electronic ***International Journal of Time Use Research***
2012, Vol. 9, No. 1, 28-58 ***dx.doi.org/10.13085/eIJTUR.9.1.28-58***

The time cost of access to food – Distance to the grocery store as measured in minutes

Karen S. Hamrick and David Hopkins

Dr. Karen S. Hamrick
Economic Research Service,
U.S. Department of Agriculture
1400 Independence Avenue, SW, Mail Stop 1800
Washington, DC 20250-1800, United States
e-mail: Khamrick@ers.usda.gov

Emerit David Hopkins
retired, USDA Economic Research Service
e-mail: DHopkins05@gmail.com

Abstract

Time use diaries are rich in information, including where and when respondents travel from place to place. Travel estimates, as well as variety of contextual information on travel, can be generated from time use data. However, using the data for travel analysis is difficult and involves detailed understanding of how the data are coded. Presented here is a methodology for estimating travel time using the time diaries from the 2003-07 American Time Use Survey. As an illustration of the methodology, the authors estimate travel time to grocery shopping. These estimates are of interest as a policy concern in the United States is whether or not some poor areas of the country have access to supermarkets that offer the variety of foods needed for a healthy diet, and in particular, fresh fruits and vegetables. Neighborhoods that have limited access to supermarkets are referred to as "food deserts." The authors found that individuals living in low-income areas with limited supermarket access spend significantly more time (an average of 19.5 minutes) traveling to grocery shopping than the national average (15 minutes), and in addition, they grocery shop less frequently, and they are more likely to be accompanied by children during travel to grocery shopping.

JEL-Codes: C81, R41, I30

Keywords: Time use, grocery shopping, food desert, trip chaining, transportation, food access, travel time

Disclaimer: The views expressed here are those of the authors and are not necessarily those of the Economic Research Service or the U.S. Department of Agriculture.

Acknowledgements: The authors are grateful for cooperation from Rachel Krantz-Kent and Curtis Polen at Bureau of Labor Statistics and Howard McGowan and Stella Kim of the U.S. Census Bureau for this project. The authors are also appreciative of helpful comments from Mary Dorinda Allard, Tracey Farrigan, Rachel Krantz-Kent, and anonymous referees.

1 Introduction

Low-income persons may have limited access to nutritious food, and as a consequence, have poor diets which may lead to obesity and diet-related diseases. This issue of "food deserts," neighborhoods that do not have access to supermarkets, received attention in the United States Congress, and the Food, Conservation, and Energy Act of 2008 directed the U.S. Department of Agriculture to conduct a study to assess the extent of areas with limited access to nutritious, affordable food. The resulting report was released in June 2009, *Access to Affordable and Nutritious Food: Measuring and Understanding Food Deserts and Their Consequences, Report to Congress* (Ver Ploeg, et al., 2009).

An aspect of the report's analysis was identifying the time cost of access to food, that is, measuring the travel time to grocery shopping. Measuring travel time can be a complex task as individuals frequently make stops on the way to their main destination, and so creating definitional rules on what to include across a population can be difficult. Time use diaries are rich in information, including travel from place to place, however using the data for analyzing travel can be difficult. Despite the difficulties, time use data is a rich source of information, not only on travel time, but also contextual information that can inform a policy issue such as food deserts.

Our original research goal was to identify and measure travel time to grocery shopping looking at different levels of supermarket access and at different levels of individual and neighborhood income. Here we focus on presenting the detail and methodology used for identifying and measuring travel time. The contribution of this research is the methodology used to measure travel time by using time diary data, specifically, the American Time Use Survey (ATUS) data, to study transportation issues. Also, we present extensive estimates and findings for our application, travel time to grocery shopping, to illustrate the insight gained from using time use data.

2 Background

In identifying and measuring travel time to grocery shopping, we built on concepts from several fields. We drew from the travel/transportation literature in order to understand how individuals transport themselves from place to place, and how transportation analysts identify and measure trips and trip distances. We considered the time use literature and in addition, the research area of food access, which is a spatial concept. These are all research areas that have long histories and extensive bodies of literature. Here we focus only on the concepts that are relevant to our research on travel time to grocery shopping.

2.1 Transportation

Travel data is collected and analyzed in order to understand individuals' travel behavior for a variety of policy, program, and marketing purposes, such as determining whether travel infrastructure capacity is sufficient, managing travel demand, determining whether individuals' travel is more- or less-energy efficient over time, and determining optimal locations for retail establishments. The transportation literature has well-defined concepts. Relevant here are the concepts of: anchor, direct trip, trip chain, intervening stop, and tour. Quoting from McGuckin and Nakamoto (2004, no page number):

1. *Anchor: A primary or substantial trip destination.*
2. *Direct trip: A trip that travels directly between two anchor destinations, such as a trip from home to work.*
3. *Chain: A series of short trips linked together between anchor destinations, such as a trip that leaves home, stops to drop a passenger, stops for coffee and continues to work.*
4. *Intervening stop: The stops associated with chained trips.*
5. *Tour: Total travel between two anchor destinations….Note that it is possible to have the two anchor destinations be the same location, as in a home-to-home or work-to-work tour*.

Anchors are typically defined as home and work. Because individuals may make stops during their travel between anchors, an extensive literature on "trip chains" has developed.[1] An example of a trip chain would be: Travel from home to school (drop off child), travel from school to café (buy coffee), then travel to workplace. The anchors are home and work, and when the individual arrives at the workplace, the tour is completed, but only after other destinations have been visited. An additional concept is that of *dwell time*, the length of time spent at a destination. A trip chain can be defined as ending if the individual spends more than a certain amount of time at a stop, which would indicate that the stop is not an intervening stop but a destination.

The above is the *trip-based* approach to analyzing travel. Another approach is the *activity-based* approach of modeling travel behavior. The activity-based approach "views travel as a derived demand; derived from the need to pursue activities distributed in space." (Bhat and Koppelman, 2003). Travel is not demanded for itself, but for the ability to fulfill an individual's demand for consumer products, or to enable an individual to commute to work.[2] This approach looks at the individual's participation in specific activities. As a result, the activity-

[1] McGuckin and Nakamoto (2004) and Strathman and Dueker (1995) are excellent introductions to trip chaining concepts. See Anas (2007) for a discussion of consumption and trip chaining.

[2] The literature on travel demand models is extensive. Cascetta (2009) has a thorough overview of the types of travel demand models, and Sheppard (1980) presents travel demand theory including the spatial issues involved in the individual's decision of whether to travel. Travel is a spatial activity, and research investigating the spatial aspect include Lin and Long (2008), who discuss the concept of neighborhood and neighborhood type and how the neighborhood built environment affects travel behavior.

based approach uses time-use data to analyze the individual's entire day of activities, and the substitution of in-home for out-of-home activities, and vice versa. This approach focuses on sequences of activities and travel. It might appear that the activity-based approach would be relevant to the question of food deserts, however we are not modeling whether or not an individual goes grocery shopping, but instead measuring their travel time. Consequently, we follow the trip-based approach in our analysis.

2.2 Time use and travel

Although there are several data sources and many studies on time spent in travel, relatively little has been done using time diary data, that is, time use data that includes a respondent's entire day and not just travel time. The transportation literature refers to *time use data*, although for most surveys the respondents are asked to report only the travel and travel-related activities, not their entire day. Full-day diary surveys are sometimes referred to in the transportation literature as *activity diary surveys* (Mokhtarian and Chen, 2004). Pas and Harvey (1997) asserted that travel-behavior researchers could benefit from time use research, and that time use data is a "potentially rich, untapped resource" (p. 331) for transportation analysis. Kitamura, Fujii, and Pas (1997) identified that full-day diary surveys could be useful for transportation planning and called for more time use data collection and research. Harvey and Taylor (2000) used national time use data from Canada, Norway, and Sweden to study social context and travel behavior. They concluded that individuals with low social interaction tend to travel more.

Recent methodology and research literature analyzing travel with full-day time diary data is sparse, and some key works are unpublished. Allard (2009) discusses how to use the American Time Use Survey data to estimate travel times. Included is detail on the ATUS coding rules. Understanding how the data are coded is necessary in order to correctly define and measure a type of travel such as commuting. Brown and Borisova (2006), using 2003-04 ATUS data, also discuss how the ATUS can be used to measure commuting time and travel time to grocery shopping. Bose (2006) discusses technical detail for using the ATUS for travel estimates. Bose and Sharp (2005) compare trip estimates using the National Household Travel Survey and the ATUS. Much of their paper is devoted to coding and other technical issues. They conclude that while the ATUS does not provide the transportation detail needed by transportation modelers and planners, the ATUS allows for research on the relationship between travel and other activities. In all of these papers, the importance of understanding the data coding detail is stressed. If the coding definitions and coding rules are not understood, the research will not be capturing the desired travel time.

Christian (2012) used the ATUS to analyze commuting time and health-related activities. For his research question, he summed all travel time from home to work and from work to home, regardless of the coded purpose of the travel in order to measure total time commuting. He

concluded that longer commutes are associated with declines in health-related activities, and in particular, sleep time.

George and McCurdy (2009) also discuss ATUS travel time coding as part of determining where individuals are during the course of the day. Their research is on modeling human exposures to environmental pollutants, and identifying where activities take place is necessary for their analysis. They used the 2003-07 ATUS data to analyze work-related travel and discussed coding difficulties that they described as "inconsistent treatment of trips to and from work and during the work period" (p. 101). They also concluded that the missing location codes for personal care activities needs to be addressed with imputation.

Srinivasan and Bhat (2008) used the 2003-04 ATUS to look at travel to study "joint activities," that is, activities where the respondent was accompanied by another person, in order to analyze activity duration and location. They found that joint activities are typically of longer durations, and travel related to these activities may involve pick-up and drop-off of the activity companions.

Spissu, et al., (2009) used Swiss time use data to identify and model discretionary activities and the accompanying travel. Their unique multi-week data allowed for analysis of inter-person variation that is especially important for activities that are not usually done daily. However, multi-week time use data is not available for the United States, and so here their research serves mainly to understand the limits of analysis with single-day diaries.

Millward and Spinney (2011) used the Halifax Space-Time Activity Research data that includes both time diaries and Global Positioning System (GPS) tracking of travel to analyze travel across the rural-urban continuum. They conclude that analyzing travel using the urban-rural dichotomy is insufficient, and more detail on the rural-urban continuum is needed to understand time use and travel behavior. The authors utilize an exceptionally detailed dataset that tracked respondents' locations on their diary days.

2.3 Food desert/access to nutritious food

A policy concern is that individuals in some neighborhoods do not have access to supermarkets, and as a consequence, do not have access to affordable and nutritious food. These "food deserts," or low-access areas, are of particular concern if the residents are low income as their options for getting to the supermarket may be limited, and they may have poor diets which could lead to obesity and diet-related diseases. Although the concept of a food desert is relatively recent,[3] there has been considerable research on the topic in the last few years. The U.S.

[3] Cummins and Macintyre (2002) state: "The term 'food desert' was reputedly first used by a resident of a public sector housing scheme in the west of Scotland in the early 1990s. It first appeared in a government publication in a 1995 document from a policy working group of the Low Income Project Team of the then Conservative government's Nutrition Task Force." (Beaumont, J., T. Lang, S. Leather, C. Mucklow. *Report from the policy sub-group to the Nutrition Task Force Low Income Project Team of the Department of Health.* Radlett, Hertfordshire: Institute of Grocery Distribution, 1995.)

Department of Agriculture report to Congress (Ver Ploeg, et al., 2009) contains new research as well as extensive synthesis of previous research, and so provides a good overview of food desert literature. Another good overview is in Jiao, et al., (2012), which focuses on identifying and defining food deserts. For an international overview, Beaulac, et al., (2009) authored a synthesis of the literature on food deserts that includes research on the United States as well as other developed countries.

A focal point of food desert research is to look at neighborhoods by income levels and other demographic characteristics. Morland, et al., (2002) focused on (U.S.) Mississippi, North Carolina, Maryland, and Minnesota, and looked at the wide array of retail venues that sell food and at several measures of neighborhood wealth. They concluded that poor and minority neighborhoods have less access to healthy foods. Morris, Neuhauser, and Campbell (1992) did a relatively early study looking at (U.S.) rural persistent-poverty counties and access to supermarkets and the cost of the Thrifty Food Plan marketbasket relative to food stamp benefit allotments. They concluded "... that in persistently poor rural American, low income households, including those receiving food stamps, are at an increased risk of food insecurity" (p. 56S).

Much of the food desert/supermarket access literature looks in depth at one city or a region. An example is Zenk, et al., (2005) who studied Detroit, Michigan (U.S.) by analyzing the demographics of census tracts and their access to supermarkets, and concluded that impoverished African American neighborhoods had, on average, a longer distance to the nearest supermarket than impoverished White neighborhoods. However, they acknowledge that a missing aspect of their analysis is travel time and they stated "travel time may be a more informative indicator of accessibility than physical distance" (p. 664). Another example is Apparicio, Cloutier, and Stearmur (2007), who studied Montrél's (Canada) neighborhoods as to their access to healthy foods. They developed three measures of accessibility to supermarkets using different geographic distance definitions. They concluded that it is important to use more than one indicator for identifying food deserts, and different indicators measure different dimensions of food deserts.

Rose and Richards (2004) state that the "time issue is important" (p. 1082) in looking at access, and developed a measure that combined where groceries were purchased (supermarket or smaller store), travel time (self-reported), and car ownership using the National Food Stamp Program Survey data. Their data were nationally representative, and they concluded that easy access to supermarkets was associated with higher household fruit consumption.

Time-use data is well-suited to analyzing the "time distance" to grocery shopping. Indeed, "travel time is the true indicator of access, for which distance attempts to account." (The Reinvestment Fund, 2012, p. 14). Some researchers estimate travel time from the geographical

physical distance to the supermarket[4] and some studies survey individuals on time spent in all travel or just on grocery-related travel.[5] However, in addition to providing an alternate measure to the geographical physical distance to a grocery store—which may not fully capture the time cost of travel to grocery shopping in a congested, urban area—time-use data also provide information about how individuals fit grocery shopping into their lives. Looking at the time use patterns of individuals who grocery shop, along with contextual information such as their mode of transportation and whom they were with, allows for a better understanding of the ease or the difficulty of the shopping trip. For our application, food deserts, time distance to grocery shopping provided an additional indicator for measuring a complex policy problem.

3 Methodology and data

We used a typology developed by our colleagues to define low-, medium-, and high-supermarket access by census tract.[6] High access is within 0.5 mile of a supermarket, medium access is 0.5 to 1.0 mile, and low access is more than 1 mile. In addition to identifying level of access, the typology also includes indicators for low-income census tracts, tracts where 40 percent or more of the population live in households with income less than 200 percent of the poverty threshold.[7]

For estimates of average time spent in travel to grocery shopping, we used the pooled 2003-2007 American Time Use Survey (ATUS) data.[8] The Bureau of Labor Statistics' ATUS is a continuous survey that began in 2003, collecting time use data nearly every day of the year,

---

4 Charreire, et al., (2010) reviewed geographic information systems (GIS) methods used to define the food environment. The studies they reviewed used Euclidean distance, Manhattan distance, or network distance to proxy for travel time.

5 Rose and Richards (2004), and Jilcott, et al., (2011). Both of these studies looked at Supplemental Nutrition Assistance Program (SNAP) recipients only.

6 The 2000 Census tract boundaries were used. Census tracts are small, statistical subdivisions of a county, with optimally 4,000 residents/tract. There are 65,443 census tracts in the United States. See http://www.census.gov/geo/www/reference.html for more info.

7 Our colleagues Vince Breneman, Phil Kaufman, and Tracy Farrigan developed this typology. Their goal was to develop area measures of access at the census tract level. They used a list of stores authorized to access Food Stamp Program/Supplemental Nutrition Assistance Program benefits, and a proprietary listing of supermarkets (from Nielsen company) to identify supermarkets, which are stores with sales of at least $2 million a year, and contain all major food departments (including fresh meat and poultry, produce, dairy, dry and packaged foods, and frozen foods), and put these supermarkets in a GIS (geographical information systems) format. They measured the distance to the nearest supermarket using the Socioeconomic Data and Applications Center grids data at the 1-square-kilometer grid level for spatial computation of distance to supermarket, calculated from the geographic center of the grid. Low-income areas were identified as grids with 40 percent of more of the residents in households with income less than 200 percent of the poverty threshold. Grids were summed up to the census tract level for the typology. More detail on the methodology of the typology is in Ver Ploeg, et al., (2009) chapter 2 and appendix C.

8 We used the U.S. Department of Labor Bureau of Labor Statistics ATUS User's Guide: Understanding ATUS 2003 to 2009 (2010), the American Time Use Survey Coding Rules (2010), American Time Use Survey Activity Coding Lexicons (various years), and the Current Population Survey: Design and Methodology (2006).

with U.S. Census Bureau conducting the interviews. One individual age 15 or older from each sampled household is interviewed about his or her activities for the 24-hour period from 4 a.m. the day before the interview to 4 a.m. on the interview day. Survey respondents are asked to identify their primary activity if they were engaged in more than one activity at a time. They are also asked to report where they were and whom they were with for most diary activities. The ATUS also includes demographic, labor force participation, and household information, along with a limited amount of geographical information.

If the respondent reports travel from place to place, moving from one address to another, they are asked to report their mode of transportation. As a consequence, the ATUS time diary data contains extensive information about Americans' travel. The data specify travel as an activity, and record mode of transportation and whom the respondent was with when traveling. If the travel was by vehicle, the data include whether the respondent was the driver or passenger.

The pooled 2003-2007 ATUS microdata files contain 72,922 completed interviews. Of those, 11,726 observations, 16 percent, are of respondents age 15 or older who grocery shopped on their diary day. The ATUS Respondent, Roster, Activity, Activity Summary, Who, ATUS-Current Population Survey, and Replicate Weights files were used for our research. In addition, because of Census Bureau's cooperation, we were able to use the confidential respondent location data in order to determine respondent's census tract.

Grocery shopping is defined in the ATUS as activity 070101, and we restricted grocery shopping to the locations of grocery store, restaurant or bar, other store/mall, outdoors away from home, or other place.[9] Grocery shopping done at other locations was not included so as to exclude online grocery shopping.[10] A limitation is that we do not know where the grocery shopping was done, that is, if it was the closest retail venue to the respondent's home or not. We also do not know if it is the preferred grocery shopping venue. We just know that it is the one that the respondent shopped at on his/her diary day.

We use the description *travel to grocery shopping* as it is precise in what we are measuring, however for ease of exposition, we also use the phrase *travel to grocery store*, although grocery shopping can be done at other places and our research is not restricted only to grocery shopping done at grocery stores. Likewise, we use *grocery store* or *supermarket* instead of *grocery shopping location*.

To deal with the complexities of trip chaining, ATUS generally codes the purpose of a travel activity based on the activity that follows the travel episode and its location. For example, if a respondent travels directly from home to his/her workplace, and starts working immediately

[9] ATUS activity code 070101 and TEWHERE = 4, 6, 7, 9, 11.

[10] TEWHERE = 1, 2, 5, 10. If the location of grocery shopping was miscoded as a mode of transportation, we recoded the location as "Unspecified place," and if the mode of transportation was miscoded as a location, we recoded the mode as "Unspecified mode of transportation." TEWHERE=89 for Unspecified place, TEWHERE=99 for Unspecified mode of transportation.

upon arrival, then the travel episode is coded as 180501, Travel related to working.[11] If the respondent went grocery shopping after work, the time spent traveling from the workplace to the store is coded as ATUS activity 180701, Travel related to grocery shopping. The exception to the "looking ahead" rule is when the respondent is traveling home, in which case the purpose of the travel is coded based on the activity that preceded it. For example, if someone grocery shops and then travels home, the travel episode would be coded as activity 180701, Travel related to grocery shopping. As a result, calculating travel time to the grocery store using the ATUS activity codes is complicated by the fact that some diaries will have only one "side" of travel related to grocery shopping coded as travel related to grocery shopping and others will have both sides—the going and coming home—of the trip coded as travel related to grocery shopping. As a result, just averaging the durations of all the occurrences of activity 180701 would not necessarily provide the travel time to grocery shopping.

To account for trip chaining travel behaviors and ATUS travel coding, we estimated average time to the grocery store as follows. For each time diary with grocery shopping as an activity in the respondent's time diary, we added up the times associated with all legs of travel from home to the place where the respondent reported grocery shopping, that is, all activities coded 18xxxx Traveling. We also added the time associated with all the legs of travel from the time the respondent reported grocery shopping until the respondent arrived home. We then compared the total travel time home-to-shopping to the total travel time shopping-to-home, and chose the shorter total time as the "time distance" to grocery shopping. In doing this we did not have to consider the coded purpose of the travel, which may be misleading, and we also did not have to consider the dwell time, the time spent on an activity between two travel occurrences. All the characteristics of travel associated with grocery shopping that we analyzed, such as the mode of transportation, were associated with the shorter duration travel side. In cases where the respondent did not start the day at home or did not end the day at home, we only had information for one side (home to grocery shopping or grocery shopping to home). In these cases we used the total travel time for that side as the time distance to the grocery shopping. See Appendix on Detailed Coding Rules for more information.

This streamlined method of identifying travel associated with grocery shopping is simpler than measures of trip time that put limits on travel legs and on dwell time, and it also avoids mis-identifying travel due to the data coding specifics. Because home is usually the ultimate destination of the individual, and so is also the destination of groceries, our method is conceptually consistent with the purpose of the trip. Our method is similar to Christian (2012), who summed all travel times from home to work and work to home, however we compare the to-grocery-shopping and from-grocery-shopping times to use the shortest of the travel times.

For most grocery shoppers in the ATUS data, the shortest travel time was between grocery shopping and home, however for 6.4 percent of the grocery shoppers in the ATUS data, the shortest time distance was from work. We decided that the work location is a relevant means

[11] ATUS coding lexicons are available at: http://stats.bls.gov/tus/lexicons.htm

of access to grocery shopping, so for these respondents we used their work-to-store or store-to-work travel time.[12] Consequently, the average time estimates we present use two anchors, home and work.

As discussed above, we did not consider dwell times or limit trip chains to a number of trip legs, as we wanted to measure travel time to grocery shopping as individuals fit it into their lives. This is unlike some of the travel literature that strives to measure the shortest commuting time without stops between home and workplace. Because of our concern about capturing the complexity of individuals' lives, and in particular, low-income individuals, measuring travel time and travel patterns as reported on the diary day was important to our analysis. A diary with an example of a Home to Grocery Shopping to Home travel tour is in table 1. A diary with an example of Home to Work to Grocery Shopping to Home travel tour is in table 2.

Estimation procedures outlined in the *ATUS User's Guide* (Bureau of Labor Statistics, 2010) were followed. All estimates presented were weighted to be nationally representative. Averages were calculated as the mean. Standard errors were calculated according to Section 7.5 of the *ATUS User's Guide*, using the balanced repeated replication method and the ATUS Replicate Weights file. A 90-percent level of confidence was used to determine whether estimates were statistically different. All differences between estimates discussed in the text are statistically different at the 90 percent level. We followed the BLS standard at the time to suppress estimates for cells with unweighted counts fewer than 60. Estimates were done in SAS 9.2 and Perl 5.6.1.

[12] When we started our research we looked at potential anchors for grocery shopping. The location that was "nearest" grocery shopping in the time diaries was the individual's home (91 percent of grocery shoppers), the location that occurred second "nearest" was workplace (8 percent), the third "nearest" was place of worship (0.5 percent), and fourth was school (0.2 percent). After that the other locations had just a tiny smattering of the share of occurrences that were "nearest." We started with the two anchors home and workplace. We tried adding the third anchor, place of worship, but the programming complexity increased tremendously with three anchors, and we ultimately made the decision to stay with the two anchors home and work.

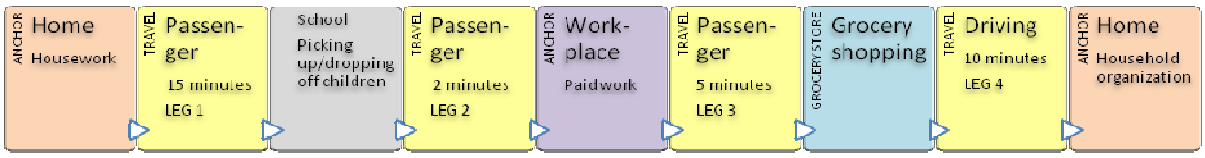
Table 1
Example of home to grocery shopping to home travel

Activity	Start time	End time	Activity	Activity description	Location	Travel time	Total time
1	04:00:00	08:00:00	010101	Sleeping	Not asked		
2	08:00:00	10:00:00	020101	Housework--interior cleaning	Home	ANCHOR	
3	10:00:00	10:20:00	180704	Travel	Driving vehicle	20	
4	10:20:00	13:20:00	070104	Shopping (not grocery, food, gas)	Other store/mall		
5	13:20:00	13:35:00	180901	Travel	Driving vehicle	15	
6	13:35:00	13:45:00	090103	Using clothing repair, cleaning services	Store/mall (not grocery, food, gas)		
7	13:45:00	13:50:00	180701	Travel	Driving vehicle	5	40
8	13:50:00	14:35:00	070101	Grocery shopping	Grocery store		
9	14:35:00	14:45:00	180701	Travel	Driving vehicle	10	10
10	14:45:00	15:45:00	020902	HH organization and planning	Home	ANCHOR	
11	15:45:00	16:00:00	180704	Travel	Driving vehicle	15	
12	16:00:00	16:30:00	070104	Shopping (not grocery, food, gas)	Store/mall (not grocery, food, gas)		
13	16:30:00	16:45:00	180704	Travel	Driving vehicle	15	
14	16:45:00	17:00:00	020902	HH organization and planning	Home		
…	…	…		…			
23	21:40:00	08:00:00	010101	Sleeping	Not asked		

Travel time to grocery shopping = min [LEG 1 + LEG 2 + LEG 3, LEG 4] = min [40, 10] = 10 minutes.
Source: American Time Use Survey (ATUS) 2003-2007, own calculations and illustration.

Table 2
Example of home to work to grocery shopping to home travel

Activity	Start time	End time	Activity	Activity de-scription	Location	Travel time	Total time
1	04:00:00	04:45:00	010101	Sleeping	Not asked		
2	04:45:00	05:15:00	010201	Grooming	Not asked		
3	05:15:00	06:15:00	020201	Food preparation	Home		
4	06:15:00	07:00:00	030101	Physical care for hh children	Home	ANCHOR	
5	07:00:00	07:15:00	180301	Travel	Passenger in vehicle	15	
6	07:15:00	07:20:00	030112	Picking up/dropping off hh children	School		
7	07:20:00	07:22:00	180501	Travel	Passenger in vehicle	2	17
8	07:22:00	11:30:00	050101	Paid work	Workplace	ANCHOR	RESET
9	11:30:00	12:30:00	110101	Eating & drink-ing	Workplace		
10	12:30:00	16:30:00	050101	Paid work	Workplace		
11	16:30:00	16:35:00	180701	Travel	Passenger in vehicle	5	5
12	16:35:00	17:20:00	070101	Grocery shop-ping	Grocery store		
13	17:20:00	17:30:00	180701	Travel	Home	10	10
14	17:30:00	17:45:00	020102	Laundry	Home	ANCHOR	
…	…	…		…			
22	23:00:00	04:30:00	010101	Sleeping	Not asked		



Travel time to grocery shopping = min [LEG 3, LEG 4] = min [5, 10] = 5 minutes.
Source: American Time Use Survey (ATUS) 2003-2007, own calculations and illustration.

4 Access-area estimates

In considering food deserts—low access to affordable, nutritious food—the interest is in low-income individuals and low-income areas. An affluent neighborhood may have zoning restrictions that allow only residential uses of land within a neighborhood or subdivision and so may not contain any retail establishments, and may be categorized as low access according to the typology above. However, affluent households would have the means to travel to grocery shopping. Our focus is on vulnerable subpopulations that may have barriers to access. We define low-income individuals as those living in a household with household income less than or equal to 200 percent of the Federal poverty thresholds according to household size. Low-income areas were defined as census tracts that had more than 40 percent of the residents living in households with income at or below 200 percent of the Federal poverty thresholds.

In order to apply these definitions and access typology (low-, medium-, and high-supermarket access) to the ATUS data, we needed to know the location of the ATUS respondents. The respondent's address and detailed geographical information is suppressed on the ATUS public use files to protect the confidentiality of survey respondents. These data only are available to staff of the U.S. Census Bureau with a need to know this information. As a result, we could do analysis by access level only with Census Bureau cooperation. Because the original project was a Congressionally-mandated study, the Bureau of Labor Statistics and the U.S. Census Bureau collaborated with the U.S. Department of Agriculture to produce the needed estimates. Since the data were restricted to Census Bureau staff, they compiled all estimates.

Using the access typology and definitions above that were defined by census tract, Census identified the access level of the ATUS respondents who grocery shopped on their diary day, and also whether or not they were in a low-income census tract. Of the 11,569 respondents over 2003-07 who grocery shopped on their diary day, 8,305 were able to be assigned an access level. Not all respondents could be assigned an access level for two reasons. First, ERS was not able to assign a level for some census tracts, typically those in Indian Reservations or tracts dominated by National Parks. Second, because of Census Bureau's sample framing method for the Current Population Survey and the American Time Use Survey, sample frames of residents in newly-built housing do not contain detailed geographical information, and specifically census tract information, and so they could not be matched. As a consequence, access-level analysis could be done on 72 percent of the ATUS respondents who grocery shopped.

The ability to utilize the respondents' location information is crucial to this food desert analysis, and allows us to identify whether a supermarket is located near the respondent's residence. However, we do not know where the respondent grocery shopped and we do not know whether the respondent grocery shopped at the closest supermarket. Respondents may selectively shop further from their neighborhood because of price, availability, or preference factors. As a consequence, our estimates may be over-estimates of travel time to the closest su-

permarket. Having stated this, the benefit of analyzing the time diary is that we are measuring what the individual actually did, and how he/she fit grocery shopping into his/her life. Our estimates are, when weighted with the ATUS sample weights, nationally representative estimates of grocery shopping behavior on an average day over 2003-07.

4.1 Travel time by access level

Table 3 shows the average time spent in travel to grocery shopping on an average day by level of access to the nearest supermarket. The table shows the average minutes spent traveling to grocery stores for shoppers who lived in low-income areas with low, medium, and high access to supermarkets. These averages are compared with the national average. Overall, the national average of time spent traveling, one-way, to the grocery store was 15 minutes, and about 14 percent of the population traveled to the grocery store on an average day.

Time spent traveling to the grocery store was greater in low-income areas with low-access. The average time spent traveling to the grocery store for those who lived in these areas, 19.5 minutes, was significantly greater than the average time spent traveling to the grocery store for those in low-income areas with high access (15.5 minutes) and for those in low-income areas with medium access (14.1 minutes). In addition, those in low-access areas shopped less frequently—on average once every 8 days versus a national average of once every 7 days.

The difference in average time spent traveling to the grocery store by access level may not be surprising given that this study's definition of access is based on distance, and that, all else equal, it is expected that those who live more than 1 mile from a supermarket would spend more time traveling to the grocery store than those who live closer to the supermarket. To put these averages into context, table 3 also reports average time spent traveling to grocery stores by households in higher-income areas separately by their access levels. As expected, those with low access spend the most time traveling to the grocery store (19.5 minutes) compared with those who are closer. But the average of those in higher income areas that are more than a mile from a store is still almost 4 minutes shorter, 15.8 minutes, than the average time of those in low-income areas who are more than a mile from a grocery store.

The final set of averages shown in table 3 compares average time spent traveling to grocery stores for those with household income below 200 percent of Federal poverty guidelines and for those with income above 200 percent of poverty. Individuals with low income who live in low-income areas with low access spend about the same amount of time traveling to grocery stores (19.3 minutes) as those who do not have low income but who live in low-income areas with low access to grocery stores (20.5 minutes). Also included are national estimates for the 13 percent of the sample with missing income information.[13]

[13] Because household income is a sensitive question, it has a higher nonresponse rate than other CPS and ATUS questions.

Table 4 shows the mode of transportation used in getting to grocery stores. These results show that the majority of people who shopped for groceries drove to the store as either the driver of a vehicle or as a passenger with another household member. Those with low income and the lowest levels of access were the most likely to drive to the grocery store (93.3 percent, compared with 87.1 percent for medium-access shoppers and 65.3 percent for high access shoppers). Those who lived closest to grocery stores in low-income areas were more likely to walk or bicycle to the store than those in low- or medium-access areas (23.1 percent, compared with 2.2 and 5.4 percent for those with low and medium access). Very few shoppers used public transportation to get to a grocery store. Only 4.3 percent of shoppers in low-access areas got rides to the grocery store with nonhousehold members or in taxis, while 9.7 percent of shoppers in high-access areas got rides to grocery stores with nonhousehold members or in taxis.

Grocery shoppers from low-access low-income areas were more likely to have been accompanied by children on their trips to the grocery store than others—29.1 percent versus a national average of 22.8 percent. Having children along on the trip is likely to make the trip more cumbersome, making travel and grocery shopping more difficult for these low-access shoppers.[14]

The last rows in table 4 show whether grocery shoppers travel to grocery shopping from home or from work, and their trip chaining patterns. For about 8 percent of the shoppers, the time distance between work and the grocery store was shorter than between home and the grocery store. Interestingly, those in low-income areas with low access were the most likely to use work as an anchor location for grocery shopping, either traveling directly between the workplace and grocery shopping, or traveling between work and grocery shopping bunched with other activities (7.7 percent directly from work and 3.6 percent bunched with other activities from work). Those from low-income areas that had medium or high levels of access were less likely to access grocery stores from work. These estimates indicate that some of those who live in low-income areas with low access choose grocery stores closer to work than to home (11.3 percent). It is then possible that employment is providing these individuals with a food environment that is not a food desert, that is, that their job is in a neighborhood with a supermarket.[15]

---

[14] Although we look only at "whom with" for the travel to and from grocery shopping, and not the whom with during the grocery shopping itself, Wiig and Smith (2009) found that when adults accompanied by children grocery shopped, that children influenced what food was purchased, particularly snack foods, frequently resulting in higher grocery bills.

[15] Both Bitler and Haider (2011) and Sallis and Glanz (2009) discuss the importance of including workplace as a food environment. Bitler and Haider state:"Healthy and nutritious food must be geographically close enough to a consumer to be useful. A precise characterization of proximity is unlikely to be fixed, either across region or within region, because proximity is affected by factors such as transportation availability (e.g., access to private or public transportation and congestion) and individual travel patterns (e.g., the relative location of one's residence and workplace). If the analyst only considers stores near where individuals live, then important food sources may be missed, such as those near where people work or near their children's schools." (pp. 155-156)

Table 3
Average time spent in travel to grocery shopping on an average day by access to grocery stores

		Average minutes travel time to grocery shopping, for those who grocery shopped		Average engaged in travel related to grocery shopping (on ave. day) in %	90% confidence intervals			
					minimum	maximum	minimum	maximum
	N		N		Average minutes		Average %	
Total population, age 15+, 2003-07	8,305	15.0	52,677	14.0	14.67	15.25	13.70	14.31
				Low-income areas				
Low access	573	19.5	4,387	12.1	18.06	20.93	11.06	13.12
Medium access	719	14.1	4,637	13.5	12.96	15.14	12.46	14.47
High access	610	15.5	4,180	12.3	14.34	16.66	11.28	13.39
				Not-low-income areas				
Low access	1,787	15.8	11,277	14.4	15.22	16.47	13.67	15.09
Medium access	2,141	12.5	12,707	14.7	12.09	12.94	14.08	15.33
High access	1,182	13.3	6,393	16.3	12.58	14.05	15.35	17.32
				Income, 2003-07				
Household income ≤ 200 poverty threshold	2,310	15.8	15,534	13.6	15.28	16.36	13.03	14.16
				Low-income areas				
Low access	286	19.3	2,107	13.6	17.32	21.27	12.15	15.14
Medium access	373	14.2	2,358	13.4	13.13	15.27	12.00	14.70
High access	307	16.4	2,185	12.5	14.57	18.15	10.97	14.04
				Not-low-income areas				
Low access	348	16.3	2,258	14.7	15.03	17.61	13.16	16.25
Medium access	403	13.6	2,562	13.3	12.55	14.69	11.98	14.61
High access	226	12.3	1,303	16.7	11.09	13.57	14.57	18.80
Household income > 200 poverty threshold	4,886	14.2	29,988	14.2	13.85	14.60	13.81	14.66
				Low-income areas				
Low access	207	20.5	1,624	11.3	18.33	22.60	9.83	12.79
Medium access	272	12.1	1,687	14.1	10.86	13.35	12.32	15.81
High access	216	13.5	1,375	12.6	11.86	15.15	10.91	14.35
				Not-low-income areas				
Low access	1,195	15.6	7,498	14.3	14.77	16.37	13.39	15.17
Medium access	1,470	11.8	8,480	15.0	11.36	12.33	14.20	15.89
High access	789	13.4	4,187	16.3	12.34	14.43	15.11	17.56

Table 3 Cont.
Average time spent in travel to grocery shopping on an average day by access to grocery stores

		Average minutes travel time to grocery shopping, for those who grocery shopped		Average engaged in travel related to grocery shopping (on ave. day) in %	90% confidence intervals			
					minimum	maximum	minimum	maximum
	N		N		Average minutes		Average %	
Income, 2003-07								
Household income missing	1,109	16.3	7,155	13.9	15.40	17.19	13.05	14.70
Low-income areas								
Low access	80	17.7	656	9.7	14.35	21.10	7.51	11.95
Medium access	74	19.4	592	12.3	14.46	24.38	9.64	14.87
High access	87	17.0	620	11.1	12.77	21.14	8.84	13.45
Not-low-income areas								
Low access	244	16.5	1,521	14.4	14.94	18.00	12.52	16.27
Medium access	268	14.4	1,665	15.0	12.90	15.81	13.14	16.88
High access	167	14.4	903	15.9	12.37	16.42	13.46	18.31

Note: Average time is one-way, not total travel time (based on shortest one-way time).
Source: 2003-2007 American Time Use Survey data; Current Population Survey sampling frame from Census Bureau; access levels based on 2000 Census of Population and a USDA ERS-compiled supermarket directory for the contiguous U.S. in 2006, own calculations.

Table 4
Characteristics of grocery shopping by level of access to supermarkets

		Low-income areas			Not-low-income areas		
	Total	Low access	Medium access	High access	Low access	Medium access	High access
				Mode of transportation in %			
Car, truck, motorcycle (driver or passenger w/hh member)	90.2	93.3	87.1	65.3	96.7	92.2	83.9
Walking or bicycle	4.8	2.2	5.4	23.1	0.3	3.1	10.0
Public transportation (bus, subway/train)	0.3	0.1	0.9	1.9	0.0	0.3	0.3
Other (passenger w/nonhh member, boat/ferry, taxi/limo, unspecified)	4.7	4.3	6.6	9.7	2.9	4.4	5.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
				With whom in %			
Alone	48.8	40.0	39.0	40.8	49.9	52.7	53.6
With household members	42.1	49.2	49.9	46.1	41.1	39.5	37.9
With others, not household members	9.1	10.8	11.1	13.1	9.1	7.8	8.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
With children (persons under 18 years old)	22.8	29.1	28.2	32.8	20.3	22.6	19.4
				Trip chaining in %			
Home to store, direct / Store to home direct	63.6	54.8	64.0	61.0	64.5	68.4	66.6
Home to store, bunched or clustered/ Store to home, bunched or clustered	28.4	33.9	31.1	34.9	26.5	25.8	26.3
Work to store, direct / Store to work direct	5.9	7.7	3.5	3.3	6.6	3.9	5.9
Work to store, bunched or clustered/ Store to work, bunched or clustered	2.1	3.6	1.3	0.8	2.5	1.9	1.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note that "with whom" is for travel to grocery store, and not grocery shopping.
The person or persons with the respondent may only be present for part of the travel.
Characteristics are of one-way shortest travel time to/from grocery store.
Source: 2003-2007 American Time Use Survey data; Current Population Survey sampling frame from Census Bureau; access levels based on 2000 Census of Population and a USDA ERS-compiled supermarket directory for the contiguous U.S. in 2006, own calculations.

4.2 Travel time by access level and employment status

Tables 5 and 6 show travel times for those employed and those not employed, respectively. The main finding here is that average travel times for those employed are about the same as for those not employed. Although travel times were about the same, those employed and those not employed do have different participation rates of grocery shopping. On an average day over 2003-07, 13.1 percent of those employed grocery shopped, and 15.6 percent of those not employed grocery shopped. This is equivalent to those employed grocery shopping on average once every 7.6 days, and those not employed shopping once every 6.4 days, more than a one-day difference.

Table 5
Average time spent in travel to grocery shopping
on an average day by access to grocery stores for employed persons

					90% confidence intervals			
	N	Average minutes travel time to grocery shopping, for those who grocery shopped	N	Average engaged in travel related to grocery shopping (on ave.day) %	minimum	maximum	minimum	maximum
					Average minutes		Average %	
Total pop., age 15+, 2003-07	5,151	14.9	33,098	13.1	14.51	15.27	12.73	13.50
				Low-income areas				
Low access	303	21.2	2,398	10.8	19.18	23.23	9.60	12.03
Medium access	404	13.4	2,560	13.3	12.22	14.59	11.88	14.65
High access	336	15.2	2,341	11.7	13.49	16.89	10.32	13.01
				Not-low-income areas				
Low access	1,141	15.7	7,464	13.1	14.88	16.51	12.17	13.94
Medium access	1,361	12.7	8,312	13.4	12.14	13.32	12.62	14.16
High access	792	12.9	4,250	16.1	12.00	13.86	14.83	17.31
				Income, 2003-07				
Household Income ≤ 200 poverty threshold	1,082	15.2	7,372	12.6	14.42	15.93	11.81	13.36
				Low-income areas				
Low access	124	22.0	920	12.0	18.36	25.67	10.12	13.83
Medium access	181	12.8	1,054	14.4	11.37	14.16	12.27	16.60
High access	145	15.3	1,029	12.1	13.09	17.51	9.90	14.32
				Not-low-income areas				
Low access	156	15.5	1,128	11.7	13.74	17.23	9.63	13.71
Medium access	189	13.4	1,254	12.4	12.12	14.67	10.65	14.06
High access	112	11.3	641	16.1	9.83	12.75	13.04	19.20

Table 5 Cont.
Average time spent in travel to grocery shopping
on an average day by access to grocery stores for employed persons

					90% confidence intervals			
	N	Average minutes travel time to grocery shopping, for those who grocery shopped	N	Average engaged in travel related to grocery shopping (on ave.day) %	minimum	maximum	minimum	maximum
					Average minutes		Average %	
Income, 2003-07								
Household Income > 200 poverty threshold	3,431	14.3	21,743	13.2	13.85	14.85	12.68	13.65
Low-income areas								
Low access	137	21.2	1,143	10.8	18.84	23.59	8.93	12.58
Medium access	183	13.0	1,200	11.8	11.13	14.79	9.89	13.70
High access	152	14.1	1,004	11.5	11.78	16.47	9.73	13.22
Not-low-income areas								
Low access	838	15.4	5,444	13.2	14.41	16.35	12.25	14.25
Medium access	1,017	12.0	6,107	13.4	11.33	12.67	12.47	14.35
High access	579	13.0	3,084	16.1	11.73	14.21	14.62	17.49
Household Income missing	638	17.0	3,983	13.7		15.71	18.28	12.61
Low-income areas								
Low access	42	--	335	--	--	--	--	--
Medium access	40	--	306	--	--	--	--	--
High access	39	--	308	--	--	--	--	--
Not-low-income areas								
Low access	147	17.5	892	13.5	15.34	19.71	10.90	16.16
Medium access	155	15.9	951	14.5	13.70	18.03	12.10	16.89
High access	101	14.7	525	16.1	12.16	17.19	12.89	19.33

Note: Average time is one-way, not total travel time
(based on the shortest one-way time).
-- indicates that estimate is suppressed due to small cell size.
Source: 2003-2007 American Time Use Survey data; Current Population Survey sampling frame from Census Bureau; access levels based on 2000 Census of Population and a USDA ERS-compiled supermarket directory for the contiguous U.S. in 2006, own calculations.

Participation rates for those employed were lower than for those not employed for all subgroups. Employed persons in low-income, low-access areas had one of the lowest rates, 10.8 percent (equivalent to once every 9.2 days), versus 13.7 percent for those not employed in low-income low-access areas (equivalent to once every 7.3 days).

Table 6
Average time spent in travel to grocery shopping on an average day by access to grocery stores for not employed persons

		Average minutes travel time to grocery shopping, for those who grocery shopped		Average engaged in travel related to grocery shopping (on ave. day) %	90% confidence intervals			
					minimum	maximum	minimum	maximum
	N		N		Average minutes		Average %	
Total pop., age 15+, 2003-07	3,154	15.1	19,579	15.6	14.61	15.51	15.05	16.14
				Low-income areas				
Low access	270	17.7	1,989	13.7	16.15	19.34	12.02	15.47
Medium access	315	14.9	2,077	13.7	13.11	16.66	12.26	15.21
High access	274	15.9	1,839	13.3	14.09	17.70	11.50	15.09
				Not-low-income areas				
Low access	646	16.1	3,813	17.0	15.19	16.96	15.84	18.21
Medium access	780	12.2	4,395	17.3	11.51	12.86	16.04	18.55
High access	390	14.1	2,143	16.9	12.83	15.30	15.34	18.44
				Income, 2003-07				
Household Income ≤ 200 poverty threshold	1,228	16.4	8,162	14.6	15.61	17.14	13.79	15.45
				Low-income areas				
Low access	162	17.5	1,187	15.0	15.57	19.43	12.85	17.21
Medium access	192	15.7	1,304	12.4	14.07	17.36	10.78	13.98
High access	162	17.4	1,156	12.9	14.63	20.24	10.69	15.20
				Not-low-income areas				
Low access	192	16.9	1,130	18.1	15.12	18.71	15.54	20.58
Medium access	214	13.8	1,308	14.3	12.03	15.64	12.39	16.28
High access	114	13.4	662	17.3	11.73	15.09	14.26	20.36
Household Income > 200 poverty threshold	1,455	14.0	8,245	17.0	13.40	14.56	16.15	17.92
				Low-income areas				
Low access	70	18.9	481	12.7	14.42	23.35	9.53	15.84
Medium access	89	10.8	487	19.6	9.54	12.16	15.94	23.33
High access	64	12.2	371	16.0	10.01	14.38	11.37	20.70
				Not-low-income areas				
Low access	357	15.9	2,054	16.9	14.71	17.18	15.16	18.68
Medium access	453	11.6	2,373	19.2	10.87	12.26	17.42	20.95
High access	210	14.5	1,103	17.1	12.57	16.41	14.97	19.30

Table 6 Cont.
Average time spent in travel to grocery shopping
on an average day by access to grocery stores for not employed persons

	N	Average minutes travel time to grocery shopping, for those who grocery shopped	N	Average engaged in travel related to grocery shopping (on ave. day) %	90% confidence intervals			
					minimum	maximum	minimum	maximum
					Average minutes		Average %	
				Income, 2003-07				
Household Income missing	471	15.4	3,172	14.1	14.18	16.54	12.91	15.27
				Low-income areas				
Low access	38	--	321	--	--	--	--	--
Medium access	34	--	286	--	--	--	--	--
High access	48	--	312	--	--	--	--	--
				Not-low-income areas				
Low access	97	15.0	629	15.8	13.15	16.90	13.21	18.35
Medium access	113	12.3	714	15.8	10.58	14.04	13.09	18.46
High access	66	14.0	378	15.5	10.58	17.33	11.75	19.34

Note: Average time is one-way, not total travel time
(based on the shortest one-way time).
-- indicates that estimate is suppressed due to small cell size.
Source: 2003-2007 American Time Use Survey data; Current Population Survey sampling frame from Census Bureau; access levels based on 2000 Census of Population and a USDA ERS-compiled supermarket directory for the contiguous U.S. in 2006, own calculations.

Tables 7 and 8 show the characteristics of grocery shoppers who were employed and those not employed, respectively. As one might expect, a larger share of those employed drove (or were driven by a household member) to grocery shopping, 92.0 percent, versus 87.3 percent of those not employed, and a larger share of those employed traveled to grocery shopping alone, 50.5 percent versus 46.3 percent. Interestingly, a larger share of those employed had children with them when traveling to grocery shopping, 24.8 percent, versus only 19.8 percent of those not employed. Perhaps this is due to picking up/dropping off children to daycare before or after work, and consequently, on the way to grocery shopping. 13.5 percent of those employed who grocery shopped had a shorter travel time to/from their workplace than to/from home, that is, their workplace was the anchor for the trip.

Table 7
Characteristics of grocery shopping by level of access to supermarkets for employed persons

		Low-income areas			Not-low-income areas		
	Total	Low access	Medium access	High access	Low access	Medium access	High access
				Mode of transportation in %			
Car, truck, motorcycle (driver or passenger w/hh member)	92.0	97.4	89.9	69.9	97.7	92.9	85.8
Walking or bicycle	4.4	0.4	5.1	19.2	0.5	3.5	9.5
Public transportation (bus, subway/train)	0.1	0.0	0.9	0.2	0.0	0.1	0.1
Other (passenger w/nonhh member, boat/ferry, taxi/limo, unspecified)	3.4	2.2	4.1	10.7	1.8	3.5	4.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
				With whom in %			
Alone	50.5	43.1	39.2	42.2	53.3	50.8	56.1
With household members	42.1	50.3	49.7	48.0	39.8	42.5	36.3
With others, not household members	7.4	6.5	11.1	9.8	6.9	6.7	7.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
With children (persons under 18 years old)	24.8	30.7	30.2	32.8	23.2	25.7	19.3
				Trip chaining in %			
Home to store, direct / Store to home direct	58.7	39.6	62.6	56.8	61.9	63.6	61.8
Home to store, bunched or clustered/ Store to home, bunched or clustered	27.7	37.9	28.8	35.8	23.6	27.1	27.5
Work to store, direct / Store to work direct	9.8	15.4	6.2	5.9	10.5	6.4	8.8
Work to store, bunched or clustered/ Store to work, bunched or clustered	3.7	7.2	2.4	1.5	4.0	3.0	1.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Characteristics are of one-way shortest travel time to/from grocery store.
Note that "with whom" is for travel to/from grocery store, and not grocery shopping.
The person or persons with the respondent may only be present for part of the travel.
Source: 2003-2007 American Time Use Survey data; Current Population Survey sampling frame from Census Bureau; access levels based on 2000 Census of Population and a USDA ERS-compiled supermarket directory for the contiguous U.S. in 2006, own calculations.

Table 8
Characteristics of grocery shopping by level of access to supermarkets for not employed persons

		Low-income areas			Not-low-income areas		
	Total	Low access	Medium access	High access	Low access	Medium access	High access
				Mode of transportation in %			
Car, truck, motorcycle (driver or passenger w/hh member)	87.3	89.1	83.6	59.4	95.2	91.3	80.1
Walking or bicycle	5.3	4.2	5.9	28.0	0.1	2.4	11.1
Public transportation (bus, subway/train)	0.6	0.2	0.8	4.1	0.1	0.5	0.8
Other (passenger w/nonhh member, boat/ferry, taxi/limo, unspecified)	6.7	6.5	9.8	8.5	4.6	5.8	8.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
				With whom in %			
Alone	46.3	36.8	38.8	39.0	44.7	55.7	48.6
With household members	42.0	48.1	50.2	43.6	43.0	34.9	40.9
With others, not household members	11.7	15.1	11.0	17.4	12.3	9.4	10.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
With children (persons under 18 years old)	19.8	27.5	25.7	32.9	16.0	17.9	19.6
				Trip chaining in %			
Home to store, direct / Store to home direct	71.4	70.2	65.9	66.3	68.3	75.8	76.1
Home to store, bunched or clustered/ Store to home, bunched or clustered	28.2	29.8	34.1	33.7	30.9	23.7	23.9
Work to store, direct / Store to work direct	0.3	0.0	0.0	0.0	0.6	0.2	0.0
Work to store, bunched or clustered/ Store to work, bunched or clustered	0.1	0.0	0.0	0.0	0.1	0.2	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Characteristics are of one-way shortest travel time to grocery store.
Note that "with whom" is for travel to/from grocery store, and not grocery shopping.
The person or persons with the respondent may only be present for part of the travel.
Source: 2003-2007 American Time Use Survey data; Current Population Survey sampling frame from Census Bureau; access levels based on 2000 Census of Population and a USDA ERS-compiled supermarket directory for the contiguous U.S. in 2006, own calculations.

5 Conclusions

5.1 Limitations

We used the American Time Use Survey, which contains a one-day time diary. Because we have only one day, we miss inter-person variation since grocery shopping is an activity that is typically not done daily. However, we do have a large, nationally representative sample—a total of 72,922 completed interviews of which 11,726 respondents grocery shopped on their diary day—so we expect that any bias would be small.

With respect to our application to food deserts and travel time to grocery shopping, we do not know if the retail venue where the respondent purchased groceries was the nearest (either in time or geographical distance) grocery store to the respondent's residence, or even the preferred grocery store. We just know that the respondent purchased groceries on the diary day. This may lead to an overestimate of the travel time to grocery shopping if some respondents did not shop at the nearest grocery store.

In merging the access typology with the Census sample frames in order to analyze travel time by census tract access level and income level, some respondents could not be matched, either from the typology side (census tracts that could not be classified) or the respondent side (Census did not have the tract information in the sample frame). As a consequence, our sample was reduced to 8,305 respondents, still a large sample, however there is the risk that estimates calculated from the smaller sample are not the same as estimates calculated from the entire sample. This could result in either an over- or under-estimate of travel times.

5.2 Travel to grocery shopping estimates

Our findings on food deserts—low-income, low-access areas—are compelling. The travel time to grocery shopping, the time cost, was greater for those living in low-supermarket-access areas than for others. Not surprisingly, residents of food deserts grocery shopped less frequently, which would lessen the ability to have fresh produce in the household. In addition, they were more likely to be accompanied by children on their trip, which could make grocery shopping more cumbersome. Analysis looking at employment status found that travel times were about the same for those employed as for those not employed. However, the groups had different participation rates of grocery shopping and different travel characteristics, such that those employed shopped less frequently than those not employed.

Our findings of travel time to grocery shopping using nationally-representative data is an important contribution to the understanding of supermarket access in low-income areas. Not only travel times, but also participation rates—the percent who grocery shopped on an average day—were estimated, as well as whom the shopper was with and their mode of transportation. Having this information provides insights into possible difficulties that some subpopulations may have in purchasing healthy, nutritious food.

Most other food desert studies have looked at specific geographic areas, whereas we used nationally representative data. Whereas Rose and Richards (2004) study had data on travel time, they did not have a diary of the entire day and so could not analyze how individuals fit grocery shopping in their lives. Other food desert researchers have stated the importance of the time element in identifying and analyzing food deserts, however few studies have done so. Our measurement and analysis is a contribution in that it provides an additional dimension to the study of the extent of low access to supermarkets across the United States. This work compliments the food desert research that others have done looking at physical geographical distance.

5.3 Estimating travel times using time-use data

Our analysis of travel times in food deserts has provided a case study for analyzing travel using time use diaries. As discussed above, the existing literature is sparse on using time diaries to study travel times and patterns. Our methodology has contributed to the time use literature by providing a streamlined method of identifying and measuring travel time to a specific activity, in this case grocery shopping, using the American Time Use Survey data. Our methodology would work with other similarly-coded time use data. In addition, our technical detail and coding rules—no doubt tedious reading—provide time use researchers with information that may help understand the complexities of transforming time diary data into travel times. Time-use data, with detailed diary information and a wealth of demographic and labor force participation information, has much to offer in understanding individuals' travel patterns and the context for their trips, information relevant to a variety of policy issues. This methodology could be used for a variety of travel time research questions, allowing for estimates of travel time as the individual fits an activity into his/her life. We hope to see more researchers using time use data to analyze travel questions in the future.

This analysis also serves as an example to demonstrate the benefit from agencies' collaboration that allowed us to utilize confidential location information, even though we did not have access to it. Continued collaboration across agencies utilizing spatial information would benefit a variety of program and policy issues.

Appendix – Detailed coding rules

Missing where codes

We had to deal with the fact that the ATUS does not ask where a person was for personal care activities in the time diary, and so the where code is missing (TEWHERE=-1). Missing TEWHERE information was re-coded as at home (TEWHERE=1) if it corresponded to a personal care activity (0101xx, 0102xx, 0104xx) or a time when the respondent refused to provide an activity (500105) or did not remember his/her activity (500106) and if the activity was ad-

jacent to an at home activity. Similarly, if these missing TEWHERE conditions were met except the activity was adjacent to an activity done at one's workplace instead of one's home, then TEWHERE was re-coded as workplace (TEWHERE=2). We recoded TEWHERE as at home (TEWHERE=1) if the first two diary entries were Personal Care (01xxxx) and the third was travel.

Excluded diaries

If the respondent was not at home for any activity in the 24-hour time diary, then that observation was not included. If the mode of travel was by airplane, the observation was excluded as the grocery shopping was likely in an airport during out-of-town travel. For individual travel times that appeared unusual, the time diary was investigated to understand the story of the respondent's day. After investigation of these extreme travel times, thirty-seven observations with grocery shopping were excluded for the following reasons: (1) we determined that the respondent was out of town when the grocery shopping took place; (2) the time diary provided insufficient data, usually because the respondent reported "can't remember" or "none of your business" for portions of the diary day (ATUS activity codes 50xxxx); or (3) the respondent had a large number of errands or other activities on the diary day such that the total travel time to grocery shopping would likely be an overestimate of the time distance to the grocery store. The resulting dataset that we used to calculate the estimates contains 11,569 observations. A small number of extreme cases were included as they appeared as legitimate trips to/from grocery shopping—respondents who had zero minutes travel to grocery shopping, which is possible if the store is in the same building as the respondent's previous activity, and respondents who had 120 minutes or longer travel to grocery shopping.

Anchors

Home (TEWHERE=1) and workplace (TEWHERE=2).

Travel and travel time

We recoded activities '500101', '500103', '500104', '500107', or '509989' as travel (18xxxx) if the TEWHERE was a mode of transportation (TEWHERE=12-19, 21, 99).

Measuring the time to grocery shopping consists of adding all the travel legs (18xxxx) from home to store (070101 and TEWHERE=4,6,7,9,11) and from store to home. Then the "before store" time is compared with the "after store" time and the minimum is chosen. Note that if there is only one "side," that is, if the respondent has no activities at home before the store, or no activities at home after the store, then the one side is used as the trip length.

If the respondent reports being at his/her workplace, then the travel "counter" is reset, and the previous legs of travel are not included.

If the respondent grocery shopped two or more times, then the "before store" time is from home (or work) to the first occurrence of grocery shopping, and the "after store" is from the last occurrence of grocery shopping to home (or work).

Exclusions

Only observations with grocery shopping (070101) with the following TEWHERE codes are included: 4 (restaurant or bar), 6 (grocery store), 7 (other store/mall), 9 (outdoors away from home), and 11 (other place).

If "before store" or "after store" travel includes TEWHERE=20 (airplane travel), the observation is excluded.

Observations with no activity done at home on the diary day are excluded.

With whom—categories:

1. Alone: TUWHO_CODE= 18, 19

2. With household members: TUWHO_CODE= 20-30

3. With others (not household members): TUWHO_CODE= 40-58

These categories total 100%.

Separate category:

4. With child/ren (own child or other child): TUWHO_CODE=22, 27, 40, 52, 57 (for

TUWHO_CODE=22 and 27, and TEAGE<18)

With whom—Rules for multiple legs of travel:

If alone and then with someone (or vice versa), then code as with someone (either with household members or with others).

If with household members and with others, then code as with household members.

If alone and then accompanied by a child, then code as with child/ren.

Note: TUWHO_CODE rules for travel legs only, that is 18xxxx activities, not the dwell activities.

Mode of transportation—categories:

1. By vehicle, driver or passenger with household member—includes:

Driver (TEWHERE=12)

Passenger (TEWHERE=13) with household member during travel (18xxxx,

TUWHO_CODE is 20 - 30). This indicates access to a vehicle.

May include walking travel legs.

2. Walking only (all travel legs= 14), bicycle only (all travel legs=17).

3. Public transportation (TEWHERE= 15-bus, 16-subway/train, 18-boat/ferry), may include walking (TEWHERE=14) or biking (TEWHERE=17) travel leg(s).

4. Other—includes:

TEWHERE= 19 (taxi/limousine service) or 21 (other mode of travel)

TEWHERE= 13 (passenger in vehicle) if with nonhousehold member

TEWHERE= 99, unspecified mode of transportation

Note that observations with TEWHERE=20 (airplane) are excluded.

Rules for mode of transportation:

Ignore TEWHERE < 12 or TEWHERE > 30 (except TEWHERE=99, unspecified mode of transportation). There are some travel activities coded as TEWHERE=9 (outdoors away from home). This is likely to be the parking lot of the store.

If multiple legs of driving (TEWHERE=12) or riding (13) with a leg of walking (14), then code as By vehicle. (Example: Before store= 12, 14. After store= 14, 12.) In this case the walking involved is likely in the store parking lot.

References

Allard, M. D. (2009), Unpublished ATUS travel paper draft, U.S. Department of Labor Bureau of Labor Statistics.

Anas, A. (2007), A unified theory of consumption, travel and trip chaining, in: *Journal of Urban Economics*, Vol. 62, No. 2, 162-186.

Apparicio, P., Cloutier, M.-S. and R. Shearmur (2007), The case of Montréal's missing food deserts – Evaluation of accessibility to food supermarkets, in: *International Journal of Health Geographics*, Vol. 6, No. 4, 1-13.

Beaulac, J., Kristjansson, E. and S. Cummins (2009), A systematic review of food deserts 1966-2007, in: *Preventing Chronic Disease*, Vol. 6, No. 3, 1-10.

Bhat, C. R. and F. S. Koppelman (2003), Activity-based modeling of travel demand, in: Hall, R. W. (ed.), *Handbook of Transportation Science*, Springer, chapter 3, no page numbers.

Bitler, M. and S. J. Haider (2011), An economic view of food deserts in the United States, in: *Journal of Policy Analysis and Management*, Vol. 30, No. 1, 153-176.

Bose, J. (2006), Using the American Time Use Survey for travel estimates, presentation at the USDA Economic Research Service, Washington, DC, February 22, 2006.

Bose, J. and J. Sharp (2005), Measurement of travel behavior in a trip-based survey versus a time use survey – A comparative analysis of travel estimates using the 2001 National Household Travel Survey and the 2003 American Time Use Survey, paper presented at the American Time Use Survey Early Results Conference, December 8-9, 2005, Bethesda, MD.

Brown, C. and T. Borisova (2006), Understanding commuting and grocery shopping using the American Time Use Survey, ERS Cooperative Agreement Final Report, Cooperative Agreement #43-3AEM-5-80107, West Virginia University.

Cascetta, E. (2009), Travel-demand models, chapter 4, Springer Optimization and its applications, in: *Transportation Systems Analysis*, No. 29, 169-257.

Charreire, H., Casey, R., Salze, P., Simon, C., Chaix, B., Banos, A., Badariotti, D., Weber, C. and J.-M. Oppert (2010), Measuring the food environment using geographical information systems – A methodological review, in: *Public Health Nutrition*, Vol. 13, No. 11, 1773-1785.

Christian, T. J. (2012), Trade-offs between commuting time and health-related activities, in: *Journal of Urban Health*, Vol 89, No. 5, 746-757.

Cummins, S. and S. Macintyre (2002), Food deserts – Evidence and assumption in health policy making, in: *BMJ*, Vol. 325, No. 7361, 436-438.

George, B. J. and T. McCurdy (2009), Investigating the American Time Use Survey from an exposure modeling perspective, in: *Journal of Exposure Science and Environmental Epidemiology*, Vol. 21, No. 1, 92-105.

Harvey, A. S. and M. E. Taylor (2000), Activity settings and travel behaviour – A social contract perspective, in: *Transportation*, Vol. 27, No. 1, 53-73.

Jiao, J., Moudon, A. V., Ulmer, J., Hurvitz, P. M. and A. Drewnowski (2012), How to identify food deserts – Measuring physical and economic access to supermarkets in King County, Washington, in: *American Journal of Public Health*, Vol. 102, No. 10, 32-39.

Jilcott, S. B., Moore, J. B., Wall-Bassett, E., Liu, D. H. and B. E. Saelens (2011), Association between travel times and food procurement practices among female supplemental nutrition assistance program participants in Eastern North Carolina, in: *Journal of Nutrition Education and Behavior*, Vol. 43, No. 5, 385-389.

Kitamura, R., Fujii, S. and E.I. Pas (1997), Time-use data, analysis and modeling – Toward the next generation of transportation planning methodologies, in: *Transport Policy*, Vol. 4, No. 4, 225-235.

Lin, J. and L. Long (2008), What neighborhood are you in? – Empirical findings of relationships between household travel and neighborhood characteristics, in: *Transportation*, Vol. 35, No. 6, 739-758.

McGuckin, N. and Y. Nakamoto (2004), Trips, chains, and tours – Using an operational definition, NHTS Conference, November 1-2, 2004.

Millward, H. and J. Spinney (2011), Time use, travel behavior, and the rural-urban continuum – Results from the Halifax STAR project, in: *Journal of Transport Geography*, Vol. 19, No. 1, 51-58.

Mokhtarian, P. L. and C. Chen (2004), TTB or not TTB, that is the question – A review and analysis of the empirical literature on travel time (and money) budgets, in: *Transportation Research Part A: Policy and Practice*, Vol. 38, No. 9-10, 643-675.

Morland, K. S., Wing, A., Rouz, D. and C. Poole (2002), Neighborhood characteristics associated with the location of food stores and food service places, in: *American Journal of Preventive Medicine*, Vol. 22, No. 1, 23-29.

Morris, P., Neuhauser, M. L. and C. Campbell (1992), Food security in rural America – A study of the availability and costs of food, in: *Journal of Nutrition Education*, Vol. 24, No. 1, 52-58.

Pas, E. I. and A. S. Harvey (1997), Time use research and travel demand analysis and modelling, in: Stopher, R. P. and M. L. Gosselin (eds.), *Understanding travel behaviour in an era of change*, Pergamon, Oxford, 315-338.

Rose, D. and R. Richards (2004), Food store access and household fruit and vegetable use among participants in the US Food Stamp Program, in: *Public Health Nutrition*, Vol. 7, No. 8, 1081-1088.

Sallis, J. F. and K. Glanz (2009), Physical activity and food environments – Solutions to the obesity epidemic, in: *The Milbank Quarterly*, Vol. 87, No. 1, 123-154.

Sheppard, E. S. (1980), Location and the demand for travel, in: *Geographical Analysis*, Vol. 12, No. 2, 111-128.

Spissu, E., Pinjari, A. R., Bhat, C. R., Pendyala, R. M. and K.W. Axhausen (2009), An analysis of weekly out-of-home discretionary activity participation and time-use behavior, in: *Transportation*, Vol. 36, No. 5, 483-510.

Srinivasan, S. and C. R. Bhat (2008), An exploratory analysis of joint-activity participation characteristics using the American Time Use Survey, in: *Transportation*, Vol. 35, No. 3, 301-327.

Strathman, J. G. and K. J. Dueker (1995), Understanding trip chaining, in 1990 NPTS, Nationwide Personal Transportation Survey – Special reports on trip and vehicle attributes, U.S. Department of Transportation Federal Highway Administration.

The Reinvestment Fund and Opportunity Finance Network (2012), Searching for markets – The geography of inequitable access to healthy and affordable food in the United States, The Reinvestment Fund.

U.S. Department of Labor Bureau of Labor Statistics (2010), American Time Use Survey User's guide – Undererstanding ATUS 2003 to 2009, http://stats.bls.gov/tus/atususersguide.pdf.

U.S. Department of Labor Bureau of Labor Statistics (2010), American Time Use Survey (ATUS) coding rules, http://www.bls.gov/tus/tu2010coderules.pdf.

U.S. Department of Labor Bureau of Labor Statistics (various years), American Time Use Survey activity coding lexicons, http://stats.bls.gov/tus/lexicons.htm.

U.S. Department of Labor Bureau of Labor Statistics and U.S. Department of Commerce Census Bureau (2006), Current Population Survey – Design and methodology, http://www.census.gov/apsd/techdoc/cps/cps-main.html.

Ver Ploeg, M., Breneman, V., Farrigan, T., Hamrick, K., Hopkins, D., Kaufman, P., Lin, B. H., Nord, M., Smith, T. and R. Williams (2009), Access to affordable and nutritious food – Measuring and understanding food deserts and their consequences, Report to Congress, Administrative Publication AP-036. Washington, DC, U.S. Department of Agriculture Economic Research Service.

Wiig, K. and C. Smith (2009), The art of grocery shopping on a food stamp budget – Factors influencing the food choices of low-income women as they try to make ends meet, in: *Public Health Nutrition*, Vol. 12, No. 10, 1726-1734.

Zenk, S. N., Schulz, A. J., Israel, B. A., James, S. A., Bao, S. and M. L. Wilson (2005), Neighborhood racial composition, neighborhood poverty and the spatial accessibility of supermarkets in metropolitan Detroit, in: *American Journal of Public Health*, Vol. 95, No. 4, 660-667.