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Time spent on childcare and the household Healthy Eating Index

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Abstract

Poor diet quality in the U.S. is directly related to high rates of a variety of diseases that disproportionally affect low socio-economic status populations. Federal food assistance programs such as SNAP and WIC attempt to mitigate these negative outcomes, but are limited by not considering household time constraints. Current research has investigated the link between time spent in food-related activities and household diet quality, but little work has investigated the link between time spent in childcare and household diet quality. This link is particularly important because a majority of food assistant participants are households with children. Using the National Household Food Acquisition and Purchase Survey and the American Time Use Survey, we investigate three increasingly detailed questions about how time spent on childcare impacts the Healthy Eating Index (HEI) 2010, a standard metric for a household's diet quality, for food-at-home (FAH) purchases. Although, we find that time spent in combined childcare is not associated with household FAH HEI, we do find a statistically significant relationship when time spent on childcare is disaggregated into its primary and secondary components. Time spent on secondary childcare is negatively associated with household HEI, while primary childcare is positively associated. In addition, when we investigate data subsamples, we find that participation in and eligibility for the Supplemental Nutrition Assistance Program reduces the impact of these household time constraints. These results suggest that policies or programs that help reduce the time spent in secondary childcare may generate diet-quality benefits.

Keywords Diet quality · Health and poverty · Childcare · Time use · Supplemental Nutrition Assistance Program

JEL codes I14 · D13 · I12 · D12

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1 Introduction

Poor diet quality in the United States is related to important non-communicable diseases such as cardiovascular disease, type II diabetes, and obesity (e.g., Ley et al. 2014; Bowman et al. 2004; Nicklas et al. 2001; Chou et al. 2004), which decreases individuals' quality of life and is economically costly (e.g., Fontaine and Barofsky 2001; Finkelstein et al. 2009; Goettler et al. 2017). These diseases are linked to poor diet quality, which in turn is linked with low socio-economic status (SES). Although the average American consistently does not come close to meeting the recommended dietary guidelines, higher SES groups have increased their diet quality over time (Kreb-Smith et al. 2010; Wang et al. 2014; Zhang et al. 2018). Despite the increase for middle and high SES households, diet quality for low SES households has remained unchanged. Therefore, the diet quality gap between low SES households and other households is increasing (Kim and Leigh 2010; Lysy et al. 2013).

Income, education, and the food environment are three factors commonly investigated to explain the diet-quality gap. Accordingly, food assistance and access policies have been implemented to address these three factors. At the national level, the Supplemental Nutrition Assistance Program (SNAP) provides monthly benefits to help low-income households afford nutritious food and learn about nutrition through the SNAP-Ed program (FNS 2018). While SNAP is successful in alleviating poverty (Tiehen et al. 2012), it has not succeeded in improving dietary disparities of low SES groups (Zhang et al. 2018). At the state and local level, 12 states passed legislation between 2001 and 2011 to promote access to healthy food. These policies include the Pennsylvania Fresh Food Finance Initiative (FFFI) and Louisiana's Healthy Food Retail Act (HFRA) (State Initiatives 2012). However, local studies (e.g., Cummins et al. 2014) and national studies (e.g., Kyureghian et al. 2012) both fail to find significant improvement on household fruit and vegetable consumption from supermarket entry or improved supermarket density in urban areas.

Although the opportunity cost of time is a key determinant of time spent in food-at-home (FAH) activities (Möser 2010) and more time spent in FAH activities is associated with a higher diet quality (Jabs and Devine 2006), food assistance programs do not consider household time constraints. Therefore, our research asks whether the general ineffectiveness by income-assistance, education, and food-access policies to alleviate persistent diet-quality disparities of low SES groups could be linked to a limiting fourth factor, the time available for diet quality-related activities. Past research has found that an increase in the opportunity cost of time decreases FAH consumption (Nayga 1996), and therefore diet quality (Lin and Guthrie 2012). These studies traditionally focus on time spent working, with particular interest on women's' working hours (Davis 2014; Etilé and Plessz 2018). In contrast, our research contributes to the literature and the food assistance policy discussion by investigating the relationship between diet quality and unpaid household work, particularly time spent in childcare.

Our focus on time spent in childcare is motivated by two facts. First, a large share of households participating in federal food assistance programs contain children. In 2018, approximately 41 percent of all SNAP households contained a child and 61 percent of households with children were headed by single adults (Cronquist 2019). In addition, nearly all households participating in the Special Supplemental Nutrition

Program for Women, Infants, and Children (WIC) contain children, with all children less than 5 years old (Thorn et al. 2018). Second, households with children spend a large majority of their time in childcare, with an estimated 2.15 h per day spent in primary childcare for households with children under 6 (ATUS Chart Series 2019). Including childcare as part of a food assistance program may have the ability to affect a household's time allocated to childcare and relax their time constraint. Although a large portion of food assistance program participants are households with children and that childcare is a large time commitment each day, there is relatively little known about how childcare impacts diet quality or may be potentially limiting the effectiveness of these programs.

In this paper, we focus our analysis on households' time spent in childcare activities at three levels and specifically investigate how these activities may affect diet quality. First, we examine time spent on all types of childcare by a large sample of U.S. households. Second, we refine our investigation by splitting total childcare in to its two components defined by the American Time Use Survey (ATUS), namely time spent in primary childcare and time spent in secondary childcare. Primary childcare is time spent caring for the child as the primary activity, while secondary childcare refers to time spent providing childcare, while performing another primary activity; e.g., doing laundry or walking the dog (ATUS User's Guide 2019). Third, we investigate data subsamples, where we split the sample by SNAP participation and eligibility to see if the association between time spent on childcare and diet quality is impacted by the federal food assistance program.

While previous research on diet quality and time use has been limited by a lack of data containing both food purchases and time allocations (Davis 2014), we attempt to overcome this data issue by estimating household time allocations through a Two-Sample Instrumental Variable (Angrist and Krueger 1992) approach. This method brings estimated time allocations from the ATUS into a separate dataset that contains a complete set of food-purchase information, namely the U.S. Department of Agriculture's National Food Acquisition and Purchase Survey (FoodAPS). After accounting for fixed effects, we find that (i) time spent in childcare, without regard to type, is not statistically significant in predicting household diet quality, (ii) secondary childcare is negatively associated with household diet quality, while primary childcare is positively associated, and (iii) SNAP participation reduces the impact of these household time constraints.

2 Background

Prior research investigating how time impacts diet quality has focused on FAH activities, finding that low SES households spend less time in FAH activities compared to higher SES households (Hamerick et al. 2011). The difference in time in FAH activities is likely not driven by preferences, however, since 85% of low-income households claim that eating healthy meals is important and 50% of low-income households claim to be "extremely" interested in learning about cooking healthy meals (Share Our Strengths 2018). Alternatively, studies find that other time obligations make it difficult for low SES households to allocate the time necessary to produce healthy meals given their limited budget (Venn and Strazdins 2017; Davis and You 2011; Davis and You 2010; Beatty et al. 2014; Rose 2007; Mancino and Constance 2007). For example, Davis and You (2011) find that 62% of single-headed households spend enough money to meet the Thrifty Food Plan guidelines, but only 13% are able to spend enough of both money and time. This growing body of research suggests that time obligations could be an obstacle to both FAH activities and overall diet quality, and therefore motivates broadening our focus to time spent on non-food related activities.

In contrast to most analyses that consider aggregate time categories (Davis 2014), we focus on childcare and its two components, primary and secondary childcare. Our narrower focus attempts to identify specific components of an aggregate time category to better inform policy. Childcare can be classified as a “committed” activity, i.e., those activities that a household must participate in given past choices (Kalenkoski and Hamrick 2013) or in the context of a theoretical optimization model, a committed variable would be a predetermined choice variable. Therefore, a household can be thought to produce a level of diet quality conditional on the amount of time it allocates to childcare and other committed activities. Furthermore et al. (2013) find that increased time spent on committed activities is associated with less time spent on food-related activities. Second, primary and secondary childcare can be classified as unpaid work (Gershuny 2011). Numerous studies show that increased opportunity cost of time increases food-away-from-home (FAFH) consumption, including increased fast-food consumption (Davis 2014). Therefore, we hypothesize that increased time allocated to committed activities may directly decrease FAH diet quality.

Although there are other committed activities, such as personal hygiene and sleep, we focus on childcare for three specific reasons. First, federal food assistance programs such as SNAP and WIC support a significant number of households with children. In 2018, SNAP served 8.1 million households with children, 41% of all SNAP households (Cronquist 2019). In addition, in 2016, nearly all of WIC’s 8.8 million participants were households with children (Thorn et al. 2018). Furthermore, the SNAP program recognizes the burden of childcare by including a childcare deduction in SNAP benefit allotment calculations (Farm Bill 2008). This effectively decreases gross income and increases the SNAP benefit amount. While we do not address this question directly, our proposed approach is a first step in evaluating if the childcare deduction appropriately offsets the impact of time categories on household diet quality production.

Second, households with children spend a large portion of each day in childcare. In the 2018 ATUS, the average amount of time spent on all household activities was 1.78 h per day. In comparison, households with a child under 18 spent on average 1.39 h in primary childcare per day, with the average increasing to 2.15 h for households with children under 6 (ATUS Chart Series 2019). However, despite these facts, federal food assistance programs do not account for time constraints, potentially limiting their effectiveness. Therefore, the final reason we focus on childcare is that policy has the potential to directly affect time spent in childcare. Free or subsidized childcare programs have been shown to increase women’s participation in the workforce (Yamaguchi et al. 2018; Bettendorf et al. 2015) and reduce informal childcare by family members (Asai et al. 2016). Therefore, if a connection between childcare and diet quality exists, considering this specific time constraint is important to inform program implementation.

We follow the recommendation of numerous studies and further disaggregate time in childcare into its primary and secondary components in order to accurately characterize how households participate in childcare (Folbre et al. 2005; Folbre and Yoon 2007; Zick and Bryant 1996). Primary childcare is time spent directly interacting with the child, while secondary childcare is time spent performing a separate primary activity while having a child in your care. Zick and Bryant (1996) find that between 30 and 34 percent of total childcare time is spent in secondary childcare leading to studies that only consider primary childcare to be criticized for under-counting parents' time spent in childcare. Furthermore, primary childcare and secondary childcare may impact household food purchasing decisions differently. One example is that secondary childcare can increase a household's "perceived time constraint", which affects food-purchasing decisions (Rogus 2018). While we know of no study directly linking childcare activities to diet quality, You and Davis (2011) estimate the marginal effects of time spent in primary and secondary childcare on a child's probability of being overweight or obese. They find that increased time in secondary childcare by either parent is negatively associated with the probability a child between the age of 13 and 15 is overweight, while time spent in primary childcare is insignificant. Therefore, in addition to theoretical precedent, there is empirical precedent for differences in childcare type.

While many diet-quality studies often focus on important, but specific, aspects of the household diet, such as total caloric intake, servings of fruits and vegetables, or consumption of whole grains (Rickard et al. 2013; Variyam 2008; Darmon et al. 2014; Darmon and Drewnowski 2008), our research uses a comprehensive measure, the 2010 Healthy Eating Index. The 2010 HEI, which measures diet quality in terms of conformance with the 2010 Federal Dietary Guidelines,[1] can be calculated with both food consumption and purchasing data and has been used to assess the diet quality of the U.S. population and subpopulations for a variety of studies (Guenther et al. 2013; Krebs-Smith et al. 2010; Volpe and Okrent 2012; Guenther et al. 2014). In addition to considering overall diet quality, using the HEI-2010 addresses a current gap in literature by investigating the relationship between input demands and reduced form commodity demands, rather than just the demand for inputs themselves (Davis 2014). While the HEI-2010 score for the average U.S. citizen has been increasing over time, low SES households have been left behind (Wang et al. 2014). Between 1999 and 2010, the HEI-2010 score increased by 2.9 points for both high and medium SES households, 5.7% and 6.4% increases respectively, while low SES households saw an increase of only 0.3 points over the same time period (Wang et al. 2014).

Previous research shows that income (Darmon and Drewnowski 2008; Rao et al. 2013) and food assistance (Anderson and Butcher 2016) can be significant factors affecting household food purchases. For example, Castner and Mabli (2010) estimate that a 10% increase in a household's food budget leads to only a 0.3% increase in its HEI; and Anderson and Butcher (2016) find that an increase in SNAP benefits increases food purchases, but does not necessarily induce healthier food purchases. Therefore, we hypothesize that a household's time constraint is important to consider

[1] The HEI was originally developed to measure the diet quality of food consumption using the National Health and Nutrition Examination Survey (NHANES).

in addition to, and in conjunction with a household's income and SNAP eligibility and participation. If this is true, policy interventions like SNAP may not work effectively for the intended target population if time is not considered. Thus, to investigate the relationship between time and these other factors we perform sub-sample analyses.

3 Theoretical framework

Because households do not aim to have low diet quality or to be unhealthy (Zachary et al. 2013; Craeynest et al. 2005; Share Our Strengths 2018), the outcome of low diet quality is likely because of tradeoffs the household must make in conjunction with other goals. Becker's (1965) household production model provides a framework for how households allocate money and time to produce commodities that the household then consumes. In our particular application, households combine purchased food items and time to produce the commodity HEI. Given our interest in childcare time allocation, we cannot estimate an indirect production function because time allocations are a choice variable. In contrast, we develop a commodity production function similar to that discussed by Rosenzweig and Schultz (1983).

We follow this approach and model households as using market inputs and time to produce household commodities and maximize utility. Household diet quality, measured by the HEI, is one of these commodities. Household HEI depends directly on purchased food items, $\mathrm{X_f}$, the amount of time spent in food activities, $\mathrm{T_f}$, and household characteristics, K. This production process is conditional on a set of committed time categories separated into three categories; primary childcare, T_p, secondary childcare, T_s, and all other committed activities, T_0. We condition the production function on committed activities because households are required to participate in committed activities and increased time allocated to them is associated with less time spent on food-related activities (Kalenkoski and Hamrick 2013). Additionally, we separate childcare from other committed activities because of the prevalence of households with children in food assistance programs (Gray et al. 2016). Finally, we separate childcare by component in order to more accurately characterize how households participate in childcare (Folbre and Yoon 2007; Zick and Bryant 1996). Therefore, the conditional commodity production function is given by

$$\mathrm{HEI} = \mathrm{H}\left(\mathrm{X_f}, \mathrm{T_f}, \mathrm{K}; T_p, T_s, T_0\right), \qquad (1)$$

The household then maximizes its conditional utility function subject to the HEI conditional commodity production function in Eq. (1) and a time constraint. This maximization yields the household's best response functions for the purchased foods and time in FAH activities, X_f^*, T_f^*. In the context of the household production model, the arguments of X_f^* and T_f^* are exogenous variables such as price, wages, and environmental variables (You and Davis 2010). An estimate of time spent in food activities is included in empirical estimation because the direct effect of time activities are of interest, however individual food purchases are not because we do not have accurate price information. Therefore, we include geographic controls to account for the price and food environment and household demographics to control for the "in the house environment". In addition, it is common to substitute household demographic variables, such as education, for the wage equation of the household following Mincer (1974). A similar approach is used by You and Davis (2010) to develop a two-stage collective household production model for household food expenditures, parental time allocations, and childhood BMI. Making these substitutions and allowing E to represent geographic control variables. The resulting hybrid production function will include both exogenous variables, i.e., household demographics and environmental variables, and endogenous variables, i.e., time allocated to food and childcare. This hybrid production function is given by

$$HEI^{*} = \mathrm{H}\left(\mathrm{E}, \mathrm{K}, \mathrm{T_f}, T_p, T_s, T_0\right), \tag{2}$$

Given our policy and childcare focus, our empirical approach is to estimate Eq. (2) for all households and one set of sub-samples. Mhurchu et al. (2013) show that low-income households have relatively higher own-price expenditure elasticities than higher-income households. In a similar fashion, households participating and eligible for SNAP may have a larger response with respect to time because of their relatively lower ability to substitute purchased goods. Therefore, we create a sub-sample, based on SNAP participation and eligibility to potentially isolate and compare these differences.

4 Empirical approach and identification strategy

Given our goal of estimating the conditional hybrid production function in Eq. (2), the ideal empirical model is given by

$$HEI_i = \alpha_i + \beta_1 TF_i + \beta_2 TP_i + \beta_3 TS_i + \gamma \boldsymbol{K_i} + \delta \boldsymbol{FE_{SSU}} + \varepsilon_i, \tag{3}$$

where HEI represents the HEI-2010 score for a household's FAH purchases for a week, TF represents time spent in food activities, TP represents time spent in primary childcare, and TS represents time spent in childcare for household i. **K** represents household characteristics including race, education, income, number of adults, car access, and nutrition education. Race, education, and income are substituted for household wage (Mincer 1974); the number of adults is used to control for multiple adults performing household tasks; and car access and nutrition knowledge are included because they have been shown to impact diet quality (Hillier et al. 2016; Lee et al. 2016). **FE** controls for geographic environment variables, such as food environment and prices, through geographic fixed effects. Although the FoodAPS cross-sectional dataset is useful in constructing most of these variables, it lacks information on time spent on childcare and FAH activities; thus, Eq. (3) cannot be directly estimated with the FoodAPS data alone. Therefore, there is a need for a time allocation estimate, which requires additional data.

To accomplish this next estimation, we employ a two-stage instrumental variable (TSIV) approach using the ATUS data. The TSIV approach was developed by Angrist and Krueger (1992) and has been used in literature ranging from educational attainment to income inequality (e.g., Angrist and Krueger 1995; Dee and Evans 2003; Hamermesh 2007) to overcome the problem of missing variables in a dataset. Briefly stated, for our case, the TSIV method relies on a preliminary model where time spent in total childcare, primary childcare, secondary childcare, and FAH activities are regressed against household characteristics in **K** plus others that are omitted from **K** using the ATUS data sample. These coefficient estimates are used with the FoodAPS data sample to create predicted time use measures. We use this method to develop FoodAPS-compatible estimates of time spent in total childcare, primary childcare, secondary childcare, and FAH activities.

The TSIV method provides a suitable identification strategy if two major assumptions hold. First, the two datasets must be jointly independent and, second, the two samples must be drawn from the same population. The first assumption holds for FoodAPS and the ATUS because the survey samples were collected independently of each other. The second assumption is expected to hold because both surveys were developed to be nationally representative, resulting in the U.S. civilian noninstitutionalized population being the population for both datasets. We conduct means tests of demographic variables used in the estimation to test the second assumption. Similar to standard instrumental variables and two-stage least squares, the estimates from TSIV cannot achieve unbiasedness. However, the bias will tend toward zero, instead of the OLS probability limit (Agrist and Krueger 1995). Therefore, there is low risk of spurious or misleading inferences due to finite-sample bias.[2] In addition, the estimates can achieve consistency when a valid instrument is used (Inoue and Solon 2010).

Armed with the TSIV method, our goal is to estimate the following model that directly incorporates estimated time spent on household activities:

$$HEI_i = \alpha_i + \beta\widehat{\boldsymbol{TA}} + \gamma \boldsymbol{K}_{i,FoodAPS} + \delta \boldsymbol{FE}_{SSU} + \varepsilon_i, \tag{4}$$

where $\widehat{\boldsymbol{TA}}$ is a vector of estimated time allocations. With the time allocations directly included, one can now see how each argument in Eq. (2) relates to its empirical counterpart, Eq. (4). We employ two specifications for Eq. (4): one specifying $\widehat{\boldsymbol{TA}}$ as estimated time in total childcare and FAH activities, and a second specifying $\widehat{\boldsymbol{TA}}$ as a vector containing the estimated times associated with primary and secondary childcare separated. The only argument in Eq. (2) that is not accounted for in Eq. (4) is T_0, other committed time activities. Using Fractional Multinomial Logit[3] to estimate $\widehat{\boldsymbol{TA}}$, allows for the errors to be correlated, but estimates time allocations in shares. Therefore, including T_0 would cause perfect multicollinearity in the empirical model and is excluded.

To estimate the time allocations, $\widehat{\boldsymbol{TA}}$, in the first stage of the TSIV method, we use a Fractional Multinomial Logit to simultaneously estimate the household's time activities from the ATUS data. More specifically, we estimate

$$\boldsymbol{TA}_{i,j} = \alpha_0 + \beta_0 \boldsymbol{K}_{i,ATUS} + \varepsilon_{i,j,0}, \tag{5}$$

simultaneously for the j time-use activities using household demographic data, $\boldsymbol{K}_{i,ATUS}$, from the ATUS sample. After this equation is estimated, $\boldsymbol{K}_{i,ATUS}$ is replaced

[2] If TSIV is applied to the same sample, called Split Sample Instrumental Variable (SSIV), then the "Unbiased" SSIV estimator can be calculated by inflating the SSIV estimator by the inverse of the estimated attenuation bias. This requires the same information in both samples, which unfortunately is not true with our data because there is no time use information in the FoodAPS data set.

[3] A more detailed discussion of Fractional Multinomial Logit is presented in Appendix 1.

with $\boldsymbol{K_{i,FoodAPS}}^1$, the same vector of household demographic as $\boldsymbol{K_{i,ATUS}}$, but from FoodAPS, in order to calculate $\widehat{\mathbf{TA}}_i$, such that

$$\widehat{\boldsymbol{TA}}_{i,j} = \widehat{\alpha_0} + \widehat{\beta_0}\boldsymbol{K_{i,FoodAPS}}^1, \tag{6}$$

When using instrumental variable techniques, care must be given to choosing proper instruments. To be clear, we need instruments that will be part of $\boldsymbol{K}^1_{i,ATUS}$ in Eq. (5) and therefore influence $\widehat{\boldsymbol{TA}}_{i,j}$, but not be part of $\boldsymbol{K_{i,FoodAPS}}$ in Eq. (4), so that the only role these instruments play in influencing HEI is via $\widehat{\boldsymbol{TA}}_{i,j}$. Thus, the instruments must be correlated with the time activities, but not directly affect household HEI scores. We employ two tactics to try to achieve proper identification of the effect that time spent on childcare has on diet quality. First, we limit our study sample to households with children (of any age) in both the FoodAPS and ATUS data sets in order to eliminate distinction between households with or without children. Second, we propose that the presence of NSA children can reasonably be assumed to correlate with childcare time, but not household diet quality. Our reasoning is as follows, while the presence of a child may impact household diet quality (Senia et al. 2017), e.g., parents purchase healthier food because they care for the child's well-being, there is not a strong reason to believe that the distinction of the child's age, i.e., school age or not, would impact household diet quality. To test the validity of our instrument, we conduct a Sargan test post estimation given by

$$\widehat{\varepsilon_i} = \alpha_S + \beta_S\boldsymbol{K_{i,ATUS}} + \epsilon_{i,S}, \tag{7}$$

where $\widehat{\varepsilon_i}$ are the residuals from Eq. (4) and $\boldsymbol{K_{i,ATUS}}$ are the regressors used in Eq. (5) to estimate the coefficients in the first stage. If the estimated coefficients for $\boldsymbol{\beta_s}$ are not statistically significant, there is evidence the instrument is uncorrelated with HEI_i and reduces doubt that the instrument is invalid.

Using predicted values as instruments requires us to simulate multiple samples using replicate weights so that the standard errors more accurately approach their theoretical true value. In order to implement this approach, we use a successive difference replication method for the ATUS estimations, with 160 replications, and jackknife replication method for the FoodAPS estimations, with 57 replications. Each of these methods follows the suggested approach given in each of the data's documentation (BLS 2017; ERS 2016).[4]

5 Data

We use the ATUS survey to estimate time spent in childcare and FAH activities for FoodAPS households. The ATUS has continually collected time-use information by telephone survey since 2003, in order "to develop a nationally representative sample of how people spend their time" (BLS 2017). Individuals are randomly selected from a subset of households that have completed interviews for the Current Population Survey (CPS). Respondents are interviewed only one time about how they spent their

[4] Specifics on each of these processes can be found in the data documentation for each of the data sets by referencing the ATUS User's Guide Chapter 7, page 34–41 and the FoodAPS User's Guide Section 6.1, pages 20–24.

time in the previous 24-h period, where they were, and whom they were with during each activity. The time allocations are characterized into over 400 specific primary activities, while only childcare and adult care can be characterized as secondary activities. In general, major time-use trends tend to be stable over time and therefore multiple years are often pooled together (Basner et al. 2007; Cawley and Liu 2012; Fox et al. 2013). However, recent research has shown that certain trends, particularly around food, have shifted as a result of the "Great Recession" (Hamerick and Abigail 2014; Aguiar et al. 2013). Therefore, we limit our ATUS sample to the years of 2010–2014, a period that includes observations from two years before and after the year the FoodAPS sample was collected. We further limit our sample to observations that have children present in the household because of our specific focus on time spent in childcare. Finally, we exclude observations with data quality issues, as noted in the data documentation, and with missing values for covariates. These exclusions result in 16,511 observations used in the time-use estimation.

We define four time allocations of interest for estimation into FoodAPS from the ATUS: time spent on total childcare, time spent on primary childcare, time spent on secondary childcare, and time spent on FAH activities. Table 1 presents how specific ATUS activity codes were grouped into the four groups along with summary statistics. Primary childcare includes time directly caring for and helping a household child. Bathing a child, putting a child to bed, and playing games with the child are common examples of activities included in primary childcare. Secondary childcare includes all other activities where the respondent was fulfilling the role as caregiver, but actively participating in another primary activity. For example, a parent may be completing household chores such as laundry, while the child plays in another room. Time spent in total childcare is simply the total amount of time spent in primary or secondary childcare. FAH activities include grocery shopping, travel associated with grocery shopping, food preparation and cleanup, and eating meals at home. Individuals in households with children spend a significant portion of their time in childcare, with about 4 h in secondary childcare and 1.5 h in primary childcare. The

Table 1 Time use variable definitions, ATUS codes, and means

Variable name	ATUS codes included	Mean minutes per day All Households	Mean minutes per day Households with a Child
Primary Childcare	Caring for and helping HH children (030100) Activities related to HH children's education (030200) Activities related to HH children's health (030300)	28.59 (0.331)	94.62 (1.103)
Secondary Childcare	All ATUS codes, excluding 030100, 030200, 030300, 600002, 020200, 070101 with child present	66.59 (0.599)	240.21 (1.846)
Combined Childcare	All Primary and Secondary Childcare ATUS codes	95.19 (0.771)	334.83 (2.190)
Food at Home Activities	Eating and drinking, including travel (600002) Food preparation and cleanup (020200) Grocery Shopping (070101)	87.8 (0.346)	101.94 (0.826)
Observations		60,008	16,511

Fractional Multinomial logit requires that the share of activities sum to one. Therefore, we cannot include any secondary activity for a primary activity we include in the estimation. While this does not impact primary childcare, it does impact FAH activities. As a result, FAH activities are not included in our calculation of secondary childcare time, but are estimated as a primary activity combined 5.5 h allocated to childcare is more than 3 times greater than the average amount allocated to FAH activities.

For information in $\boldsymbol{K_{i,FoodAPS}}$ and calculation of *HEI*, we rely on USDA Economic Research Service's FoodAPS dataset, which is a nationally representative survey of U.S. household food purchases and acquisitions collected between April 2012 and January 2013. Information on foods purchased and otherwise acquired for consumption at home and away from home was collected through barcode scanning, receipt validation, and food diaries. The 4826 respondents were interviewed at the beginning and the end of a seven-day period and reported food acquisitions throughout the entire week. During the interviews, information was collected about the households' sociodemographic characteristics, food shopping patterns, diet and health knowledge, and the economic well-being. When compared to the Consumer Expenditure Survey and the IRI food purchasing consumer panel dataset, FoodAPS reports slightly higher food expenditures (Clay et al. 2016). The discrepancy is likely due to FoodAPS's focus on all food acquisitions rather than just purchases. Although relatively new, FoodAPS has already been used extensively to investigate a wide variety of food-choice issues (Smith et al. 2016; Todd and Scharadin 2016).

Each food item in FoodAPS is assigned both micro- and macronutrient information and Food Pattern Equivalent values. However, the nutrition information is relatively incomplete and inaccurate for FAFH acquisitions in the FoodAPS sample. Therefore, we calculate the 2010 HEI score using a similar approach as Mancino et al. (2018), but only include FAH acquisitions. Although the incompleteness limits our analysis to FAH, we believe this focus creates only a minor concern because of our interest in federal food assistance policy and its direct affect on FAH purchases. We use the detailed FAH nutrition information to calculate *HEI*, which measures diet quality in terms of conformance with Federal dietary guidance for each FoodAPS household.[5] The HEI score ranges from 0 to 100 and is based on 12 components, including nine adequacy components (e.g., whole fruit, whole grains, and dark green and orange vegetables) and three moderation components (e.g., empty calories, sodium, and refined grains). Components are measured using a density approach to set standards, such as per 1000 calories or as a percent of calories. The 2010 HEI captures the key recommendations of the 2010 Dietary Guidelines and has been used to assess the diet quality of the U.S. population and subpopulations, to evaluate interventions, to research dietary patterns, and to evaluate various aspects of the food environment using both food consumption and purchasing data (Guenther et al. 2013; Reedy et al. 2010; Volpe and Okrent 2012; Guenther et al. 2014). For 102 of the FoodAPS households, *HEI* is not able to be calculated because of insufficient food acquisitions throughout the survey week.

The geographic fixed effects, $\boldsymbol{FE}$, are created by taking advantage of FoodAPS' three-stage sampling method. First, 948 primary sampling units (PSU) were defined by metropolitan statistical area boundaries. Using a stratified sample, 50

[5] The HEI was originally developed to measure the diet quality of food consumption using the National Health and Nutrition Examination Survey (NHANES); however, it has been extended for use in food purchasing studies as well. (Guenther et al. 2013; Krebs-Smith et al. 2010; Volpe and Okrent 2012; Guenther et al. 2014)

PSUs were selected. Within each PSU, eight secondary sampling units (SSU) were defined using the Census Block Group (CBG) definition, resulting in 400 SSUs. Finally, within each SSU, household addresses were sampled according to other household characteristics. As a result of the third sampling stage, five SSUs were not used leaving 395 SSUs in the final sample. We use the SSUs as our geographic fixed effects, $\boldsymbol{FE}$, to control all household-invariant characteristics at the CBG level, including the local food environment and local food prices. In addition, household characteristics such as income, education, nutrition knowledge, and car access are used as controls. These household demographics are represented $\boldsymbol{K_{FoodAPS}}$ in empirical Eq. (4) and by E and K in theoretical Eq. (2). After limiting the sample to households with children, 2100 households are used in the estimations. Table 2 presents variable definitions and summary statistics for FoodAPS data used in our estimation.

Considering the time use estimates of interest, the means for time spent in primary childcare, secondary childcare, and FAH activities are 93, 248, and 102 min per day respectively. These are very similar to the average minutes per day spent in each activity by ATUS respondents with children (Table 1). FAH activities and primary childcare differ by a minute or less, while secondary childcare has the largest difference of only 8 min. The similarity between the mean ATUS time allocations and the mean estimated FoodAPS time allocations suggests that the estimates are an accurate proxy.

Collection time periods differ between the ATUS and the FoodAPS datasets. The ATUS is collected over a 24-h period, while the FoodAPS is collected over a 7-day period. We are implicitly assuming that the collection period for the ATUS is a representative day and the collection period for FoodAPS is a representative week. More specifically, the estimated time allocations are minutes per day because of ATUS' 24-h collection period, while our calculation of the *HEI* uses a household's FAH purchases for an entire week. While *HEI* could be calculated for each day, it would not be appropriate using FAH purchases. Households normally conduct FAH shopping trips for multiple days at a time, meaning that calculating *HEI* for a single day would likely misrepresent a household's consumed diet quality and lead to many zero values for days no FAH purchases were made. Therefore, we calculate *HEI* for the entire week in order to more accurately capture a household's consumed diet quality. Past literature has both addressed (You and Davis 2019) and not addressed (Hamermesh 2007) the collection time period difference when using the ATUS in conjunction with other data sets. We follow Hamermesh's approach and interpret the coefficient estimate on each of the estimated time allocation variables, $\boldsymbol{\beta}$ from Eq. (4), as the change in the average weekly HEI-2010 score associated with a change in a daily time allocation.

Within the full FoodAPS sample, the sub-sample we consider investigates how SNAP participation and eligibility interact with the impact of time spent in childcare on household HEI. The sub-sample divides households into three categories: households participating in SNAP, SNAP eligible households not participating in the program, and households not eligible to participate in SNAP. Although there are other numerous poverty measures, choosing SNAP eligibility is consistent with our focus on the effectiveness of federal food assistance programs. Although SNAP eligibility is difficult to assess because it can vary from state to state (Todd and Boohaker 2019), information on predicted SNAP eligibility is available in FoodAPS.

Table 2 Variable names, definitions, and means of FoodAPS variables

Variable	Definition	Mean	Std. Dev.
Household HEI-2010 score	HEI-2010 score for all FAH acquisitions by household	51.66	(0.416)
Estimated minutes in FAH Activities	The predicted minutes per day the household spent in grocery shopping, cooking, clean up, etc.	101.83	(0.831)
Estimated minutes in Primary Childcare	The predicted minutes per day the household spent in primary care (bathing the child, helping with homework, etc.)	93.56	(1.567)
Estimated minutes in Secondary Childcare	The predicted minutes per day the household spent in secondary childcare (doing laundry while taking care of child)	248	(2.286)
Number of Adults	The number of people over 18 present in the household	2.15	(0.023)
Natural log of HH income	The natural log of the household's monthly income	8.35	(0.045)
Household has access to a car	Binary variable equal to 1 if the household has access to a car, either owned or borrowed, for grocery shopping	0.93	(0.012)
Primary respondent heard of MyPlate Standards	Binary variable equal to 1 if the household's primary respondent has heard of the federal MyPlate guidelines	0.32	(0.020)
Highest level of education is associates degree	Binary variable equal to 1 if the highest level of any household member is an associates degree	0.35	(0.026)
Highest level of education is high school	Binary variable equal to 1 if the highest level a household member is high school diploma	0.34	(0.021)
Does not own residence	Binary variable equal to 1 if the household does not own the residency	0.41	(0.024)
Primary Respondent is Black	Binary variable equal to 1 if the household's primary respondent is black	0.15	(0.015)
Primary Respondent is Hispanic	Binary variable equal to 1 if the household's primary respondent is Hispanic	0.19	(0.012)
Observations		2100	

Therefore, we use a household's predicted SNAP eligibility to categorize households in the food assistance sub-sample.

6 Results

Table 3 presents results for two specifications of our fixed-effects model corresponding to Eqs. (4a) and (4b) and the results for our subsample analysis. All specifications regress household HEI scores against 9 household-level characteristics[6] and fixed effects at the secondary sampling unit level, which for FoodAPS is

[6] The household characteristics are income, car access, number of household members over 18 years old, knowledge of MyPlate standards, level of education (post-secondary education as base group), household ownership status, race, and ethnicity.

Table 3 Estimation results for Eqs. (4a), (4b), and SNAP participation/eligibility subsample

Variables	Eq. (4a) Combined Childcare	Eq. (4b) Separated Childcare	Not Eligible for SNAP	Eligible Non-SNAP	SNAP
Estimated Childcare	−11.20 (7.02)				
Estimated Primary Childcare		33.03*** (11.73)	30.74 (20.48)	27.10 (22.85)	26.47* (15.48)
Estimated Secondary Childcare		−56.45*** (14.08)	−76.51*** (20.66)	−49.25** (24.96)	−69.74*** (16.02)
Estimated FAH Activities	63.57** (31.96)	98.30*** (34.50)	172.37*** (40.35)	128.75** (57.44)	141.12*** (38.62)
Number of People over 18	−0.73** (0.33)	−0.66** (0.33)	−0.12 (0.66)	−0.79 (0.64)	−0.26 (0.42)
Natural log of HH Income	0.48** (0.23)	0.29 (0.24)	0.48 (0.99)	0.57 (0.49)	0.27 (0.25)
Household has access to a car	1.92** (0.89)	1.76** (0.88)	12.75*** (3.25)	1.69 (2.18)	−0.17 (1.06)
Aware of MyPlate Standards	1.96*** (0.66)	1.88*** (0.65)	−0.41 (0.98)	2.26 (1.39)	3.06*** (0.98)
Associates Degree	−3.29*** (0.97)	−2.35** (0.98)	−3.01*** (1.16)	−6.03*** (1.87)	−4.13*** (1.59)
High School Diploma	−4.03*** (0.98)	−3.08*** (0.97)	−4.38*** (1.31)	−6.61*** (1.83)	−4.46*** (1.53)
Household Rents	−2.04*** (0.66)	−2.13*** (0.65)	−0.20 (0.66)	−0.75 (1.20)	−2.17** (0.93)
Prim. Respondent is Black	0.38 (1.04)	1.29 (1.04)	2.59* (1.49)	0.08 (1.84)	1.20 (1.08)
Prim. Respondent is Hispanic	0.34 (1.04)	0.44 (1.03)	1.32 (1.34)	2.90* (1.54)	1.50 (1.10)
Constant	47.94*** (2.81)	51.30*** (2.93)	36.82*** (9.72)	48.37*** (5.72)	52.27*** (3.61)
Observations	2100	2100	706	486	908
R-squared	0.043	0.053	0.107	0.106	0.074

*Statistical significance at 10% level, **Statistical significance at 5% level, ***Statistical significance at 1% level

Table 4 Marginal rate of substitution calculations between FAH activities and Childcare Activities

Sample	Primary Childcare		Secondary Childcare	
	MRS	Minutes	MRS	Minutes
Full	−0.34	−20.16	0.57	34.46
SNAP	−0.19	−11.25	0.49	29.65
Eligible	−0.21	−12.63	0.38	22.95
Not Eligible	−0.18	−10.70	0.44	26.63

Minutes are a change in FAH minutes per day holding HEI constant given an hour increase in childcare

defined as a CBG.[7] Columns one and two of Table 3 correspond to Eqs. (4a) and (4b) and include predicted time allocations for total childcare and primary/secondary childcare, respectfully, as well as the predicted time allocation for FAH activities. As stated before, these predicted time allocations require data from the ATUS as well.[8] Columns three though five present sub-sample analysis results for our preferred specification (4b) to investigate the interaction between time allocations and participation and eligibility in SNAP. In Table 4, we present marginal rates of substitution (MRS) for the time activities estimated in the study. The MRS represents how time in FAH activities would need to change for a change in childcare time to keep household HEI constant.

6.1 Full sample

Before discussing results for our main variables of interest, namely, the coefficients for the predicted time allocations for childcare found in models (4a) and (4b), we briefly discuss the results of household characteristics, which serve as controls in the estimation of HEI. In general, results in Table 3 show that higher levels of education,[9] income, owning one's residence, access to a car, and being aware of MyPlate guidelines are all associated with higher household HEI-2010 scores. In contrast, more people over 18 in the household is negatively associated with HEI. The estimated coefficients on each of these household variables are consistent with past literature (e.g., Braveman et al. 2010; Inagami et al. 2009; McLeod et al. 2011) and are very stable across all model specifications.

In the column labeled Eq. (4a),[10] the coefficient on time spent in total childcare (–11.20) is negative, but not statistically significant. Although the coefficient has the expected sign, we may initially conclude that childcare time does not affect

[7] We also estimate all our models with fixed effects at the primary sampling unit level, as well as at the county level, and obtain similar results.

[8] Estimation of (4a) and (4b) requires estimation of Eq. (5) using the ATUS data applied to a fractional multinomial logic model. These important results, which focus on household time activities rather than their effect on diet quality, are presented in Appendix 1.

[9] The base group for level of education is a Bachelor's degree or higher. Therefore, the negative coefficients for High School Diploma and Associates degree indicate the positive impact of education on HEI.

[10] Appendix 2 provides results for a means test comparing the ATUS and FoodAPS sample. This comparison is necessary to show that the TSIV assumptions are satisfied.

household HEI; however, as implied from our earlier discussion, this null result may stem from inadequately distinguishing between primary and secondary components. First, this may be a result of Simpson's paradox (Blyth 1972), a general statistical principle stating that aggregate results may not have the same pattern as disaggregate results. These differences may exist because similar to healthy eating, primary childcare is an activity that provides long-term returns for the child. More time spent in primary childcare has been shown to positively impact education and social outcomes (Belsky et al. 2007; Hart and Risley 1995). As a result, parents that spend more time in primary childcare may be more likely to purchase food that is more nutritious because they value long-term returns. In contrast, secondary childcare likely acts as a distraction from the primary activity and contributes to overall stress, which has been shown to impair long-term decision-making (Starcke and Brand 2016). Therefore, it is important to consider primary and secondary childcare separately.

In the column labeled Eq. (4b), we indeed find that the coefficients on childcare are statistically significant when separated into its two components. The estimated coefficient for secondary childcare is –56.45, while the estimated coefficient for primary childcare is 33.03. The difference in sign follows the inference suggested above and matches empirical precedent for differences in primary and secondary childcare (You and Davis 2011). This may suggest that the impact of total childcare in column (4a) is relatively low because of the two opposing impacts seen in column (4b). Specifically, households focused on long-term decision-making will allocate more time to primary childcare, as well as purchase more nutritious food items. Despite primary childcare motivating a long-term mindset, secondary childcare creates difficulties in following through on those inclinations. The stress and distraction from multi-tasking can drive households to make "easier" food decisions, which are often less nutritious. Using the results from column (4b), we find that a 1-h reduction in secondary childcare leads to a 2.35-point increase in household HEI,[11] suggesting that secondary childcare may be a significant contributor to the diet quality gap.

The specifications in (4a) and (4b) also include the predicted time spent in FAH activities. The estimated coefficients are similar in sign (63.57 and 98.30, respectively), and significant for both specifications. Using (4b), these results imply that 30 min of additional FAH time per day would increase HEI by 2.01 points. The inclusion of FAH activities provides two important insights. First, the results show that time spent in childcare impacts household HEI directly and not just through limiting FAH time. In other words, it is not simply time committed to childcare constraining the amount of time spent in FAH activities, but that primary and secondary childcare affect household nutrition potentially through motivating long and short-term decision making. Second, the positive sign follows past literature that finds increased time in FAH activities is associated with increased diet quality (Monsivais et al. 2014; Wolfson and Sara 2015; Jabs and Devine 2006). This second point is an additional piece of evidence supporting the validity of the TSIV approach.

[11] A 1-h reduction in secondary childcare is equal to 0.042 of a day. Multiplying this by the estimated coefficient gives $(-0.042) \times (-56.45) = 2.35$.

In order to further test the validity of the TSIV time-allocation predictions, we perform a post-estimation Sargan test for the preferred specification (4b). While none of the regressors are statistically significant in this regression, it is most important to note that the coefficient on the presence of NSA children was not significant. Therefore, our instrument is not correlated with the error term of the second-stage regression. The results of this test can be found in appendix Table 7. Collectively, we believe that the consistency of the sign and magnitude of control variable coefficients, consistency of our estimates with past literature, and the results of the Sargan test provide strong evidence supporting the appropriateness and accuracy of TSIV time-allocation predictions from the ATUS data.

6.2 Subsamples regarding income and food assistance

To investigate how predicted time allocations interact with income and food assistance program participation, we re-estimate model (4b) with the sample split into three groups; households that receive SNAP benefits, households that are eligible but do not participate in SNAP, and households not eligible to receive SNAP. Table 3 shows these results. First, the sign of primary childcare remains positive, but it is no longer significant. Given Simpson's paradox (Blyth 1972) and the larger effect of secondary childcare, this change in significance is not concerning. In contrast, we find that predicted time spent in secondary childcare impacts households in each of these subsamples differently. The positive impact on HEI score by decreased secondary childcare is weakest for eligible, non-participants (−49.25). Although similar in direction, reducing secondary childcare is expected to have a stronger effect for SNAP participating and non-eligible households (−69.74 and −76.51, respectively). These results suggest that a household can be more responsive to changes in childcare time if their budget constraint is more relaxed. Therefore, by comparing SNAP participants to SNAP eligible non-participants, we expect a reduction in time spent in secondary childcare to be more effective in increasing diet quality when paired with food assistance programs.

Comparing the coefficients for estimated time spent in FAH activities, similar trends are present. As a household's budget constraint is relaxed, with eligible non-SNAP households the most constrained and not eligible households the least constrained, the impact of additional time spent in FAH activities increases. These results are intuitive because if a household purchases less nutritious cheap food, their diet quality will only slightly increase even if more time is devoted to FAH activities. In addition, the predicted time spent in primary childcare is marginally statistically significant for SNAP participating households, but is statistically insignificant for the other two subsamples. These results may suggest that much of the impact of primary childcare on the true time constraint is controlled for with accounting for time in FAH activities. Therefore, secondary childcare may have more of an effect on household HEI by impacting the "perceived" time constraint.

6.3 Marginal rates of substitution for time activities

Table 4 presents the MRS between primary and secondary childcare and FAH activities holding household HEI constant for the full sample and the SNAP sub-samples.

The MRS are calculated by setting the total derivative for the estimated conditional production function in Eq. (4b) to zero.[12] Therefore, the values in columns two and four of Table 4 can be interpreted as the number of minutes a household would need to increase or decrease their participation in FAH activities for an hour change in primary and secondary childcare.

The MRS calculations show that primary childcare and FAH activities are substitutes, while secondary childcare and FAH activities are complements with respect to HEI. If a household increases time spent in primary childcare by 1 h, we estimate the household would be able to decrease time spent in FAH activities by 20 min. This suggests that some activities associated with primary childcare may be indirectly increasing household diet quality. For example, a parent may help a child with homework for health class about healthy eating and in turn increase the probability of healthy food purchases. In contrast, if secondary childcare increases by 1 h, a household would have to increase time spent in FAH activities by 34.5 min. This supports our inference that the stress and distraction from multitasking may make participating in the primary activity less efficient.

The MRS between FAH activities and primary childcare is similar for each of the SNAP eligibility and participation sub-samples. The increase in FAH activities to account for a 1-h reduction in primary childcare only differs by 2 min between SNAP ineligible households and SNAP non-participating eligible households. In contrast, Table 4 shows that SNAP participating households have the highest MRS between secondary childcare and FAH activities. A 1-h increase in secondary childcare would need to be balanced by a half hour increase in FAH activities for a household's diet quality to remain the same. Low-income and SNAP participating households already have a difficult time meeting the time requirements necessary to meet nutritional standards (Davis and You 2010; Davis and You 2011; Rose 2007). These results suggest that SNAP and low-income households are not only expected to devote increased time to FAH activities in order to focus on raw ingredients, but also to compensate for increased participation in secondary childcare. Given our results suggest a negative association between secondary childcare and HEI, it is reasonable to consider childcare when considering food assistance policies. For example, pairing free after school programs with food assistance programs may be one way to help reduce households' secondary childcare time and possibly improve low-income households' diets.

7 Concluding comments and discussion

In this paper, we argue that time spent in childcare can be an important determinant of households' diet quality, as measured by the HEI. However, the food-acquisition dataset we use to calculate household HEI does not contain household time allocations. To overcome this obstacle, we use the ATUS dataset and a TSIV method to

[12] The general equation for the MRS is given by, $\frac{dy}{dx} = -MU_x/MU_y$. Therefore, the MRS for FAH activities with respect to primary childcare for the full sample is calculated as $\frac{dFAH}{dPC} = -\frac{33.03}{98.30} = -0.34$.

bring predicted time allocations into the FoodAPS dataset in order to estimate several specifications of our fixed-effects model. Thus, this research represents one of the first attempts to show that time spent in at least some types of childcare activities is negatively associated with household dietary quality, as reflected by the HEI.

Our findings attempt to answer three increasingly more detailed questions about the link between time spent in childcare activities and household HEI: First, we find that when predicted time spent in childcare is not disaggregated it is not statistically significant in relation to household HEI. Second, when predicted time spent on childcare is disaggregated into both primary and secondary childcare, we find that predicted time spent on secondary childcare is negatively associated with household HEI. Third, when we investigate data subsamples, we find that the negative result for time spent on secondary childcare is stronger for SNAP participants compared to eligible non-participants. In addition, we find opposite results with primary childcare being positively associated with HEI, but secondary childcare being negatively associated with HEI. These opposite results, which are robust across data subsamples,[13] differ from results obtained by You and Davis (2011), who found that primary and secondary childcare times have roughly the same importance to childhood overweight status. However, given that household diet quality and childhood overweight status differ across several dimensions (e.g., contributing factors, short-term vs. long-term outcome realization, and unit of analysis), different results across the two studies may be reasonable.

We found that predicted time spent in secondary childcare is negatively associated with household HEI. While secondary childcare, by definition, does not decrease the overall amount of time available for other activities and therefore does not technically affect a household's time constraint, previous research shows that it does increase the "perceived time constraint" (Herrington and Capella 1995; Mothersbaugh et al. 1993), which has been shown to impact the diet quality of food purchases (Rogus 2018). Numerous psychology studies show that decision making, especially long-term decision making, is impaired under stress or distraction (Starcke and Brand 2016). Therefore, although the true time constraint has not changed the "perceived time constraint" has increased making a household more likely to substitute short-term decisions for long-term decisions. Thus, the negative association between time spent in secondary childcare and HEI can be attributed to an increase in the "perceived time constraint" causing the household to move away from a long-term focus.

In contrast, we found a positive association be between primary childcare and household FAH HEI. At first glance, this association may seem counterintuitive from a time-constraint point of view because more time spent in primary childcare may constrain the amount of time available for healthy meal production. However, given that in our theoretical approach, the production of diet quality is conditional on primary childcare, it may be reasonable to view time spent in primary childcare and food-related activities as substitutes rather than complements. Past research suggests

[13] Subsample analysis by nutrition education and food environment produced robust results in terms of both significance, sign, and in general, magnitude.

that both primary childcare (Belsky et al. 2007; Hart and Risley 1995) and nutrition (Asfaw 2018; Bitler et al. 2019) are investment activities that provide long-term returns for the child, as measured by health, education, and social outcomes. Therefore, if a household is pursuing the goal of child development, then it is reasonable to believe there may be a positive relationship between conditional diet quality and time spent in primary childcare. On the other hand, it may be reasonable to think that primary childcare may also increase the “perceived time constraint”. This is less likely, however, due to the nature of primary versus secondary childcare. Primary childcare requires focus on the childcare activity, (i.e., reading a story, helping with homework). Therefore, that time is less likely to be viewed as “not completing” another activity. In contrast, secondary childcare naturally invokes this view through multi-tasking.

The opposite results we find for primary and secondary childcare may suggest investigating their impacts from a new angle. Rather than considering them both as factors that equally affect a household’s time constraint, our results suggest separate mechanisms may be at work. Further investigation into the topic may consider approaching the topic more generally, allowing a diet quality production function to interact with other household production functions. This type of treatment would allow time spent in childcare to enter into multiple household production functions and potentially better account for synergistic uses of time. In addition, future studies may consider how to directly address the differences between the “perceived” time constraint and the real time constraint. We believe that this may be an important consideration when investigating the differences between primary and secondary childcare.

When interpreting the results, there are a few limitations for consideration in future studies. First, we limited time activities to primary childcare, secondary childcare, and FAH activities because of our focus on federal food assistance programs. In addition, the use of TSIV to create predicted time allocations meant not including “other committed activities”. The exclusion of these additional activities has the potential to introduce omitted variable bias. However, this bias is most likely to impact the coefficient on primary childcare and FAH activities, rather than secondary childcare, because secondary childcare is completed in conjunction with other activities. The direction of the potential bias is likely negative for primary childcare and FAH activities,[14] pulling both coefficient estimates closer to 0. Future studies may consider investigating the impact of more household activities on household HEI to better account for household time constraints and mitigate any potential omitted variable bias.

Second, we control for multiple adults performing household tasks by including a variable for the number of adults in the household. However, given that childcare time is known to be unevenly split, a more accurate proxy for splitting the responsibility would be beneficial if data is available. Finally, it is important to note the

[14] The sign of the estimated coefficient and the sign of the correlation between the included and excluded variable are used to predict the sign of the direction of the bias. In this case, both estimated coefficients are positive. If we assume time on other activities decreases time in primary childcare and FAH activities, then the correlation is negative. Therefore, the predicted direction of the bias is negative.

R-squared values on our full and sub-sample estimations for our preferred specification: Our preferred specification, Eq. (4b), has an R-squared value of 0.053, which may be considered low explanatory power. However, our goal is not to accurately predict household HEI, but to test whether time spent in childcare affects it. Therefore, given the complexity of the household diet quality decision, explanatory power of this level is useful in informing policy on the determinants of household diet quality. In addition, the R-squared values increase to between 0.07 and 0.11 once we subsample by food assistance participation and eligibility.

If constructed properly, a policy addressing household time constraints has the opportunity to address diet quality directly. A program that provides free or subsidized childcare, such as an after school program has the potential to positively affect household HEI. Demand-side food-assistance policies such as SNAP, Women, Infant, and Children (WIC), and Temporary Assistance for Needy Families (TANF)[15] supplement a household's income. Although the qualifications for each program are different, they each assume that a household's budget is the only binding constraint. In addition, state and local supply-side policies, such as FFFI and HFRA,[16] attempt to create healthier food environments. While the food environment has been shown to have an impact on diet quality, each of these programs assumes the availability of healthy food is a household's only limitation. In contrast our analysis shows that time constraints, particularly childcare may be an important limiting factor. For example, even if a household has the income and food availability to prepare a healthy meal, time limitations may force them to tend towards less healthy convenience foods. While further investigation into this area is needed, our research suggests that the effectiveness of current policies aimed at improving diet quality may be limited if time constraints, particularly with respect to childcare, are not considered.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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[15] SNAP, WIC, and TANF are three major food assistance programs. SNAP is the largest food assistance program, serving approximately 36 million people in May 2019. While there are additional state and federal qualifications, in general households earning under 130% of the poverty line are eligible. In contrast, the eligibility for WIC and TANF are more restrictive. For example, in addition to meeting income guidelines, only pregnant, postpartum, and breastfeeding women, infants and children up to age 5 are eligible for WIC.

[16] The FFFI is Pennsylvania financing program intended to stimulate investment of private capital in low-wealth communities, remove financing obstacles and lower operating barriers to supermarkets in low-wealth communities, and reduce the high incidence of diet-related diseases by providing healthy food. Similarly, Louisiana's HFRA was enacted in 2009 and provides grants and loans to make healthy food available in low-income communities.

8 Appendix 1. Discussion of Fractional Multinomial Logit and estimation results for equation 10

Papke and Wooldridge (1996) first used this method to investigate 401(k) participation and it has since been used to estimate share allocations of land, budget, and time (Mullahy and Robert 2012, Mullahy 2014). While there are multiple fractional regression techniques, such as the beta-distribution, zero-one inflated beta distribution and Dirichlet distribution, these models are not appropriate for the estimation of (7) because they do not allow for both extreme values (i.e., 0's and 1's) and the errors to be naturally correlated as the fractional multinomial logit (FMNL) does (Garay 2015). Allowing for the errors to be naturally correlated is necessary because spending more time on one activity means spending less on another given the fixed amount of time in a day. In addition, allowing for extreme values is necessary because a household may spend no time in a particular activity (e.g., a household with no children has no time spent in childcare). A concern with using FMNL is that it satisfies the independence of irrelevant alternatives criteria. In order to test this criterion, we varied the excluded group in estimation and found that in general, the sign, magnitude, and significance of the results were robust throughout the variations.

Using FMNL during the first stage regression also allows for the share of day in other activities, the share of the day not spent in primary, secondary, or FAH activities, to be accounted for in the "outside" group. Given that the shares sum to one, one time activity must be excluded for estimation. Although the estimates for the outside group can be calculated, they must also be excluded from the second stage regression to avoid perfect multi-collinearity. We focus our time variable estimations on the particular variables of interest to introduce as little estimation error as possible and try to account for other time activities through household characteristics. For example, we include a binary employment variable to account for similar information that would be in an estimated time spent working variable.

Tables 5 and 6

Table 5 Results for Eq. 8 using combined childcare

Variables	FAH activities	Childcare	Variables	FAH activities	Childcare
Child Aged 1–2	0.071*** (0.023)	0.167*** (0.018)	Hispanic	0.165*** (0.025)	−0.043 (0.030)
Child Aged 3–5	0.070*** (0.018)	0.124*** (0.016)	Married	0.159*** (0.030)	0.027 (0.027)
Annual Income	−0.000*** (0.000)	−0.000* (0.000)	Some Post HS Education	−0.009 (0.024)	−0.001 (0.021)
Resides in Metro	0.014 (0.022)	−0.010 (0.025)	Bachelors Degree	0.024 (0.029)	0.034 (0.026)
Resides in Midwest	−0.014 (0.023)	0.021 (0.025)	Unemployed	0.478*** (0.029)	0.690*** (0.025)
Resides in South	−0.090*** (0.024)	−0.017 (0.027)	NILF	0.691*** (0.024)	0.798*** (0.021)
Resides in West	−0.007 (0.025)	−0.002 (0.025)	Self-Employed	0.022 (0.033)	−0.017 (0.036)
Rents Residence	−0.020 (0.023)	−0.063*** (0.021)	Car Access	−0.284*** (0.023)	−0.249*** (0.022)
Avg. Age of Household	0.013 (0.010)	0.014 (0.009)	HH mem. >65 years old	−0.102* (0.054)	0.028 (0.063)
Residence is Free	−0.091 (0.084)	−0.028 (0.073)	Sing. Head of HH	−0.084 (0.053)	−0.213*** (0.068)
Black	−0.080* (0.048)	−0.094*** (0.034)	Fem. Sin. Head of HH	0.161*** (0.049)	0.291*** (0.067)
Asian	0.287*** (0.035)	−0.117*** (0.038)	Constant	−2.716*** (0.209)	−1.371*** (0.177)
Observations	16,511	16,511		16,511	16,511

Table 6 Results for Eq. 8 using primary and secondary childcare

Variables	FAH activities	Primary childcare	Secondary childcare
Child Aged 1–2	0.072*** (0.023)	0.521*** (0.027)	0.012 (0.023)
Child Aged 3–5	0.070*** (0.018)	0.294*** (0.024)	0.055*** (0.020)
Annual Income	−0.000*** (0.000)	0.000*** (0.000)	−0.000*** (0.000)
Married	0.159*** (0.030)	−0.023 (0.040)	0.042 (0.032)
Some Post HS Education	−0.009 (0.024)	−0.012 (0.032)	0.003 (0.025)
Bachelor's Degree	0.025 (0.029)	0.178*** (0.034)	−0.019 (0.031)
Graduate Degree	0.056* (0.034)	0.202*** (0.046)	−0.071** (0.033)
Unemployed	0.479*** (0.029)	0.752*** (0.041)	0.667*** (0.030)
Not in Labor Force	0.691*** (0.024)	1.011*** (0.032)	0.711*** (0.023)
Self-Employed	0.022 (0.033)	−0.004 (0.045)	−0.020 (0.042)
Black	−0.081* (0.048)	−0.253*** (0.045)	−0.038 (0.038)
Asian	0.287*** (0.035)	−0.015 (0.051)	−0.165*** (0.044)
Other Race	0.011 (0.066)	−0.115 (0.083)	0.007 (0.064)
Hispanic	0.165*** (0.025)	−0.145*** (0.035)	−0.006 (0.036)
Resides in Metro	0.014 (0.022)	0.053 (0.034)	−0.032 (0.029)
Resides in MW	−0.014 (0.023)	−0.024 (0.035)	0.039 (0.029)
Resides in South	−0.091*** (0.024)	−0.086** (0.034)	0.012 (0.032)
Resides in West	−0.007 (0.025)	−0.065* (0.037)	0.024 (0.029)
Rents Residency	−0.020 (0.023)	−0.091*** (0.031)	−0.052** (0.025)
Avg. HH Age	0.013 (0.010)	0.030** (0.014)	0.008 (0.010)
Residence is Rent Free	−0.091 (0.084)	0.085 (0.121)	−0.076 (0.081)
Access to Car	−0.284*** (0.023)	−0.260*** (0.041)	−0.246*** (0.025)
HH member >65 years old	−0.101* (0.054)	0.150** (0.075)	−0.015 (0.078)
Single-Head of Household	−0.084 (0.053)	−0.145 (0.094)	−0.244*** (0.076)
Female Single-Head of Household	0.161*** (0.049)	0.347*** (0.093)	0.273*** (0.077)
Constant	−2.717*** (0.209)	−3.138*** (0.274)	−1.500*** (0.198)
Observations	16,511	16,511	16,511

9 Appendix 2. Means test comparing sample demographics between the ATUS and FoodAPS

Table 7 presents the means of key demographic variables for both FoodAPS and the ATUS, along with *P* values comparing the means from each sample. Only two of the 23 sample demographics are different at a 5% statistical significance. Although there are two means that differ between the two samples, the overall lack of statistically significant differences suggests that both surveys can be considered sampled from the same population. Thus, using TSIV is appropriate for these two datasets.

Tables 7 and 8.

Table 7 Key demographic variables for Food APS and ATUS data sets

Variables	ATUS	FoodAPS	2-tailed *P* value	Variables	ATUS	FoodAPS	2-tailed *P* value
Annual Income	75,060.77 (564.79)	73,222.95 (2946.06)	0.54	Highest Educ is Graduate Deg.	0.21 (0.00)	0.19 (0.02)	0.30
Unemployed	0.09 (0.00)	0.10 (0.01)	0.42	Single Head of Household	0.11 (0.02)	0.15 (0.02)	0.12
Resides in a Metro Area	0.84 (0.01)	0.90 (0.03)	0.06	Rents Residence	0.37 (0.01)	0.42 (0.03)	0.06
Child between 1 and 2	0.27 (0.00)	0.26 (0.02)	0.57	Resides for Free	0.01 (0.00)	0.02 (0.01)	0.10
Child between 3 and 5	0.38 (0.01)	0.39 (0.02)	0.63	Average Age of Household	37.15 (0.08)	37.37 (0.27)	0.43
Child between 6 and 12	0.69 (0.01)	0.67 (0.02)	0.33	Black	0.11 (0.00)	0.14 (0.02)	0.10
Child between 13 and 17	0.24 (0.00)	0.26 (0.02)	0.33	Hispanic	0.22 (0.00)	0.20 (0.02)	0.20
Self-Employed	0.09 (0.00)	0.12 (0.02)	0.08	Northeast	0.17 (0.00)	0.16 (0.03)	0.76
Has Car Access	0.88 (0.00)	0.92 (0.02)	0.01	Midwest	0.23 (0.01)	0.30 (0.03)	0.03
Household member >65	0.04 (0.00)	0.05 (0.01)	0.28	South	0.36 (0.01)	0.34 (0.04)	0.64
Highest Educ is Post HS	0.50 (0.01)	0.53 (0.02)	0.11	West	0.24 (0.01)	0.20 (0.04)	0.28
Highest Educ is Bachelors	0.25 (0.00)	0.24 (0.02)	0.61				
Observations	16,511	2100		Observations	16,511	2100	

Table 8 Results of a Sargan test for the preferred specification (10b)

Variable	Sargan Test	Variable	Sargan Test
Child Aged 1 to 2	−0.45 (0.60)	Hispanic	0.12 (0.62)
Child Aged 3 to 5	−0.33 (0.51)	Married	0.36 (0.55)
Annual Income	0.00 (0.00)	Some Post HS Education	0.44 (0.50)
Resides in Metro	0.08 (0.95)	Bachelors Degree	0.58 (0.66)
Resides in Midwest	0.14 (0.78)	Graduate Degree	−0.15 (0.97)
Resides in South	0.11 (0.72)	Unemployed	0.19 (0.73)
Resides in West	0.02 (0.78)	NILF	0.18 (0.53)
Rents Residence	0.22 (0.55)	Self-Employed	1.01 (0.72)
Avg. Age of Household	−0.03 (0.18)	Car Access	−0.18 (0.77)
Residence is Free	1.60 (1.52)	HH member >65 years old	1.41 (1.16)
Black	−0.09 (0.68)	Single Head of Household	−1.87 (1.72)
Asian	0.32 (1.52)	Female Single Head of Household	2.72 (1.77)
Other Race	−0.29 (0.72)	Constant	−0.38 (3.78)

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