bus Weekly pass	<input style="width: 30px; height: 20px;" type="text"/>			
Bus (Company charter)	<input style="width: 30px; height: 20px;" type="text"/>	Bus monthly pass	<input style="width: 30px; height: 20px;" type="text"/>			
Rail	<input style="width: 30px; height: 20px;" type="text"/>	Rail Monthly pass	<input style="width: 30px; height: 20px;" type="text"/>			
Other	<input style="width: 30px; height: 20px;" type="text"/>	Cost of Pass				
		(in Rupees)				
		<input style="width: 60px; height: 20px;" type="text"/>				

Analysis of Activity-travel behaviour in the context of Developing countries
 SUBBARAO, SSV; KRISHNA RAO, KV

Occupation:

Employed (Full time) Higher level	<input type="checkbox"/>
Employed (Full time) Middle level	<input type="checkbox"/>
Employed (Full time) Lower level	<input type="checkbox"/>
Employed (part time) Higher level	<input type="checkbox"/>
Employed (part time) Middle level	<input type="checkbox"/>
Employed (part time) Lower level	<input type="checkbox"/>
Self employed	<input type="checkbox"/>
Daily wages	<input type="checkbox"/>
Student	<input type="checkbox"/>
Seeking employment	<input type="checkbox"/>
Home maker/house wife	<input type="checkbox"/>
Retired with income	<input type="checkbox"/>
Retired with no income	<input type="checkbox"/>
Others	<input type="checkbox"/>

Type of workplace:

Residential	<input type="checkbox"/>
Industry / factory/ ware house	<input type="checkbox"/>
Office / Bank	<input type="checkbox"/>
Shop	<input type="checkbox"/>
Educational Institute	<input type="checkbox"/>
Hotel / Restaurant	<input type="checkbox"/>
Entertainment / Tourism	<input type="checkbox"/>
Agriculture	<input type="checkbox"/>
Construction	<input type="checkbox"/>
Others	<input type="checkbox"/>

Figure 3 – Person information sheet

Activity Diary

Later part of the instrument is activity diary. For this specific application, a diary booklet was prepared to collect activities in a 24-hour period and the format is in such a way the diary to be carried with each survey respondent having age above 5 years during the diary day. Therefore, the size of the diary was designed to be small enough to fit into a pocket or a purse or handbag. The resulting instrument is a booklet measuring 17 cms by 13 cms and containing 76 pages that permit an individual to record up to 28 activities in a day. The record for an activity and the associated travel covers 4 pages per one day activities, so that 60 of the 76 pages are repetitions of the activity information for 15 days. The diary collects detailed travel and activity information. In developing countries like India, people will speak in different regional languages. Hence for the convenience of all respondents, the diary was prepared in three languages i.e. English, Hindi and Marathi. Initially diary is prepared in English and later translated into Hindi and Marathi. People were asked to fill the diary in their familiar language. After translating into these languages, the diary was verified by respective professionals who are familiar in that background of language. A sample sheet, filled for a typical day is also prepared and distributed to the respondent. Instructions for filling activity diary are incorporated in the booklet itself for avoiding confusion. To capture the individual response on the activity pattern, a detailed activity classification was prepared based on the past studies. That classification also incorporated in the survey instrument as a reference to the respondents.

In activity diary, respondents have to fill activity timing in 12 hour format, description of activity, activity location, and mode of travel, travel time, travel cost and waiting time. In description of activity, respondent has to write the activity information manually. If activity needs travel, respondent need not mention activity location. Information about the combined

activities carried out by the respondent with household members or others is collected for getting interaction between the household members. Comfort level for using public transport is asked on a 5 point scale by giving codes for different comfort levels. Manual filling of all the above mentioned information can leads to non-response. But due to lack of research in this area in developing countries like India and getting information about all the possible activities conducted by the households, the diary is prepared in such a way that the respondents should write all the information about their activities. The activities are broadly divided into three categories. First category is work related activities, contains employment related, education related and business related activities. Second category is the maintenance activities, which includes personal care, household maintenance, shopping and caring for others. Finally all the optional activities come under leisure activities, which include recreational activities, social and community interaction and voluntary services. A pilot survey is conducted for the standardization of the survey instrument. Figure 4 provides detailed information about the characteristics of the activity diary.

Act- vity No. (1)	Activity timing (In 12 hr format) (2)		Description of the activity (3)	Activity location (4)	Mode of travel (5)	No. of Persons Accompanied in activity (6)		Travel time (in min) (7)	Travel cost (in Rupees) (8)	Waiting time for next mode (in min) (9)	Comfort level for using PT (10)
	Start Time	End Time				Household members	others				

Figure 4 – Activity diary information sheet

5. PILOT SURVEY

The main objective of pilot survey is to evaluate the performance of activity diary against the travel diary, which is commonly adopted for the data collection in Indian conditions. The diaries were tested by collecting samples from different residential locations in Greater Mumbai. Sampling process ensured that sufficient variation was present in the sample regarding location and socio-economic variables. In addition to the diary, each respondent is provided with the questionnaire about their household and personal characteristics. Each respondent was individually asked to fill the household characteristics for cross checking the data. One day or two day diaries will not clearly capture the activity patterns of people, and these diaries seriously limit the kind of analyses one can conduct, and even leading to wrong interpretations and conclusions. Hence for pilot survey, a 15 day diary data is proposed to collect from the respondents for carrying out the study, even though recording activities for a long period is difficult. Drop-off and Pick-up method was identified as the appropriate survey method for collecting data for such a long period of 15 days. Both in-home and out-of home activities are collected in this survey. Based on the response from the pilot survey suitable modification can be done in the instrument. Main survey has to be conducted for the required sample size. Richardson et.al. (1995) suggested that a sample size of 5 to 10 percent of total

survey budget for pilot survey. Accordingly a sample of 42 households was collected for the pilot survey. The responses are obtained from 20 households with a net response rate of nearly 50 percent. After conducting survey, data processing has been done, which involves data entry, data editing, identifying non-response samples, and data coding. A detailed analysis is to be carried out for understanding different activities carried out by the people and the general activity patterns of the people in India based on their socio-economic characteristics of the individuals.

Non-response and Missing activity data

Reasons for non-response in data collection can be attributed to respondent's unwillingness to fill diary for a period of continuous 15 days, unable to carry diary continuously with them, their busy schedule, illiteracy, loss of booklet, requests to contact next week etc. Due to continuous reminders in the form of SMS's to their mobiles everyday and phone calls in every alternate day, missing activities are very less. In the case of household characteristics, the most non-response parameter is household income. All the respondents have given the information about personal characteristics without fail. In diary characteristics, non-response comes in writing their in-home activities and travel cost. For entering their in-home activities, respondents are taking them to personally and feeling shy in revealing their activities. If people are using their own motorized vehicle, they are unable to mention their exact travel cost. An important observation is that people's response in weekends is higher than the weekdays. Diary details of the housewife's and children are observed to be not entered properly. Response percentages are shown in Table 1.

Table 1 – Non-response rate for DAP method in percent

Reason	Percent
Successfully collected	47.62
Showing un-willingness	21.43
Requested to contact next week	9.52
Loss of booklet	4.76
Illiteracy	16.67

6. DATA ANALYSIS

Socio-economic characteristics of the household like household characteristics and person characteristics influence the travel behaviour and activities carried out by the members of the family. An analysis was carried out under broader framework based on revealed information obtained from the pilot survey data. From the sample data, distribution by the gender has been 53.3 percent males and 46.7 percent females. Maximum number of people in the selected region is living in flats, but household ownership is evenly distributed. The distribution of households based on their household ownership in percent is provided in the Table 2. Data shows that 50 percent of the households staying in their own flats. Distribution of households based on their household sizes is also provided in the Table 3. Data shows that average number of households in a family is 3.19. Figure 5 shows the distribution of

household income. The bar chart shows that households having income ranges of 10000-30000 are more in the sample data. More than 80 percent of the households are having at least one licensed driver in their household to drive a motorized vehicle.

Table 2 – Distribution of households by household ownership

Household ownership	Percent
Own House	50
Rented House	22
Govt. Quarters	28
Employer provided	0

Table 3 – Household size distribution

No. of members in the household	Percent
1	0
2	29
3	29
4	36
5	6

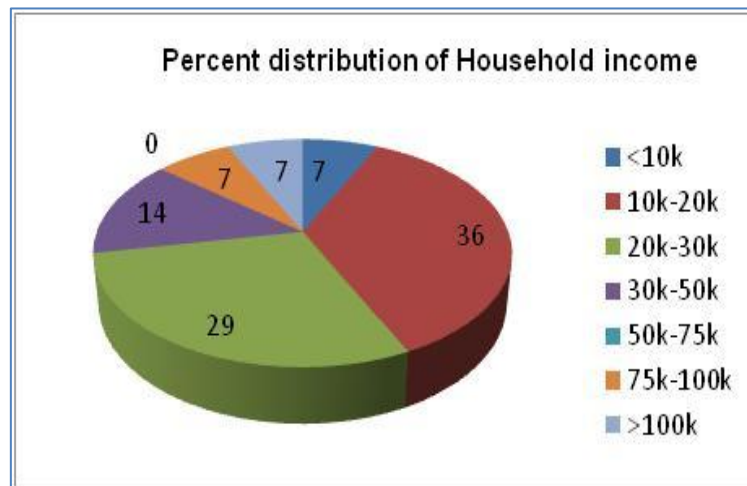


Figure 5 – Distribution of households based on income of household

In person characteristics, survey population by gender is dominated by male at the rate of 54 percent. According to the distribution of household members by age group, nearly 33 percent of the households are in the age group of 26 to 40 years and another 33 percent are in the age group of 41 to 60 years. Figure 6 shows the distribution of households based on their age group. License holding respondents are 52 percent in the study area, in which 20 percent of the respondents having car license, 25 percent of the respondents having two

wheeler license and 7 percent respondents having both car and two wheeler license. Distribution of respondents by their education level is shown in Figure 7. In which nearly 65 percent of respondents having education level of minimum higher secondary and 45 percent of respondents have studied graduation and above. Distribution of household members based on their occupation is also provided in the Figure 8. Statistics shows that, 20 percent of the respondents are students, 18 percent of the respondents are employed in supervisory level and nearly 16 percent of the respondents are self-employed. And 60 percent of the respondents are working people.

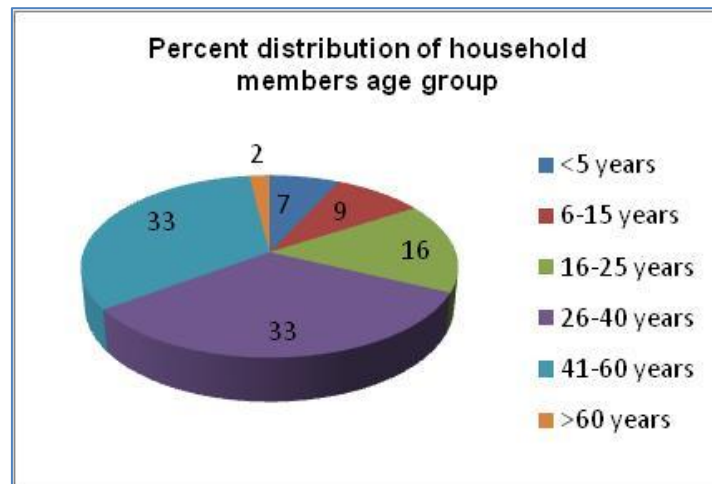


Figure 6 – Distribution of household members based on their Age group

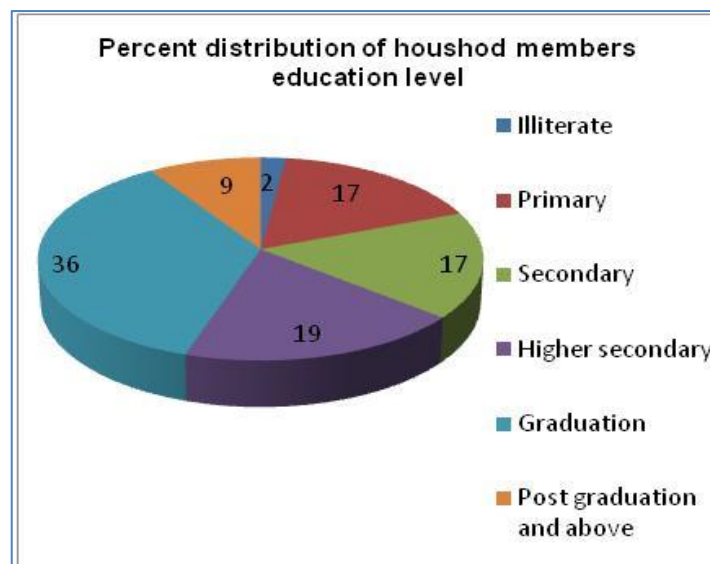


Figure 7 – Distribution of household members based on their Education level

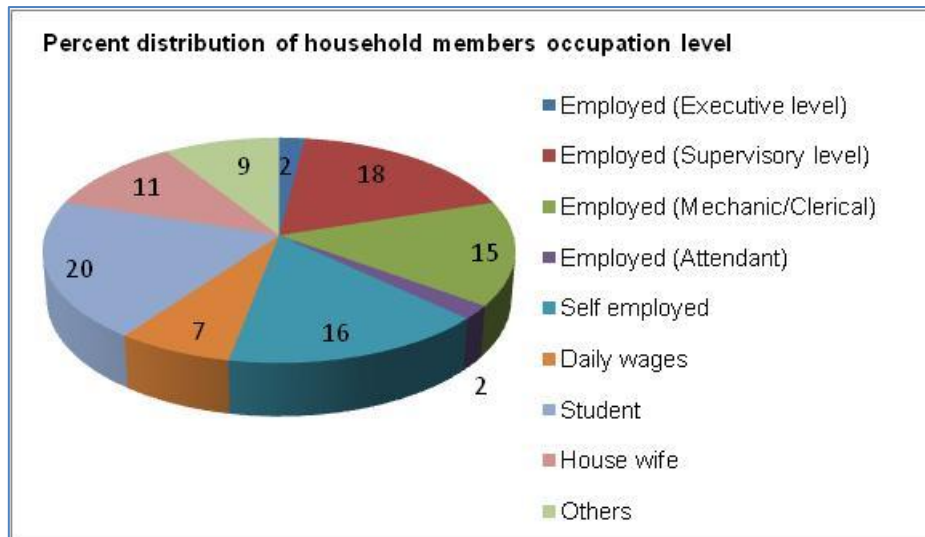


Figure 8 – Distribution of household members based on their occupation level

Analysis of diary

The survey instrument, Activity diary is collected 15 days activity information in a continuous time frame. Different types of activities considered for this study is explained in Appendix-1. Average number of activities reported by a person per day is 19.06. Average number of activities made by a person in a weekday is 18.97 and in a weekend is 19.27. Percent of home based activities conducted by a person per day is 64 and 36 percent of the activities are conducted at out-of-home. Based on their purpose, activities are divided into three types i.e. work related, maintenance related and leisure activities. Percent of work related activities carried out by a person in weekdays are 20.4 and in weekends are 9 percent. Percent of maintenance related activities carried out by a person per day in weekdays are 62.4 and in weekends are 64.8 percent. Similarly, percent of leisure activities carried out by a person in weekday is 16.6 and in weekends is 26 percent. Percent Distribution of average number of activities conducted based on their purpose by Male, Female and Student is represented in Table 4. Gender wise distribution (Male, Female and Student) of percent trips made by a worker and non-worker in weekday and weekend is shown in the Table 5. Distribution of average number of trips made by a worker and non-worker in a continuous time frame of 15 days is represented in the chart shown in the Figure 9.

Table 4 – Percent of activities based on their purpose

Purpose	Percent of activities		
	Male	Female	Student
Work related	22.55	11.57	9.66
Maintenance	57.14	68.53	60.74
Leisure	20.31	19.90	29.59

Table 5 – Percent trips based on their Gender wise distribution

Person	Percent of Trips				Student
	Male		Female		
	Worker	Non-worker	Worker	Non-worker	
Weekday	53.31	33.33	55.56	40.32	51.50
Weekend	46.69	66.67	44.44	59.68	48.50

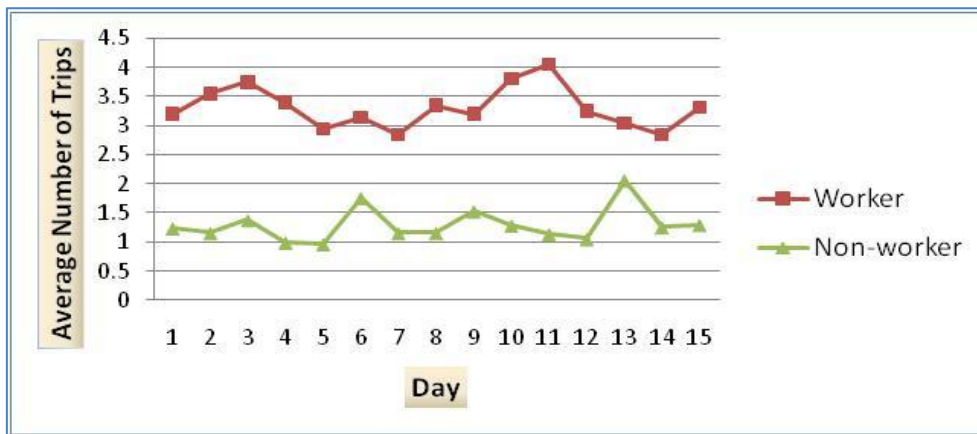


Figure 9 – Distribution of Average number of trips per day by worker and non-worker

For the purpose of analysis, trips in the pilot survey data is classified into 4 categories i.e. H-W-H (Home based work trips), H-NW-H (Home based non-work trips), NH-W-NH (Non-home based work trips) and NH-NW-NH (Non-home based non-work trips). Gender wise distribution of this specific classification is represented in the Table 6. Modes available to the respondents are divided into four categories namely car, two wheeler, public transport and walk. Walk mode includes trips conducted by walk and bicycle. Distribution of trips based on their mode choice in a continuous 15 days time frame is represented in the Figure 10. From the chart it can be observed that trips made by public transport and walk are considerably higher than car and two wheeler trips. Percent distribution of trips made by male, female and student based on their mode choice in the weekday and weekend is represented in Table 7. The main observation from this table is trips made by car are considerably increased during the weekends and trips made by two wheelers are decreased. This is because of more number of people planning their weekend trips with family.

Analysis of Activity-travel behaviour in the context of Developing countries
 SUBBARAO, SSV; KRISHNA RAO, KV

Table 6 – Percentage of trips performed in each trip category

Category of trip	Percent of trips in each category					
	Male		Female		Student	
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
H-W-H	36.2	19.52	28.45	24.43	45.45	6.25
H-NW-H	28.87	44.69	20.2	47.96	12.12	59.38
NH-W-NH	24.56	14.73	46.63	8.6	30.31	12.5
NH-NW-NH	10.37	21.06	4.71	19	12.12	21.87

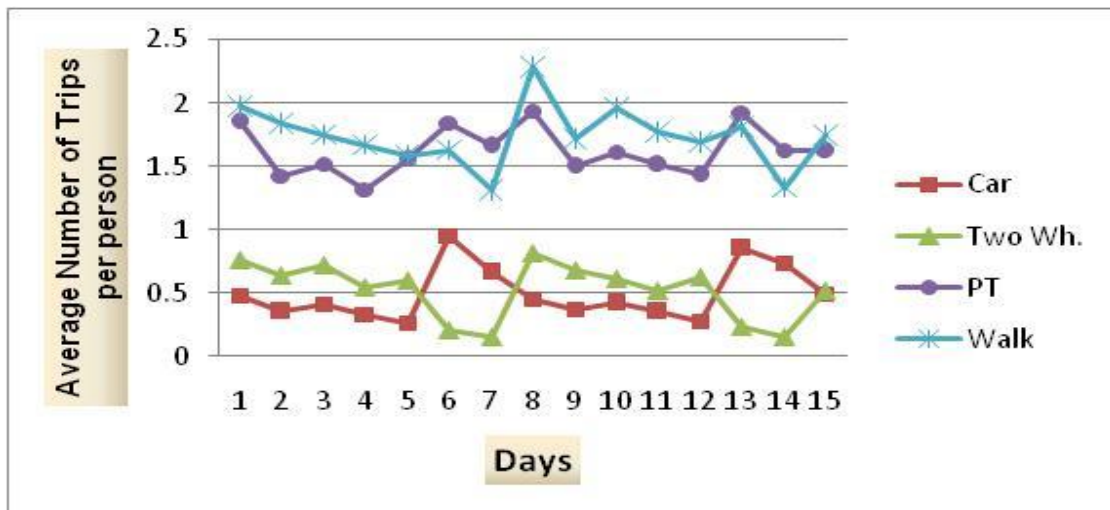


Figure 10 – Distribution of trips based on their mode choice

Table 7 – Percent of trips based on mode of travel

Mode choice	Percent trips by each mode					
	Male		Female		student	
	weekday	weekend	weekday	weekend	weekday	weekend
Car	12.75	18.75	4.3	12.9	5.88	25
Two-wheeler	19.46	4.17	7.52	0	14.71	9.37
Public transit	26.17	40.97	44.09	45.16	41.18	37.5
Walk	41.61	44.09	44.09	41.94	38.23	28.13

Interaction among the household members is another important parameter in the activity based travel demand modelling. This interaction leads to increasing or decreasing the number of activities in a particular day. In a weekday, 6.41 percent of the activities were carried out with household members and 4.74 percent of the activities were accompanied by others. In a weekend, 17.38 percent of the activities were carried out with household members and 8.04 percent of the activities were accompanied by others. Major observation from above values is more number of joint activities was conducted in weekends.

7. EXPERIENCE WITH THE DIARY FORMAT AND SURVEY

The format of the survey instrument is found satisfactory based on the results obtained from the diary analysis. In household information, name of the head of household and contact address with phone number introduced for making further contact if any required information not available. Type of residence is divided by observing several places in the city of Mumbai. For avoiding confusion to the respondents, non-workers category was further divided into <5 years, student, house wife, retired and others. The problem with the writing of codes is eliminated by asking the respondent to tick the appropriate category. In household information, household income is the most missing parameter in the survey. Respondents are not willing to disclose their monthly income. For checking the vehicle ownership, number of licensed drivers in the household was also included at the end of household information sheet. In person information sheet, occupation of the respondent is subdivided into several categories by taking into the consideration of employees in all levels, students and retired people. For assessing the travel cost of the respondent, type of travel pass and cost of pass information was also collected. In the travel mode choice, respondents can choose more than one mode. Hence diary can collect the information about all the common modes the respondent will use in his/her daily travel. In activity information sheet, the respondents can enter maximum of 26 activities per day. This space is provided based on experiences in the earlier studies conducted in India and by consulting academic experts. In activity information sheet, respondents were asked to write the description of activity instead of simply writing the code of activity. This will be useful for identifying the entire activities conducted by respondent. The major missing or non-responded data in activity diary is travel cost and in-home activity information. Respondents who are using private vehicles, they are unable to mention about their travel cost. Therefore, if the activity needs travel respondents were asked to mention origin and destination of the travel. So that assessment of the travel cost will be easy. The respondents have asked to fill the diary in a continuous time frame for a period of 15 days. Even though it is difficult to fill the diary and writing description of activities for such a long period, it is necessary for avoiding non-missing of the occasional activities and getting the qualitative information. Till now in India, nobody has attempted to collect activity information in such a long period. Hence this study will be a good contribution to the research in this area.

At the time of survey, major problems in developing countries like India are the chance of losing the survey sample and non-response. For contacting respondent for such a long period may not possible due to several reasons like household building may not be traceable, wrong entry of the permanent address, house locked etc. Hence it is difficult to

locate the household in the next contact. Hence Drop off And Pick up method (DAP) is adopted for the collection of data. Non-response problem is increased in this method due to unable to carrying diary all the time, loss of diary, survey time period, length of survey, low literacy rates and unwillingness to provide information about their in-home activities. Hence reminders have been sent to all the respondents very frequently. Other causes for non-response is lack of literature available in the experiences in survey instrument design and difficulty in getting permission for entry into a High Income Group (HIG) housing society. In India, cities with multilingual nature are significant in number. Hence the diary is prepared in three languages (English, Hindi and Marathi) for avoiding increase in non-response.

8. CONCLUSIONS AND FURTHER STUDY

Pilot survey was conducted to evaluate the performance of newly designed survey instrument and adopted data collection method. Drop off and pick up (DAP) method is considered as suitable for Indian conditions based on past studies, its length of survey and time period of survey. Response rate can be increased by providing incentives to the respondent. Analysis of responses has been done based on the 15 days respondent's diary information. Detailed analysis has been presented in the previous sections covering household characteristics, person characteristics and dairy information. Results obtained from the diary clearly highlight that socio economic characteristics of the person and household have considerable effect on the responses and their activity behaviour. The survey instrument can capture the interaction between household members by providing the joint activity information. Due to collecting activity information in a continuous time frame, the diary can also capture the interaction between the in-home activities and out-of-home activity information.

The main contribution from this study is a new survey instrument called activity diary has been designed in the context of developing countries, which overcome the limitations of the travel diary, which is commonly used in developing countries like India. This diary collects data about both travel and activity information in a continuous time frame and it can be effectively applied in the study area. A detailed analysis has been carried out based on the pilot survey data. This analysis can be helpful for assessing performance of activity diary and quality of data in the context of developing country.

This study has been done as a part of development of a prototype activity based model in the context of developing economy. Main survey has been planned in different metropolitan cities from India. Data obtained from this survey will be useful for analyzing activity-travel patterns of the individuals and households. This data can be used for formulating different models like tour level, trip level and person day activity models which will be useful for travel demand forecasting. Finally this study leads to development of a micro-simulation based prototype of activity based travel demand model.

9. REFERENCES

- Ampt, E. (1989). Comparison of Self-Administered and Personal Interview Methods for the Collection of 24-Hour Travel Diaries. Proceedings of the WCTR, Yokohama, Japan, pp. 195-206.
- Ampt, E. and Richardson, A. J. (1994). The Validity of Self-Completed Surveys for Collecting Travel Behavior Data. Proceedings of the 22nd European Transport Form Conference, Seminar H: Transportation Planning Methods, U.K, Vol. II, pp. 77-88.
- Ampt, E. and Stopher, P. (2006). Mixed method data collection in travel survey: Challenges and opportunities, ITLS-WP-06-24, Adelaide, October.
- Arentze, T. and Timmermans, H. (1998). Data Needs, Data Collection, and Data Quality Requirements of Activity-Based Transport Demand Models. Workshop on Modellers' Surveys: New Concepts and Research Needs, Irvine, CA, March.
- Arentze, T., Dijst, M., Dugundji, E., Joh, C.H., Kapoen L., Kryasman S., Maat, K., and Timmerman, H. (2001). New Activity Diary Format: Design and Limited Experiment Evidence. Transportation Research Record- 1768, Transportation Research Board, Washington, D.C, pp. 79-84.
- Armoogum, J. and Madre, J. L. (2000). Item Nonresponse, Sampling, and Weighting, Transport Surveys: Raising the Standard. Transportation Research E, Transportation Research Board, Transportation, 19, pp. 159-176.
- Axhausen, K.W. (1994). Designing Environmentally aware travel diaries. Paper presented at the VSP Advanced Studies Institute at the Tinbergen Institute, Amsterdam, April 5-9.
- Axhausen, K. W. (1995). Travel Diary Content: A Brief Review of Its Development. Presented at the 74th Annual Meeting of the Transportation Research Board, Washington, DC.
- Axhausen, K.W. (1995b). The Data Needs of Activity Scheduling Models. Activity-based Approaches to Travel Analysis, Pergamon, Oxford, pp. 229-241.
- Cambridge Systematic Inc. (1995). Data Collection in the Portland Oregon Metropolitan Area. Draft Interim Report prepared for Federal Highway Administration, report no. DOT-T-97-09.
- Clarke, M., Dix, M. and Jones, P. (1981). Error and Uncertainty in Travel Surveys. Transportation, 10, pp. 105-126.
- Census of India. (2001). Government of India, India.
- CTS. (2008). Comprehensive Transportation Study (CTS) for Mumbai Metropolitan Region, India.
- de Heer, W. F. and Moritz G (2000). Data Quality Problems in Travel Surveys an International Overview. Transport Surveys: Raising the Standard. Transportation Research E-Circular E-C008, Transportation Research Board.
- Doherty, S. T., and Miller. E.J. (2000). A Computerized Household Activity Scheduling . Journal of Transportation, Vol. 27, No. 1, 2000, pp. 75-97.
- Gershuny, J. (1992). Time-Budget Research in Europe. EUROSTAT, Doc E3/IS/5/92.
- Golob, F.T. and McNally, G.M. (1997). A model of activity participation and travel interactions between household heads. Transportation Research, Vol. 31B, pp. 177-194.
- Hagerstrand, T. (1970). What about people in regional science. Regional science association papers, 24, pp. 7-21.

- Haraldsen, G. (1999). The Design of Time-Use Surveys in Developed and Developing Countries. IATUR Time Use Conference, University of Essex, 6-8 October.
- Hawkins, R. and Stopher, P. (2004). Collecting Data with GPS: Those Who Reject, and Those Who Receive. Working paper, Institute of Transport Studies (Sydney and Monash).
- Hirway, I. (2001). Time Use Surveys: Concept, Classification and Related Issues Lessons from the Indian Pilot Time Use Survey. Workshop on Integrating Paid and Unpaid Work into National Policies (ESCAP), pp. 24-27.
- Jones, P., F. Koppelman, and J.P.Orfeuill. (1990). Activity analysis: State-of-the art and future directions. P.Jones, ed., Developments in dynamic and activity based approaches to travel demand analysis, Aldershot: Gower.
- Kalfs, N. and Saris, W.E. (1997). New Data Collection Methods in Travel Surveys. Activity-Based Approaches to Travel Analysis, Pergamon, Oxford.
- Kato, H. and Matsumoto, M. (2006). Intra-household Interaction Analysis among a Husband, a Wife, and a Child using the Joint Time-Allocation Model. Transportation Research Board annual meeting 2007 CD ROM.
- Kato, H. and Matsumoto, M. (2009). Intra-household Interaction in a nuclear family: A utility maximizing approach. Transportation Research Part B, 43, pp. 191-203.
- Kochan, B. (2004). Dynamic activity-travel diary data collection using a GPS-enabled personal digital assistant. Transportation research institute (IMOB), Hasselt university.
- Lawton, T.K. (1995). Activity and time use data for activity based forecasting. Conference on Household Travel Surveys: New Concepts and Research Needs, Irvine, California.
- Martin, L.G. (2006). Personal data collection using mobile ICTs: Old wine in new bottles. Second International Specialist Meeting on ICT, The Netherlands.
- Meyburg, A.H., and Brög, W. (1981). Validity Problems in Empirical Analyses of Non-Home Activity Patterns. Transportation Research Record 807, Transportation Research Board, Washington, D.C, pp. 46-51.
- Murakami, E. and Wagner, D.P. (1999). Can Using Global Positioning Systems (GPS) Improve Trip Reporting?. Transportation Research-C, pp.149-165.
- Patten, M.L. and Goulias K.G. (2003). Integrated Survey Design for a Household Activity-Travel Survey in Centre County, Pennsylvania. Submitted for 83rd annual transportation research board meeting.
- Pribyl, O. and Goulias, G.K. (2005). Simulation of daily activity patterns incorporating interactions within households: Algorithm overview and performance. Submitted at the 84th annual Transportation Research Board meeting, and publication in the Journal of Transportation Research Board, Washington.
- Richardson, A.J., Ampt, E.S. and Meyburg, A.J. (1995). Survey Methods for Transport Planning. Eucalyptus Press, University of Melbourne, Australia.
- Stecher, C. C., Brickas, S. and Goldenberg, L. (1996). Travel Behaviour Survey Data Collection Instruments. Transportation Research Board Conference Proceedings No. 10, Transportation Research Board, Washington, DC, pp. 154-169.
- Stopher, P.R. and Sheskin, I.M. (1982). Method for Determining and Reducing Nonresponse Bias. Transportation Research Record 886, Transportation Research Board, Washington, D.C, pp. 35-41

- Stopher, P. R. (1992). Use of an Activity-Based Diary to Collect Household Travel Data. *Transportation*, 19, pp. 159-176
- Stopher P. R., and Wilmot, C. G. (2000). Some New Approaches to Designing Household Travel Surveys-Time-Use Diaries and GPS. Paper presented at the 79th Annual TRB meeting, Washington DC.
- Stopher, P. R. (1996). Household Travel Survey: Cutting-Edge Concepts for the Next Century. *Transportation Research Board Conference Proceedings No. 10*, Transportation Research Board, Washington, DC, pp. 12-14.
- WFSL study. (2005). A report submitted by Indian Institute of Technology Bombay, Mumbai.

APPENDIX - I

General Activities:

1. WORK RELATED ACTIVITIES:

- Employment Related:
 - Main job/Other job --- Regular hours/ overtime hours/ Extra hours (not paid as overtime)/ other
 - Work in internship, apprenticeship, etc. ---- Regular hours/ overtime hours/ Extra hours (not paid as overtime)/ other
 - Unpaid work in family business / Breaks and interruptions from work
 - Training and studies in relation to work
 - Looking for work/setting up business
- Education Related:
 - General education: School/ college/ technical institutes/ university
 - Job related training/ Travels related to learning/ Non formal education for children, other training/ education
 - Homework /study/research associated travels

2. MAINTENANCE ACTIVITIES

- Personal care
 - Sleeping/ napping/ eating/ drinking/ taking rest/ relaxation/ going to beauty parlour
- Household maintenance
 - Preparing Meals/snacks/drinks/other food related activities
 - Shopping for goods and services
 - Home maintenance/ Cleaning --- Indoor cleaning/out door cleaning/cooking food items/ gardening plants/ care of textiles/ Grinding flour/ Taking car for service etc.
 - Household management --- Paying household bills / Budgeting, organizing, planning, selling, disposing of household assets / other specified personal care activities
 - Using telephone/ cell phone /Internet browsing / sending/reading/receiving email
- Caring for others
 - Caring for children/ teaching, training, helping children/ caring for adults/other specified caring for others/ caring for elders and disabled persons

- Accompanying children to places ---- accompanying children to receive personal services/ accompanying children to receive medical/health services/ accompanying children to school, day-care centres/ accompanying children to sports, lessons etc.

3. LEISURE ACTIVITIES

- Recreational activity
 - Games, sports, watching television, movies etc.
- Social and community interaction
 - Participating in social events: wedding, funeral, births and other celebrations
 - Participating in religious activities: religious ceremonies, practices and processions
 - Visiting entertainment and cultural venues/ Attendances at sports event
 - Participating in community functions in music/ dance etc.
 - Travels related to social, cultural and recreational activities
- Voluntary services
 - Voluntary community works/ Informal help to other households
 - Participation in meetings of local and informal groups
 - Involvements in civic and related responsibilities: voting, rallies, attending meetings
 - Travels related to voluntary, organizational and community services