An Exploratory Analysis of Children's Daily Time-Use and Activity Patterns Using the Child Development Supplement (CDS) to the US Panel Study of Income Dynamics (PSID)

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ABSTRACT
This research paper examines the weekday and weekend activity participation characteristics of school-going children. Specifically, the research focuses on the overall time-use of children in different types of activities, as well as on several dimensions characterizing the context of participation in activities. These include the temporal (day of week and participation duration), spatial (location), with-whom (*i.e.*, accompanying individuals), and episode sequencing dimensions. The data for our analysis is drawn from the 2002 Child Development Supplement to the Panel Study of Income Dynamics.

1. INTRODUCTION

1.1 Background and Research Objective of Study

The focus of analysis in existing activity-based research has almost exclusively been on the activity-travel patterns of adults [16-18 years of age and older; for instance, see (*1*), (*2*), (*3*)]. One reason for this emphasis on adults' activity-travel patterns is ostensibly that most children do not have the choice of driving on their own, and therefore do not "add" cars directly onto the transportation network. However, by the same token, children depend, to a large extent, on household adults or other adults to drive them to activity events. Such serve-passenger activities constrain adults' activity-travel patterns in important ways. For instance, a parent driving a child to school during the morning peak is unlikely to shift away from the morning peak because of a congestion pricing strategy, even if the parent has a flexible work schedule. Similarly, in the case of a parent dropping a child off at soccer practice, it is not the parent's activity but the child's activity, and its location, that determines the temporal and spatial dimensions of the trip (*4*). Further, the dimension of "who" is responsible for serving the trip for the child's activity determines which adult's activity-travel pattern is impacted [see (*5*) for a recent study emphasizing the *with whom* and *for whom* characteristics of activity participation]. Of course, in addition to serve-passenger activities, children can also impact adults' activity-travel patterns in the form of joint activity participation in such activities as shopping, going to the park, walking together, and other social-recreational activities.

The intricate interactions and effects of children's activity-travel patterns on adults' activity-travel patterns can be captured in limited ways by the commonly used approach of including "exogenous" variables representing the number, presence, and age distribution of children. However, such a limited approach is not as behaviorally interesting or appropriate as considering the activity-travel patterns of children, and explicitly inter-linking these with those of adults' activity-travel patterns (*5*). In addition, the consideration of children's activity-travel patterns is important in its own right. Specifically, children's activity-travel patterns contribute directly to travel by non-drive alone modes of transportation. Also, understanding the overall time-use patterns of children, and the context of their non-motorized travel and physical activity participation, is important for promoting the health of children (*6*). This is an issue that is gaining increasing attention at the interface of the transportation and public health fields, because of the positive correlation between physically active lifestyles and the development of strong, healthy, and intelligent children (*7*, *8*).

In summary, there are several compelling reasons to examine and analyze children's activity-travel patterns. This motivates the objective of this research, which is to descriptively examine the weekday and weekend activity participation characteristics of school-going children. In doing so, we focus on the overall time-use of children in different types of activities, as well as on several dimensions characterizing the context of participation in activities. These include the temporal (day of week and participation duration), spatial (location), with-whom (*i.e.*, accompanying individuals), and episode sequencing dimensions.

1.2 Overview of Earlier Research Relevant to the Current Study

The earlier research efforts in the area of children's time-use and activity-travel patterns may be classified into two broad areas: (1) Time-use studies that provide aggregate daily or weekly time-use statistics, with limited to no examination of the context of participation in activities, and (2) Studies that model the factors affecting children's participation in specific activity episodes,

such as physical activity participation and hours of television viewing. We briefly discuss the literature within each of these categories in turn in the subsequent two paragraphs.

The time-use studies have been primarily undertaken in the sociology, developmental psychology, economics, and education fields. These studies examine children's time-use in one or more countries [(*9*), (*10*); see (*11*) for a review] or study changes in time-use over time [see (*12*)]. Many of these studies also examine time spent with family and friends, with an emphasis on time spent with parents (*9*, *11*). The latter emphasis is a result of the desire to examine the effects of parental involvement on children's cognitive and social-emotional development, especially in the context of changing family structure and maternal employment patterns (*13*, *14*, *15*). Some of the time-use studies also examine the after-school activities of children, with the intention of assessing the need for, and benefits of, after-school programs (*16*, *17*, *18*, *19*). Overall, the broad time-use studies have provided a rich basis for understanding the social-psychological aspects of children's development. However, they either do not focus, or focus in only very limited ways, on the temporal, spatial, "with-whom", and episode sequencing contexts of children's activity-travel participation.

A second broad area of children's activity studies has examined the factors affecting participation in such specific activities as physically active pursuits or sedentary activities (for example, watching television). Many of these studies are motivated by the growing child obesity problem in the United States (*20*), and the well established epidemiological link between physical activity and obesity reduction/other health benefits. Studies focusing on the correlates of physically active and inactive lifestyles in children include *21-27*. Some related studies have sought to identify relationships between the time spent in physical activity and time spent in sedentary activities [see (*28*)] or a relationship between the time spent in both activities to unhealthy attributes in children [see (*29*), (*30*), (*31*)]. Another recent study assessed how television viewing affects time spent in other free time activities and with family members (*32*).

1.3 The Current Study and the Paper Structure

The current study is close to the spirit of the first category of time-use studies of the previous section in that it examines time-use in all of the children's activities, and not just in specific physically active or physically inactive activity categories. However, our underlying objective of contributing toward activity-based travel analysis requires a much more detailed analysis of the context of activity participation than is examined in the traditional time use studies. In this regard, our study is similar to the recent research work of Stefan and Hunt (*33*), who examined activity-travel patterns of Canadian children. But we focus on US children, adopt a more disaggregate taxonomy of activity purposes, examine the "with whom" dimension of activity participation, analyze the location of out-of-home activities, and explore episode sequencing characteristics. Also, in contrast to some other studies that have focused on the travel patterns of US children [see (*34*), (*35*)], the current study adopts activity episodes as the unit of analysis and considers the comprehensive context of activity episode participation. We envision our exploratory analysis as an important first step toward informing the development of joint activity-based travel models for children and adults.

The data for our analysis is drawn from the 2002 Child Development Supplement (CDS) to the Panel Study of Income Dynamics. The CDS provides a rich base to examine the many dimensions of activity participation. Specifically, the survey collects information on all aspects of both in-home and out-of-home activity participation of a sample of children for one weekday and one weekend day. The survey explicitly obtains information on all persons (both household

and non-household members) accompanying the respondent for each activity episode. The survey also uses a disaggregate activity classification scheme and employs an extensive location typology to capture the spatial dimension of activity episode participation. The time-use and activity patterns of school-going children aged 5-18 years are considered in the analysis.

The rest of this paper is structured as follows. The next section describes the data source and sample formation procedure. Section 3 presents aggregate characteristics of children's time-use by activity purpose and by activity location. Section 4 examines the location and with whom dimensions of children's participation in activity episodes. Section 5 examines the sequencing of children's activity episodes. Finally, Section 6 summarizes the important findings from the research.

2. DATA SOURCE AND SAMPLE FORMATION

2.1 Data Source

The data source for this analysis is the 2002 Child Development Supplement (CDS) to the Panel Study of Income Dynamics (PSID). The PSID is a longitudinal study that collected demographic, employment and health information from a nationally representative sample of individuals and households. The CDS surveyed over 2,500 children through health and achievement test surveys, primary caregiver and child interviews, and a two-day time-use diary - one for a weekday and the other for a weekend day. The time-use diary collected information on the type, number, duration, and location of activities for each 24-hour survey day beginning at midnight. The diary also collected information on who was present, and participating, and who was present, but not participating, in each activity. Paper diaries were mailed to children, filled out on or around the activity day, and then retrieved and reviewed by an interviewer either by phone or in person. Older children and adolescents were expected to fill out their own diary, while primary caregivers aided younger children.

2.2 Sample Formation

The process of generating the sample for analysis involved several steps. First, only individuals aged five through eighteen who were enrolled in primary or secondary school were considered for the analysis. Also, only children who filled out time diaries on both the weekday and weekend day were included. Based on these criteria, a total of 1970 children were selected for analysis. Second, activity types were reclassified from the 365 original purposes into 11 activity types: (1) Work (for pay), (2) Household Chores (including non-paid child care), (3) Meals (including snacks), (4) Organized Activities (*i.e.* lessons, meetings, and clubs), (5) Studying (including non-school classes and homework), (6) Recreation (*i.e.* unorganized hobbies and sports, outings, reading, playing, TV viewing, and music), (7) Social (including conversations, being intimate, parties, visiting, and religious services), (8) Personal Business (*i.e.* shopping, obtaining services, paying bills, writing e-mails or letters), (9) Personal Care, (10) Receiving Child Care (*i.e.* daycare, being babysat), and (11) School. Additionally, because of the rather diverse nature of the organized activities, recreation, and personal business purpose categories, these were further classified into several finer categories for exploration. Third, activity episode locations were collapsed into eleven location types: (1) Home, (2) Parent's work place, (3) Child's work place, (4) Someone else's home (including other parents' home), (5) restaurant, (6) Outdoor recreational area, (7) School, (8) Church, (9) Store/retail business, (10) Non-retail business (including indoor recreational facilities and daycare), (11) Other. Fourth, "with whom" participation categories were created for each activity episode, based on the presence of other

individuals who were around and/or participated in each episode. The "with whom" information was grouped into ten mutually exclusive and collectively exhaustive categories: (1) No one else (or alone), (2) Only with Mother, (3) Only with Father, (4) Only with sibling(s), (5) Immediate family combinations (more than one of father, mother, and siblings), (6) Only with extended family, (7) All other family combinations (immediate and extended family combinations), (8) Only with child's friend, (9) Only with other non-relative, (10) Other combinations. Finally, out-of-home activity episodes (or stops) and tours (home-to-home sojourns) were identified by re-organizing the activity episodes based on location of performance (in-home or out-of-home), followed by the tracing of the sequence of out-of-home and in-home episodes.

3. AGGREGATE TIME-USE CHARACTERISTICS

This section provides a broad overview of children's time-use by presenting participation rates and duration of time spent in (1) different types of activities across all children and by age groupings (Section 3.1), and (2) different types of finer activity categories within the broad activity purposes of organized activities, recreation, and personal business (Section 3.2).

3.1 Participation and Time Spent in Activity Purposes by Age

Table 1 presents participation percentages and average duration of participation by activity purpose for the weekday and weekend day, respectively (the weekend numbers are in parenthesis). In these tables, an entry of '–' in any cell implies that the participation rate in the corresponding activity purpose is less than 0.5%. Also, the average duration of participation in each activity purpose is computed as the mean of the total duration of participation across all episodes of that purpose, across children who participate in the activity purpose.

The second column of the table, labeled "Total", presents statistics for the entire sample of children. This column indicates that, as expected, a high fraction of children participate in school activity on weekdays (the average duration is about 6.5 hours), while almost no child participates in school activity on weekends (see the first row corresponding to "school" in Table 1). Also, almost every child eats, recreates, and pursues personal care activities each day (the reason for the meal percentage being less than 100% may be attributed to meals not being considered as the primary activity). In addition, except for the three purposes of school, studying, and receiving child care, children participate at least as much (and generally much more) in each of the other activity purposes over the weekend days than the weekdays. The difference is particularly noticeable for the recreation, social, and personal business (including shopping) purposes. For the recreation purpose, the participation rates are not very different between weekdays and weekend days, though the average duration of participation among children who recreate is about 3.5 hours on weekdays and 6.5 hours on weekend days. For the social and personal business purposes, there is a substantial increase in both the participation rates and mean durations over the weekend days [see (*9*) and (*11*) for similar results].

The rest of the columns in Table 1 provide the participation rates and mean durations by age group. The row corresponding to the "work" purpose shows that the work participation rate is substantive only for adolescents (15 to 18 year olds). These adolescents work, on average, for about 4.5 hours on a weekday and 6 hours on a weekend day. Finally, as children get older, the participation rates and mean durations in organized activities, social activities, and personal business increase, while the participation rate and duration of time spent receiving child care decreases. This is consistent with the increased professional, social, and shopping activities among adolescents compared to younger children (*9*, *36*).

3.2 Participation Rates and Durations in Disaggregate Activity Purposes

The organized activity, recreation, and personal business purposes comprise a rather diverse set of activity types, with potentially quite different contextual dimensions. In this section, we examine participation rates, and durations of participation, in each of the disaggregate activity types that make up the broader activity purposes identified above. Figure 1 presents the results. For each of the three broad activity purposes, the figure provides the percentage of individuals participating in the broad activity purpose who participate in each of the finer activity types. For example, the weekday bar for "sports practice or games" for organized activities shows that about 60% of children who participated in organized activities took part in "sports practice or games". In addition, the number just above the bar indicates that, among the children who participated in "sports practice or games", the mean duration of participation is 118 minutes.

As can be observed from the figure, the most common organized activity type participated in during the weekday is "sports practice or games", while the corresponding type during weekend days is "clubs and other meetings". As one would expect, for both "sports practice or games" and "clubs and other meetings", the mean duration among those who participate in these activities is longer over the weekends than the weekdays.

The recreation activity comprises many different kinds of sub-activities (see bottom panel of Figure 1). Not surprisingly, TV or movie watching is the dominant type of recreation activity on both weekdays and weekend days, with almost 85-90% of recreators undertaking this activity. The mean durations in this activity is also quite substantial (about 2 hours on weekdays and more than 3 hours on weekend days). Overall, children participate much more in physically passive recreational activities, and spend substantial amounts of time in such activities, than in physically active recreational activities.

In the category of personal business activities (top right figure), shopping represents the largest percentage of personal business activities on both the weekday and weekend days, though its share on weekend days is much higher. For all other personal business activity categories, the participation rate on weekdays is higher. The mean durations, however, is always higher on weekend days for all personal business activities.

In the rest of this paper, we do not maintain the disaggregate classification of this section, to limit the scope of the study and maintain focus. However, the diverse nature of the broad activity types should be recognized in the ensuing discussions.

4. EPISODE-LEVEL ANALYSIS

The previous section provided a descriptive analysis of children's overall time-use patterns during the day. In this section, we examine the detailed context of children's activity episodes. Specifically, the location of performance, and the type of companionship arrangement, of episodes are analyzed. The contexts of "where" and "with whom" dimensions of episode participation are important determinants of travel patterns and the inter-relationships between activity-travel patterns of different individuals.

4.1 Location of Activity Episode Participations

Table 2 provides the percentage of episodes in each non-school activity purpose that is pursued in-home and out-of-home (the percentages add up to 100% for each row). The results show that work and organized activity episodes are most likely to be pursued out-of-home on both weekdays and weekend days, with over 90% of these episodes pursued out-of-home. In contrast,

episodes corresponding to meals, household chores, studying, recreation, and personal care are primarily pursued in-home, particularly on weekdays. On weekend days, the absence of school-related activity provides more flexibility to port these activities out-of-home. The predominantly in-home nature of recreation activities is also consistent with "television or movie viewing" and "playing video or computer games" being the primary kinds of recreational activities (see Section 3.3).

There is a more even split between the in-home and out-of-home locations for social, personal business, and "receive childcare" episodes, though there are also much more differences in these splits between weekdays and weekend days compared to other episode types. For social and personal business episodes, the location is skewed toward the out-of-home category on weekend days. The substantially high percentage of out-of-home personal business episodes over the weekends may be attributed to shopping being the dominant personal business activity on weekends (see Figure 1). For the "receive childcare" episodes (last row of table), the percentage is much higher for the out-of-home category on weekdays (when adults are likely to be at work) and much higher for the in-home category on weekend days (when adults seek child care at home to maximize the time gained from the child care arrangement to pursue out-of-home activities).

Table 2 also provides the most common locations where out-of-home episodes of each activity purpose are pursued (see the final column of Table 2; the percentage next to each location corresponds to the percentage of episodes of each activity purpose pursued at that location). The location information is given for all the non-school activity purposes, except for work, household chores, and personal care (children work primarily at their work place, while household chores and personal care are almost exclusively pursued in-home). The results in Table 2 show that someone else's home is a very common location for participation in all types of out-of-home episodes, except for organized activities and personal business episodes. This is particularly the case for recreation and social episodes on both weekdays and weekend days, and for "receiving child care" episodes on weekend days. Another very frequent location for participation in all types of out-of-home episodes (except personal business episodes) on weekdays is school. On the other hand, on weekends, a rather large fraction of organized activity and social out-of-home episodes are pursued at church.

4.2 Companionship Arrangement of Activity Episodes

As indicated in the introductory section of the paper, the joint activities of children with other individuals introduce linkages in the activity-travel patterns of all the individuals involved. Thus, it is of interest to understand the individuals who accompany children in their activity episode participations. For in-home episodes, the only activity type whose episodes have a rather high chance of being pursued alone is personal business (about 27% of in-home personal business episodes are pursued alone). Among episodes pursued jointly or with other persons around, a vast majority of in-home episodes of all types involve only the immediate family (mother, father, sibling or combinations), or immediate family and other non-family members. In the rest of this section, we do not present the companionship arrangement for in-home activity episodes because of the dominance of immediate family members as accompanying individuals.

The companionship arrangement (*i.e.*, who participated with the child) for out-of-home non-school episodes is presented in Table 3. The work activity purpose does not appear in the table, because, by definition, work activities are pursued alone. Also, we do not include the household chore activity purpose in Table 2 because a large fraction of episodes for this purpose

are pursued in-home (see Table 2). The reader will note that the percentages add up to 100% for each row in Table 3. The first number in the table indicates that 10.2% of weekday meal episodes are pursued alone. Other numbers in the table are to be interpreted similarly. Several insights may be drawn from the table. First, studying, followed by recreation episodes, are the most likely to be pursued alone relative to episodes of other types. Second, the results show that children are more likely to be accompanied by only their mother than only their father on weekdays for all episodes except social episodes. This is consistent with the notion that the mother bears more of the responsibility for child-care and related child activities (*37*, *38*). It may also be the result of men being more likely to be employed in a household and working longer hours (*39*), which constrains their time with children. The latter explanation is compatible with the finding that the participation levels of children with only their fathers increase between weekdays and weekend days for all episode types, except social activity episodes (see *40* for similar results). Third, children are most likely to pursue episodes with only their siblings for recreational episodes compared to other episode types. Fourth, children participate much more with their immediate family (combinations of parents and siblings) in all activity episodes over the weekends. This is particularly the case for out-of-home meals, social, and personal business episodes. Overall, the higher participations with the immediate family over the weekend are a clear result of more time availability to be together as a family over the weekends. Fifth, children participate with only their friends rather substantially, particularly in social and recreational episodes. In addition, children participate at rather high intensity levels with combinations of family and non-family members.

Overall, it is indeed remarkable that children mostly participate with other individuals in their activities rather than alone, even in in-home activities. Further, children participate with their immediate family members (and no one else) at less than 50% for all episode types. The rather high fraction of joint out-of-home episodes undertaken with non-household members (with or without family members) emphasizes the importance of recognizing inter-household interactions in the context of a household's social network, in addition to intra-household interactions.

5. EPISODE SEQUENCING

The analysis thus far has focused on overall time-use during the day (Section 3) and the location/with whom dimensions of individual episode participations (Section 4). In this section, we examine how children organize their weekday and weekend days by examining the sequencing of out-of-home activity episodes (*i.e.*, stops) in terms of the organization of the episodes into tours (home-to-home sojourns). Specifically, we examine the propensity of children to undertake multiple types of out-of-home activity episodes, as a part of the same sojourn or home-based tour. The activity episode chaining for each activity purpose *T* is described in terms of a *chaining propensity index*, which is defined as the ratio of the number of multiple-stop tours containing an episode of *T* to the total number of tours containing an episode of activity purpose *T*. For example, if out of 1000 home-based tours, each comprising at least one shopping activity episode, 700 tours comprise only one or more shopping episodes and the remaining 300 comprise one or more other (non-shopping) stops in addition to shopping, then the chaining propensity for shopping is 300/1000 = 0.3. Thus, for activity purpose *T*, a chaining propensity of 1 would indicate that all episodes of purpose T are chained with out-of-home activity episodes of other purposes, while a chaining propensity of 0 would imply that episodes of purpose *T* are never chained with out-of-home activity episodes of other purposes.

The chaining propensities by activity purpose are presented in the first part of Table 4 for both weekdays and weekends. In the overall, 41% of all out-of-home tours involving children's episodes are chained (*i.e.* involve activity episodes of different purposes), while 43% of all tours on weekend days are chained (see first row of Table 4). The marginally higher chaining on weekend days is presumably a reflection of more relaxed time constraints, and more impulsive participations in other activity purposes when participating in a specific activity purpose. A further examination of the chaining propensity by activity purpose reveals several interesting results. Among all purposes, school episodes are the only ones that are more likely to be undertaken in isolation than being chained with episodes of other activity purposes (this is particularly the case during weekend days). For weekday work episodes, the propensity to chain with episodes of other activity purposes is about the same as the propensity to not chain, while weekend work episodes are more likely to be undertaken in isolation. Perhaps the relatively strict spatial and temporal constraints within which the school/work activity is undertaken, and the long durations invested in episodes of these purposes, make it undesirable for children to chain these activity episodes with other out-of-home activity episodes. Among non-school and non-work purposes, episodes for meals and personal care are the most likely to be chained. This is quite intuitive, since out-of-home meals and personal care episodes are likely to be pursued in combination with other episode types such as shopping. Finally, a comparison of the differences in chaining propensities across weekdays and weekend days reveals that out-of-home episodes for studying, social, and "receiving child care" are particularly likely to be chained with episodes of other purposes over the weekdays relative to weekend days.

The chaining propensity by activity purpose provides a good indication of the motivation behind the sequence of episode participations, but does not provide information about the spatial location component of chaining. For example, a shopping episode at a shopping mall may be followed by a meal episode at the mall, in which case both of these episodes would appear as being chained. However, there is no spatial dislocation (*i.e.*, no travel) between the two episodes. To examine the extent of chaining in terms of travel, the second part of Table 4 provides the information on chaining of out-of-home episodes by activity location. The first row clearly indicates that, while the chaining propensities by purpose are about the same on weekdays and weekends, there is much more spatial diversity (scattering) in the location of participation of the episodes over the weekend days. Specifically, only 26% of weekday tours involve episode participations at multiple locations, compared to 66% of weekend tours. This is indeed interesting, suggesting that individuals appear to be more willing to invest time in travel, perhaps to their desired locations for participation in each type of activity, over the weekends. On the other hand, there is a tendency to pursue activities at a single location in tours on weekdays. Among the different activity location categories, episodes undertaken at the parents' work place are most likely to be chained with other locations, while those undertaken at school and church are the least likely to be chained (especially on weekdays).

6. CONCLUSION

The activity-based approach to travel analysis has received substantial attention in the transportation field. In recent years, the importance of recognizing and accommodating inter-household and intra-household linkages in activity-travel patterns has been emphasized [see (*2*), (*5*), (*41*)]. However, almost all earlier activity-based analyses have focused solely on the activity-travel patterns of adults. In these studies, children are considered only to the extent that their demographic characteristics (presence, number, and age distribution) impact the adults' activity-

travel patterns. On the other hand, explicitly considering children's activity patterns is important for accommodating the linkages between children's and adult's activity-travel patterns, and for the accurate forecasting of activity-travel patterns in general. In this research, we descriptively examine the weekday and weekend activity participation characteristics of school-going children. In doing so, we focus on the overall time-use of children in different types of activities, as well as on several dimensions characterizing the context of participation in activities.

There are several important findings from the study. First, the types of activities children pursue are quite different based on age. This is particularly the case for organized activities, social, and personal business (including shopping) activities, with older children participating more often in these activities, and for longer durations, than younger children. As expected, adolescents (15-18 years) are also much more likely to participate in work activities compared to younger children. Second, there are substantial variations in time-use between weekdays and weekend days, particularly for the recreation, social, and personal business purposes. It is particularly interesting to note the time investment patterns in recreation. Almost all children recreate over the weekday and weekend day, and the time investment in recreation is, on average, 3.5 hours on a weekday and 6.5 hours on weekend days. Within the category of recreation, the dominant type of recreation among children is "TV or movie viewing" and "playing video/computer" games. This reinforces the notion that children participate much more in physically passive recreational activities, and spend substantial amounts of time in such activities, than in physically active recreational activities (see *32*). Third, a rather substantial fraction of out-of-home episodes are pursued at someone else's home on both weekdays and weekends, and at school on weekdays. Fourth, children mostly participate with other individuals (rather than alone) in out-of-home activity episodes, and a significant proportion of these joint participations are with individuals who are not family members. The rather high fraction of joint out-of-home episodes undertaken with non-household members (with or without family members) emphasizes the importance of recognizing inter-household interactions in the context of a household's social network, in addition to intra-household interactions. Fifth, the relatively strict spatial and temporal constraints within which the school/work activity is undertaken, and the long durations invested in episodes of these purposes, appear to make it undesirable for children to chain these activity episodes with other out-of-home activity episodes. Sixth, there is substantial spatial scattering in the location of participation of the episodes in tours over the weekend days, and a tendency to pursue activities at a single location in tours on weekdays. These results perhaps reflect lesser time constraints and more impulsive episode chaining on weekend days relative to weekdays.

The findings from this study, and previous studies in children's time-use, indicate that children's activity and travel patterns differ from the patterns of adults. Therefore, children should be studied and treated as a distinct group, both in the context of activity-based modeling and in understanding the determinants of participation in non-motorized travel and physical activity. This research reveals that a variety of activity types may occur at a specific location (for example at school or at someone else's home), emphasizing the need to more thoroughly investigate the relationship between activity type and activity location. Specifically, future research should jointly analyze the purpose and location of children's after school and weekend activity participation. Further, this research indicates the high prevalence of children's activity participation with non-family members and in activities at someone else's home. These results highlight the need to examine children's inter-household interactions, as well as children's intra-household interactions, within a joint framework.

Overall, our findings provide insights into children's time use and activity participation characteristics, including the context of participation in activities. In light of our findings, we recommend that future travel surveys and models be suitably enhanced to (1) recognize intra-household and inter-household interactions, (2) include multi-day data collection programs, and (3) explicitly consider children's activity-travel behavior characteristics.

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REFERENCES

1. Bhat, C. R., and S. Srinivasan. A Multidimensional Mixed Ordered-Response Model for Analyzing Weekend Activity Participation. *Transportation Research Part B*, Vol. 39, No. 3, 2005, pp. 255-278.

2. Koppelman, F. S. and J. P. Gliebe. A Model of Joint Activity Participation Between Household Members. *Transportation*, Vol. 49, 2002, pp. 49-72.

3. Bhat, C. R. and R. Misra. Comprehensive Activity-Travel Pattern Modeling System for Non-Workers with Empirical Focus on the Organization of Activity Episodes. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1777*, TRB, National Research Council, Washington, D.C., 2002, pp. 16-24.

4. Kitamura, R. Serve Passenger Trips as a Determinant of Travel Behaviour. In Carpenter, S. and P.M. Jones (eds.) *Recent Advances in Travel Demand*. Gower, Aldershot, UK, 1983.

5. Goulias, K. G. and T. Kim. An Analysis of Activity Type Classification and Issues Related to the With Whom and For Whom Questions of an Activity Diary. Presented at the 84th Annual Meeting of the Transportation Research Board, Washington, D.C., 2005.

6. Krizek, K., A.S. Birnbaum, D.M. Levinson. A Schematic For Focusing on Youth in Investigations of Community Design and Physical Activity. *American Journal of Health Promotion,* 2004.

7. Center for Disease Control (CDC). Youth Risk Behavior Surveillance – United States, 2005. *Morbidity and Mortality Weekly Report*, Vol. 55, No. SS-5, 2006.

8. Transportation Research Board and Institute of Medicine. Does the Built Environment Influence Physical Activity? Examining the Evidence. TRB Special Report 282, 2005.

9. Hofferth, S. L. and J. F. Sandberg. How American Children Spend Their Time. *Journal of Marriage and Family*, Vol. 63, 2001, pp. 295-308.

10. Zill, N., C. W. Nord, and L. S. Loomis. Adolescent Time Use, Risky Behavior, and Outcomes: An Analysis of National Data. Report prepared for the Office of Human Services Policy, U.S. Department of Health and Human Services, Washington, D.C., 1995.

11. Larson R. W. and S. Verma. How Children and Adolescents Spend Time Across the World: Work, Play, and Developmental Opportunities. *Psychological Bulletin*. Vol. 125, No. 6, 1999, pp. 701-736.

12. Hofferth, S. L. and J. F. Sandberg. Changes in American Children's Time, 1981-1997. Research Report: Population Studies Center at ISR, University of Michigan, 2000.

13. Bryant, W. K. and C. D. Zick. An Examination of Parent-Child Shared Time. *Journal of Marriage and the Family*, Vol. 58, No. 1, 1996, pp. 227-237.

14. Asmussen, L. and R. Larson. The Quality of Family Time Among Young Adolescents in Single-Parent and Married-Parent Families. *Journal of Marriage and the Family*, Vol. 53, No. 4, 1991, pp. 1021-1030.

15. Sandberg J. F. and S. L. Hofferth. Changes in Children's Time with Parents: United States, 1981-1997. *Demography*, Vol. 38, No. 3, 2001, pp. 423-436.

16. Shann, M. H. Students' Use of Time Outside of School: A Case for After School Programs for Urban Middle School Youth. *The Urban Review*, Vol. 33, No. 4, 2001, pp. 339-355.

17. Posner, J. K. and D. L. Vandell. After-School Activities and the Development of Low-Income Urban Children: A Longitudinal Study. *Developmental Psychology*, Vol. 35, No. 3, 1999, pp. 868-879.

18. Posner, J. K. and D. L. Vandell. Low-Income Children's After-School Care: Are there Beneficial Effects of After-School Programs? *Child Development*, Vol. 65, No. 2, 1994, pp. 440-456.

19. Hofferth, S. L. and J. Jankuniene. Life After School. *Association for Supervision and Curriculum Development*, 2001, pp.19-23.

20. Center for Disease Control (CDC). Physical Activity and Good Nutrition: Essential Elements to Prevent Chronic Diseases and Obesity 2005. CDC At A Glance, 2005, http://www.cdc.gov/nccdphp/aag/aag_dnpa.htm. Accessed June 15, 2006.

21. Zakarian, J. M., M. F. Hovell, C. R. Hofstetter, J. F. Sallis, K. J. Keating. Correlates of Vigorous Exercise in a Predominantly Low SES and Minority High School Population. *Preventive Medicine*, Vol. 23, 1994, pp. 314-321.

22. Aaron, D. J., K. L. Storti, R. J. Robertson, A. M. Kriska, and R. E. LaPorte. Longitudinal Study of the Number and Choice of Leisure Time Physical Activities from Mid to Late Adolescence. *Archives of Pediatric and Adolescent Medicine*, Vol. 156, 2002, pp. 1075-1080.

23. Sallis, J. F., J. E. Alcaraz, T. L. McKenzie, and M. F. Hovell. Predictors of Change in Children's Physical Activity Over 20 Months. *American Journal of Preventive Medicine*, Vol. 16, No. 3, 1999, pp. 222-228.

24. Sallis, J. F., J. J. Prochaska, and W. C. Taylor. A Review of Correlates of Physical Activity of Children and Adolescents. *Medicine and Science in Sports and Exercise*, Vol. 32, No. 5, 2000, pp. 963-975.

25. Janz, K. F., J. D. Dawson, and L. T. Mahoney. Tracking Physical Fitness and Physical Activity from Childhood to Adolescence: the Muscatine Study. *Medicine and Science in Sports and Exercise*, 1999, pp. 1250-1257.

26. Copperman, R., and C. R. Bhat. An Analysis of the Determinants of Children's Weekend Physical Activity Participation. Forthcoming, *Transportation*, 2006.

27. Gordon-Larsen, P., R. G. McMurray and B. M. Popkin. Determinants of Adolescent Physical Activity and Inactivity Patterns. *Pediatrics*, Vol. 105, No. 6, 2000, pp. e83.

28. Feldman, D. E., T. Barnett, I. Shrier, M. Rossigni, and L. Abenhaim. Is Physical Activity Differentially Associated with Different Types of Sedentary Pursuits? *Archives of Pediatric and Adolescent Medicine*, Vol. 157, 2003, pp. 797-802.

29. Anderson, R. E., C. J. Crespo, S. J. Bartlett, L. J. Cheskin, and M. Pratt. Relationship of Physical Activity and Television Watching with Body Weight and Level of Fatness Among Children. *Journal of the American Medical Association*, Vol. 279, No. 12, 1998, pp. 938-942.

30. Robinson T. N., L. D. Hammer, J. D. Killen, H. C. Kraemer, D. M. Wilson, C. Hayward and C. B. Taylor. Does Television Viewing Increase Obesity and Reduce Physical Activity? Crosssectional and Longitudinal Analyses Among Adolescent Girls. *Pediatrics*, Vol. 91, No. 2, 1993, pp. 273–280.

31. Durant R. H., T. Baranowski, M. Johnson, and W. O. Thompson. The Relationship Among Television Watching, Physical Activity, and Body Composition of Young Children. *Pediatrics*, Vol. 94, No. 4, 1994, pp. 449–455.

32. Vandewater, E. A., D. S. Bickham, and J. H. Lee. Time Well Spent? Relating Television Use to Children's Free Time Activities. *Pediatrics*, Vol. 117, No. 2, 2006, pp. 181-191.

33. Stefan, K. J. and J. D. Hunt. Age-Based Analysis of Children in Calgary, Canada. Presented at the 85th Annual Meeting of the Transportation Research Board, Washington, D.C., 2006.

34. McDonald, N. An Exploratory Analysis of Children's Travel Patterns. Forthcoming, *Transportation Research Record*, 2006.

35. Clifton, K. J. Independent Mobility Among Teenagers: An Exploration of Travel to After-School Activities. Presented at the 82nd Annual Meeting of the Transportation Research Board, Washington, D.C., 2003.

36. Bhat, C. R., and A. Lockwood. On Distinguishing Between Physically Active and Physically Passive Episodes and Between Travel and Activity Episodes: An Analysis of Weekend Recreational Participation in the San Francisco Bay Area. *Transportation Research Part A*, Vol. 38, No. 8, 2004, pp. 573-592.

37. Bryant, W. K., and C. D. Zick. Are We Investing Less in the Next Generation? Historical Trends in Time Spent Caring for Children. *Journal of Family and Economic Issues*, Vol. 17, 1996b, pp. 365–92.

38. Sayer, L. C., S. M. Bianchi, J. P. Robinson. Are Parents Investing Less Time with Children? Trends in Mothers' and Fathers' Time with Children. *American Journal of Sociology*, Vol. 110, No. 1, 2004, pp. 1-43.

39. Korenman, S., M. Liao, and J. O'Neill. Gender Differences in Time Use and Labor Market Outcomes. Presented at the American Time Use Survey (ATUS) Early Results Conference, 2005.

40. Yeung, W. J., J. F. Sandberg, P. E. Davis-Kean, and S. L. Hofferth. Children's Time With Fathers in Intact Families. *Journal of Marriage and the Family*, Vol. 63, No. 1, 2001, pp. 136-154.

41. Srinivasan, S., and C. R. Bhat. A Multiple Discrete-Continuous Model for Independent- and Joint- Discretionary-Activity Participation Decisions. *Transportation*, 2006 TRB Special Issue, Vol. 33, No. 5, 2006, pp. 497-515.

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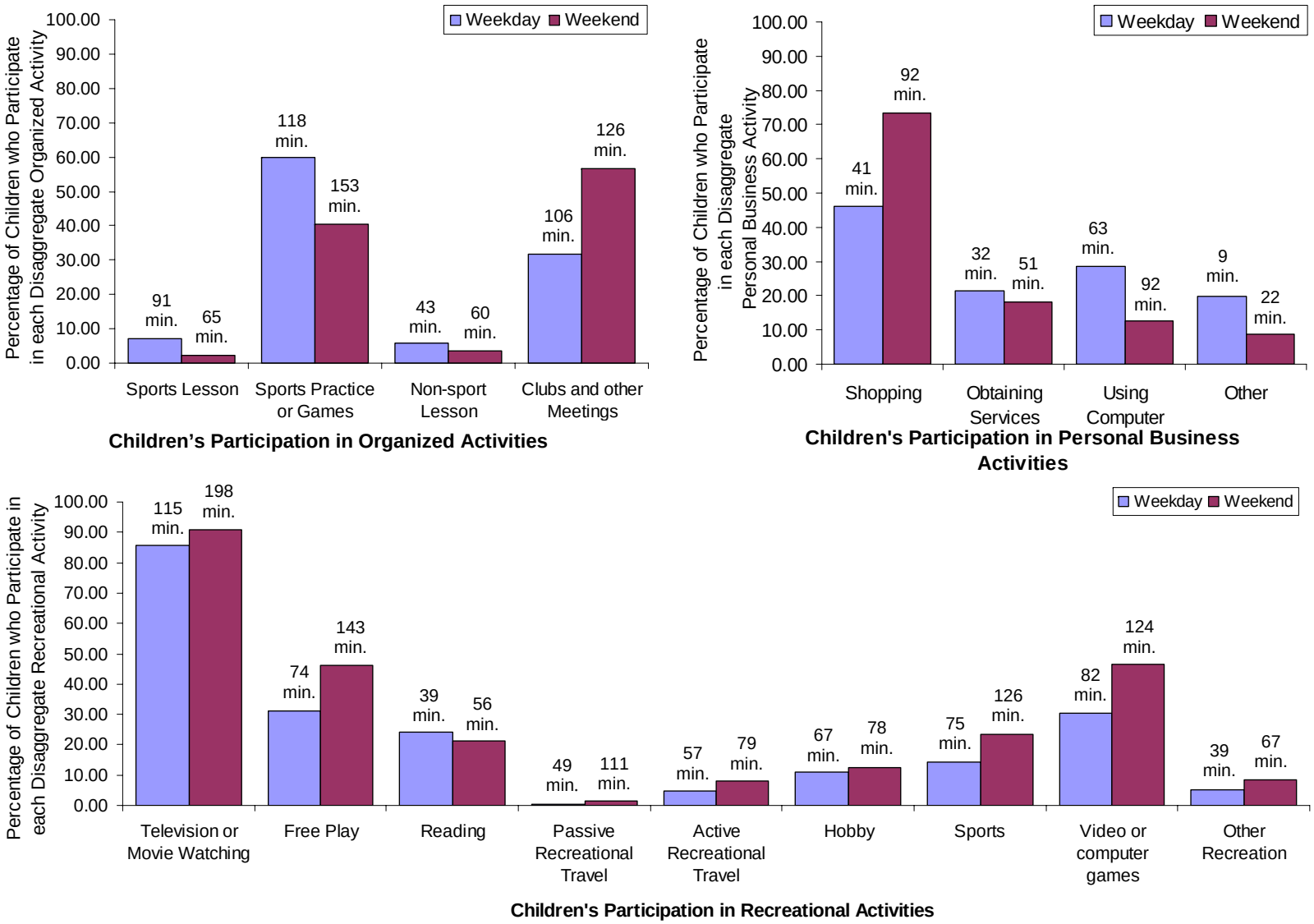

FIGURE 1 Children's participation in disaggregate organized activities, personal business, and recreational activity purposes.

TABLE 1 Weekday (Weekend) Activity Purpose Participation Percentages and Average Minutes of Total Daily Activity

	Total (N = 1970)		5 to 10 years (N = 874)		11 to 14 years (N = 617)		15 to 18 years (N = 479)	
	%	Minutes	%	Minutes*	%	Minutes	%	Minutes
School	86.8	407.0	89.8	399.3	86.1	420.7	82.3	403.7
	--	--	--	--	--	--	(0.6)	(311.7)
Work	3.2	256.7	--	--	--	--	12.5	265.9
	(3.3)	(352.3)	--	--	--	--	(12.3)	(363.8)
Meals	94.3	57.0	97.8	60.3	94.7	56.9	87.5	50.3
	(95.1)	(78.4)	(98.9)	(85.9)	(95.1)	(74.0)	(88.1)	(68.5)
Household Chores	40.2	46.8	38.7	40.2	44.4	51.8	37.6	51.5
	(51.6)	(76.6)	(52.2)	(65.5)	(55.4)	(82.7)	(45.5)	(91.5)
Organized Activities	15.3	107.5	11.2	85.4	16.0	105.8	21.9	129.9
	(14.3)	(136.9)	(13.3)	(118.1)	(13.9)	(140.5)	(16.5)	(163.1)
Studying	60.3	70.8	65.8	54.6	60.3	76.1	50.3	101.5
	(16.4)	(94.1)	(12.1)	(66.0)	(18.2)	(100.5)	(22.1)	(116.7)
Recreation	94.5	217.1	97.9	204.3	95.6	228.2	86.8	227.7
	(97.9)	(384.9)	(99.5)	(104.4)	(98.9)	(395.7)	(93.7)	(331.9)
Social	37.5	72.6	28.4	51.7	37.6	67.1	53.9	97.6
	(60.1)	(139.9)	(53.7)	(133.8)	(59.5)	(135.9)	(72.4)	(152.7)
Personal Business	23.2	50.8	20.6	37.8	22.9	54.2	28.6	64.5
	(41.2)	(90.2)	(38.7)	(80.2)	(41.8)	(100.8)	(44.9)	(94.3)
Personal Care	98.9	64.4	99.3	65.5	98.7	61.3	98.5	66.4
	(96.1)	(65.4)	(98.1)	(64.8)	(92.9)	(62.5)	(96.7)	(68.6)
Receive Child Care	7.0	117.5	12.9	123.2	3.6	96.0	--	--
	(2.2)	(66.1)	(3.7)	(56.7)	(1.1)	(68.6)	--	--

TABLE 2 Percentages of In-Home and Out-of-Home Activity Purpose Episodes

Activity Purpose	Day of Week	Percent. In-Home	Percent. Out-of-Home	Out-of-home Activity Locations
Work	Weekday	1.8	98.2	--
	Weekend	8.9	91.1	
Meals	Weekday	89.6	10.4	School (36.3%); Someone Else's Home (29.7%); Restaurant (25.3%)
	Weekend	76.9	23.1	Someone Else's Home (43.6%); Restaurant (43.4%)
Household Chores	Weekday	95.6	4.4	--
	Weekend	88.8	11.2	
Organized Activities	Weekday	0.0	100.0	School (59.1%); Non-retail Bus. (18.7%); Church (13.3%)
	Weekend	1.8	98.2	Church (43.5%); Non-Retail Bus. (23.5%); School (17.1%)
Studying	Weekday	90.4	9.6	Someone Else's Home (36.2%); School (31.2%); Non-Retail Bus. (19.2%)
	Weekend	89.7	10.3	School (35.6%); Someone Else's Home (28.9%); Non-Retail Bus. (22.2%)
Recreation	Weekday	88.5	11.5	Someone Else's Home (50.1%); Non-Retail Business (15.6%); School (13.9%)
	Weekend	79.4	20.6	Someone Else's Home (62.5%); Outdoor Rec. Area (15.5%); Non-Retail Bus. (12.46%)
Social	Weekday	71.2	28.8	Someone Else's Home (42.8%); School (23.5%); Church (15.1%)
	Weekend	48.0	52.0	Someone Else's Home (45.1%); Church (42.6%); Non-Retail Bus. (4.8%)
Personal Business	Weekday	31.7	68.3	Store (67.4%); Restaurant (11.4%); Other (10.3%)
	Weekend	13.2	86.8	Store (83.9%); Restaurant (5.6%); Other (4.9%)
Personal Care	Weekday	97.8	2.2	--
	Weekend	92.4	7.6	
Receive Child Care	Weekday	10.8	89.2	School (45.0%); Non-Retail Bus. (37.9%); Someone Else's Home (15.38%)
	Weekend	66.7	33.3	Someone Else's Home (75.0%); School (12.5%); Non-Retail Bus. (6.25%)

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TABLE 3 Percentages of each Companion Type Arrangement for Out-of-home Activity Episodes

Activity Purpose	Day of Week	Companion type arrangement (%)									
		No one else (alone)	Only mother	Only father	Only sibling(s)	Immed. family combin.	Only extended family	All other family combin.	Only child's friend(s)	Only non-relatives	Other combin.
Meals	Weekday	10.2	5.5	1.7	4.1	12.8	5.2	9.6	14.0	22.4	14.5
	Weekend	5.3	4.1	3.1	2.3	26.3	8.8	21.0	12.1	3.6	13.4
Lessons/ Meetings/ Clubs	Weekday	0.0	2.7	0.7	0.0	2.0	0.0	0.0	6.7	64.3	23.6
	Weekend	2.7	1.3	1.9	3.7	5.6	0.0	1.9	7.5	52.3	23.2
Study/ Class	Weekday	27.0	6.4	1.4	4.3	2.1	3.5	1.4	7.8	32.6	13.5
	Weekend	22.2	2.2	6.7	2.2	8.9	4.4	0.0	13.3	33.3	6.7
Recreation	Weekday	11.8	2.1	0.9	8.4	5.7	9.6	5.0	27.4	13.9	15.3
	Weekend	10.6	1.4	2.6	7.9	7.7	12.2	9.5	29.2	5.1	13.8
Social	Weekday	1.8	4.6	5.6	2.5	7.0	6.0	5.3	36.1	13.3	17.9
	Weekend	3.9	4.3	1.4	2.1	19.3	6.4	14.9	18.4	10.3	19.0
Personal Business	Weekday	6.7	23.0	4.3	6.4	24.1	8.5	3.2	8.2	5.3	10.3
	Weekend	6.3	21.4	6.5	3.9	31.0	2.2	11.2	8.1	2.6	6.9

TABLE 4 Chaining of Activity Episodes by Purpose and Location

Purpose	Weekday	Weekend	Location	Weekday	Weekend
Overall	0.41	0.43	Overall	0.26	0.66
School	0.48	0.38	Parent's work location	0.86	0.78
Work	0.52	0.40	Child's work location	0.57	0.27
Meals	0.93	0.91	Someone else's home	0.65	0.48
Household Chores	0.77	0.80	Restaurant	0.70	0.82
Organized Activities	0.65	0.58	Outdoor recreational area	0.55	0.52
Studying	0.88	0.60	School	0.25	0.34
Recreation	0.62	0.62	Church	0.29	0.39
Social	0.70	0.58	Store/Retail business	0.68	0.55
Personal Business	0.67	0.56	Non-retail business	0.62	0.51
Personal Care	1.00	0.99	Other	0.75	0.67
Receive Child Care	0.96	0.79			