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Feminist Economics

ISSN: 1354-5701 (Print) 1466-4372 (Online) Journal homepage: www.tandfonline.com/journals/rfec20

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To cite this article: Oluwatosin Aderanti, C.S. Srinivasan & Giacomo Zanello (05 Oct 2025): Sharing work and food within the household: Intra-couple time allocation effects on nutritional outcomes in rural Telangana, India, Feminist Economics, DOI: 10.1080/13545701.2025.2548289

To link to this article: https://doi.org/10.1080/13545701.2025.2548289

Published online: 05 Oct 2025.

Feminist Economics, 2025
https://doi.org/10.1080/13545701.2025.2548289

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SHARING WORK AND FOOD WITHIN THE HOUSEHOLD: INTRA-COUPLE TIME ALLOCATION EFFECTS ON NUTRITIONAL OUTCOMES IN RURAL TELANGANA, INDIA

Oluwatosin Aderanti, C.S. Srinivasan, and Giacomo Zanello

ABSTRACT

In the context of the ongoing rural transformation in many countries, women's opportunities for economic participation are expanding. However, there is limited understanding of how policy interventions can support rural households to adapt to the increasing opportunity cost of women's time in household activities. This article presents empirical evidence on the relationship between couple interdependencies in time use and nutritional outcomes in rural Telangana, India. The study uses innovative datasets that combined accelerometer-based physical activity data, time use, food intake, and sociodemographic data – within the Actor-Partner Interdependence Model (APIM) framework. Findings show that differences in time allocation patterns between spouses in a household affect individual nutritional outcomes; when the husband allocates more time to economic activities, it tends to reduce the adequacy of the wife's energy intake; conversely, when the wife allocates more time to domestic activities, it tends to reduce the husband's energy intake adequacy.

KEYWORDS

Intra-couple time allocation, nutritional outcomes, physical activity, actor-partner interdependence model, Telangana, India

JEL Codes: J22, Q12, D13

HIGHLIGHTS

- In India, spending time in economic work improves nutritional outcomes for women.

- Increasing time in domestic and care work increases nutritional outcomes for men.
- Interdependence between men and women in households influences individual nutrition.
- Women's empowerment should be accompanied by sharing of domestic work in households.

INTRODUCTION

Malnutrition continues to be a development challenge in many low- and middle-income countries (LMICs), where around 185 million people cannot afford sufficient daily energy intake at an average cost of $0.79 (FAO et al. 2020). In the past decades, many agricultural and development interventions aimed at enhancing, diversifying, and substituting livelihood means have targeted women based on the central role that they play in ensuring household nutrition (Haddad, Hoddinott, and Alderman 1997; Food and Agriculture Organization 2011; Fiorella et al. 2016). Even though interventions targeted at women can lead to greater participation in economic activities, increased productivity, and higher household incomes, it is not certain that nutritional outcomes will improve. This disconnect may arise because women in households headed by men still lack the capacity to influence decision making regarding the allocation of increased income and the use of their own time (Kadiyala et al. 2014).

Building on the intrahousehold resource allocation literature, this article presents empirical evidence on spousal interdependencies in time use and nutritional outcomes by investigating own and partner effects of intrahousehold work division on nutritional outcomes among rural households in rural Telangana, India.[1] We hypothesize that the time allocation of male and female spouses and the interdependencies between both individuals are consequential for nutritional outcomes. Inequity in intrahousehold work division has been linked to malnutrition, as women disproportionately bear household domestic work (including childcare) in addition to economic labor (Gillespie, Harris, and Kadiyala 2012). Recent debates have suggested that sharing domestic responsibilities with men will reduce the burden borne by women and potentially improve women's well-being (Madzorera and Fawzi 2020; Rao and Raju 2020; Asadullah, Niaz, and Kambhampati 2021), yet successful policy action to redefine men's household role will require understanding the well-being outcomes for both women and men.

There are two major motivations for this article. First, there is a research gap in the assessment of an individuals' partner effects, despite the extensive literature on household behavior.[2] We assess partner effects in this study based on the premise that within households, couples share work and they also share food, especially in rural agricultural contexts where production and consumption decisions are interwoven (Folbre 1986; Singh, Squire, and Strauss 1986; Doss and Quisumbing 2020). Even when couples adopt separate economic production spheres, it can be expected that they share some production and consumption between them. Second, there is thin evidence on how spouses in rural agricultural households in LMICs are adapting to rural transformation. Agriculture remains a major contributing sector to the rural economy in terms of employment and income, as increases in agricultural labor productivity and mechanization of farm activities are leading rural households to diversify into the rural non-farm sector (IFAD 2016). Men dominate rural nonfarm employment participation, including the time allocated to such activities (Binswanger-Mkhize 2013; IFAD 2016), but there are more opportunities for women to participate in economic activities outside of the home as a result of better education, changing sociocultural norms, and improvements in rural-urban transportation linkages (Binswanger-Mkhize 2013; Ohlan 2016). This form of rural transformation increases women's opportunity cost of time spent on food preparation and care activities. The ensuing time reallocation can have implications for household nutritional outcomes (Da Corta and Venkateshwarlu 1999).

Our analysis adopts the Actor Partner Interdependence Model (APIM) framework to capture partner and own effects. APIM is a model of interdependency between individuals (such as women and men) in a dyadic relationship (such as wife and husband). It postulates that own and partner's characteristics simultaneously influence the outcomes of both individuals (Cook and Kenny 2005). The analysis allows to capture the effects of one person's characteristics on own outcomes and on the other person's outcome (partner effect). In studying bidirectional effects on two individuals, APIM presents a straightforward transition from economic theories which have either considered households as unified in their interests and preferences or treated individuals as independent decision-making units. The identification of women's and men's time use and their implications on their own and partner's nutritional outcomes is the contribution of this article to the intrahousehold allocation literature. We examine the following research question: Among couples in farming households in rural Telangana (India), how does the distribution of time spent on economic, domestic, and leisure activities impact not only their own nutritional outcomes but also those of their partners?

LITERATURE REVIEW

This literature review explores time allocation and nutritional outcomes in rural agricultural settings, first distilling evidence on the effects of women's time allocation on own nutritional outcomes and then focusing on the effects of intrahousehold time allocation on the nutritional outcomes of other family member(s).

Women's time allocation and nutritional outcomes

As a result of ongoing rural transformations, there has been an increase in the number of women active in agriculture, including in the time women allocate to agricultural activities across all regions in LMICs – a trend known as the "feminization of agriculture" (Food and Agriculture Organization 2011; Asadullah, Niaz, and Kambhampati 2021). Data collected from the rural areas of Telangana in India show that women now spend, on average, an additional two hours per day in agricultural activities than men and perform male-associated tasks such as land clearing, irrigation, and plant protection on the farm (Padmaja et al. 2019). Conversely, men's time commitment to farm work is on a downward trend due to the mechanization of male-dominated tasks and the result of men's out-migration from rural areas (Padmaja et al. 2019). These changes in men's and women's time allocation are expected to have consequences for nutritional outcomes, yet empirical evidence is still very limited.

Women's time use tends to have a strong effect on their own well-being outcomes, however, the direction of the effect is not univocal (Ghosh and Bharati 2005; Johnston et al. 2018; Ruel, Quisumbing, and Balagamwala 2018). Hitomi Komatsu, Hazel J. Malapit, and Sophie Theis (2018) found that women's agricultural time use is associated with a reduction in the consumption of diverse diets among women in Mozambique. They reported better nutritional outcomes among individuals in poor farming households. Other studies reported a negative association between agricultural time use and nutritional outcomes as well. The limited available evidence on this topic suggests that the ability of women to translate agricultural time allocation into desirable nutritional outcomes is mediated by diverse factors. Rohini Ghosh and Premananda Bharati (2005) found that the effect of agricultural time allocation on body mass index is mediated by sociodemographic factors, although women in paid agricultural work experienced better nutrition than unpaid working women. Also examining the differentiating effects of paid and unpaid work on household nutrition among women in five Indian states, Nikita Sangwan and Shalander Kumar (2021) found that women in paid farm work have better nutrition compared with peers in non-paid work – as a result of the increase in bargaining power emanating from women's labor force participation. Further, the effects of time use on the nutritional well-being of women and men vary across agricultural seasons as the energy demand of work is highest during land maintenance and harvest seasons (Picchioni et al. 2020; Rao and Raju 2020; Srinivasan et al. 2020). This seasonality effect is intensified among individuals in non-mechanized farming households

(Daum, Capezzone, and Birner 2019; Komatsu, Malapit, and Balagamwala 2019) and the landless (Vemireddy, Vidya, and Pingali 2021). In their review, Deborah Johnston et al. (2018) concluded that increased time allocated to agriculture, and the resulting nutritional outcomes will depend on how different individuals in an agricultural household respond to the changes in time use.

In addition to women's time allocation to agricultural activities, women (and girls) disproportionately perform more than three-quarters of household domestic and care work (Charmes 2019). However, the evidence linking participation in domestic work and well-being in rural areas is very sparse. Often, time use in domestic activity is explained in the context of trade-offs with agricultural and childcare activities, but not how it directly relates to well-being. Sonalde Desai and Devak Jain (1994) argue that domestic work reduces women's available time to both childcare and economic activities; to the extent that domestic work can be a greater obstacle than childcare to women's labor force participation. A multi-country study across Asia and Africa on women's time use and dietary diversity found that time spent cooking is positively associated with women's dietary diversity in Bangladesh and Cambodia, while time committed to domestic work is positively associated with diverse diets among women in Cambodia, in Ghana (poorer households), and in Nepal (Komatsu et al. 2018). The authors suggest that the positive association between domestic/care tasks and more diverse diets could be a result of "staying close to the pot." Studying the time allocation to leisure activities and nutritional outcomes, Greg Seymour et al. (2019) investigated the association of women's time poverty and household nutrition in Bangladesh and found that women's time poverty (defined as allocating less than 50 percent of median time on leisure and self-care related activities) is not significant in its association with household nutritional outcomes. Indeed, time-poor women have relatively better nutritional outcomes.

The paradox seen in this strand of literature is that although women's agricultural economic time use suggests better nutritional outcomes through the increase in and control of incomes, benefits can be outweighed by increasing time spent in strenuous physical activities leading to greater energy expenditure (Nichols 2016) and sociocultural norms entrenched in intrahousehold negotiations can limit a woman's use of her monetary and time resources (Agarwal 1997; Bittman et al. 2003). However, Sangwan and Kumar (2021) and Mara van den Bold et al. (2021) find no deleterious effects resulting from increasing agricultural time on nutritional status. Their conclusions may be due to the small additional time spent in agriculture following the interventions reported in their studies. Moreover, women may regard improvements in household food security and income as beneficial even though such involves trade-offs to their own well-being (Kabeer 2001).

Reviews undertaken by FAO et al. (2020) and Johnston et al. (2018) show that the information about men's time use is often less researched. Despite the significant focus on women's time use and nutritional outcomes, women more than men continue to be malnourished in rural areas of LMICs where most people depend on agriculture for their livelihoods.

Intrahousehold time allocation and nutritional externalities

Intrahousehold externalities affect individual well-being (Basu, Narayan, and Ravallion 2001) but there are few pieces of empirical evidence assessing the relationship between men's time allocation and women's nutritional outcomes and vice versa. Sasha A. Fleary and Patrece L. Joseph (2022) use APIM to analyze data from the US to show interdependencies in health literacy, time use, and dietary behaviors between parents and adolescents. In the development literature, intrahousehold externalities are largely streamlined to maternal time use and its consequences on women's caring responsibilities for children's nutrition (Ruel and Alderman 2013; Fadare et al. 2019). Such focus on maternal time use and child nutrition is based on the established linkages between the well-being of mother and child. However, in the face of deprivation, gendered pay gaps and ownership of assets, the maintenance of adequate nutrition among the poor and the very poor may lie in interdependencies between men and women within the household (Rao, Pradhan, and Roy 2017). Such interdependent view has largely been ignored, and women tend to have been targeted individually.

STUDY AREA AND DATA COLLECTION

Study area

The secondary data used for analysis were collected in Jogulamba Gadwal District, south of Telangana State in India. The district has 20 percent scheduled castes, 1.5 percent scheduled tribes[3] and more than three-quarters of its 609,990-population scattered in 255 rural villages. About 60 percent of its total land area is cultivated for food and cash crops, often on small and marginal plots. Due to a substantial increase in the amount of monsoon rainfall and the adoption of irrigation facilities in recent years, the semi-arid climate is increasingly turning favorable to agricultural production (Government of Telangana 2019; Figure 1).

State government reports show a gradual decline in poverty in these areas; between 2014 and 2020, per capita annual income (adjusted for inflation) rose more than 10 percent to 69,113 Rupees, equivalent to USD 1,100.[4] Rural income growth has been driven by agricultural production expansion and participation in the Mahatma Gandhi National

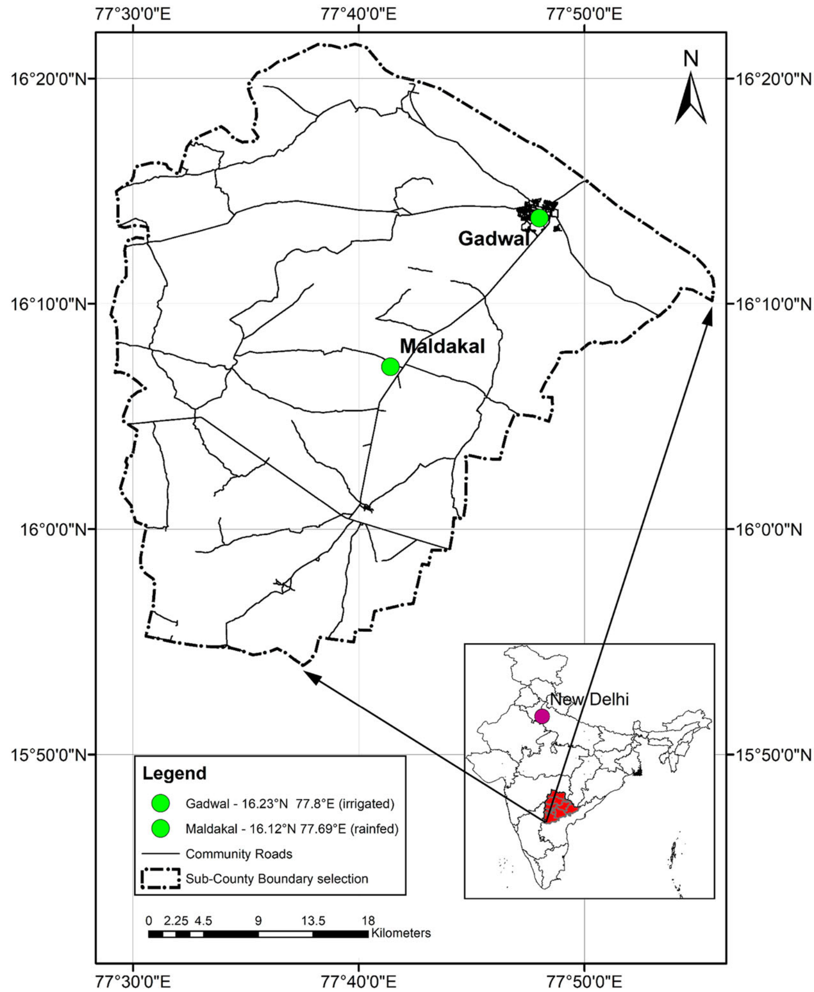

Figure 1 Survey area in Telangana State, India.
Source: Zanello et al. (2020).

Rural Employment Guarantee Act (MGNREGA) social welfare program. Data show that about 20 percent of the Jogulamba district population participates in MGNREGA and despite the mixed impacts[5] of the MGNREGA on agriculture in the area, agriculture and allied (crops, livestock, fisheries, forestry) sector contribution to the overall product output rose to 21 percent in 2021 (Government of Telangana 2021). The growth can be attributed, in part, to other government interventions in the form of inputs support, land redistribution, irrigation, and insurance schemes.

Despite per-capita income increase in the study area over the last decade, malnutrition within the population has remained high, especially among women. Figures from the Indian National Family Health Survey show that 22 percent of women and 17 percent of men are underweight (BMI < 18.5 kg/m^2) in rural Telangana in 2019–20;[6] this is a decline from 29 percent among women and 25 percent among men in 2015–16. The current prevalence of anemia among women is 58 percent, up from 57 percent in 2015–16 (Ministry of Health and Family Welfare, Government of India 2020; Christopher et al. 2021). In comparison to the other states in India, the high malnutrition rate is linked to the large number of scheduled castes and scheduled tribes in Telangana.

Further, the patterns of time use in this region show rural men and women commit over eight hours to work-related activities daily (Government of India 2020). There are however substantial gender disparities albeit to a lesser degree compared to the rest of India: 55.7 percent of rural Telangana women participate in paid work, a figure three times the national average (Government of India 2020). Using data from the Time Use Survey-2019, Figure 2 shows the allocation of time among men and women living in rural areas of Telangana state. Compared to men, women allocate on average 225 minutes more per day to care, domestic, and volunteer work, 158 minutes less to employment and production of goods for own use, and tend to spend on average twenty-nine minutes more in work-related activities daily than men – the time they seem to reallocate from socializing, self-care, and maintenance activities.

Data collection

Survey

The dataset used in this article is described in Giacomo Zanello et al. (2020). Twenty households were randomly selected after the households in the area had been stratified by their ownership of irrigation infrastructure and the size of their landholdings.[7] In each household, an economically active man and woman, between 16 and 64 years old, took part in the study. All households were employed primarily in crop production; eighteen households cultivated their own land and two were sharecroppers. They cultivated predominantly rice, cotton, yam, chilies, and groundnuts. Respondents were visited daily for four non-consecutive weeks during June-November 2018, corresponding to each of the four agricultural seasons of land preparation, sowing, land maintenance, and harvest when Kharif[8] crops are cultivated.

At the beginning of the fieldwork, individuals self-reported information on their own health, and anthropometric measurements of height and weight were taken. All the questionnaires administered to respondents

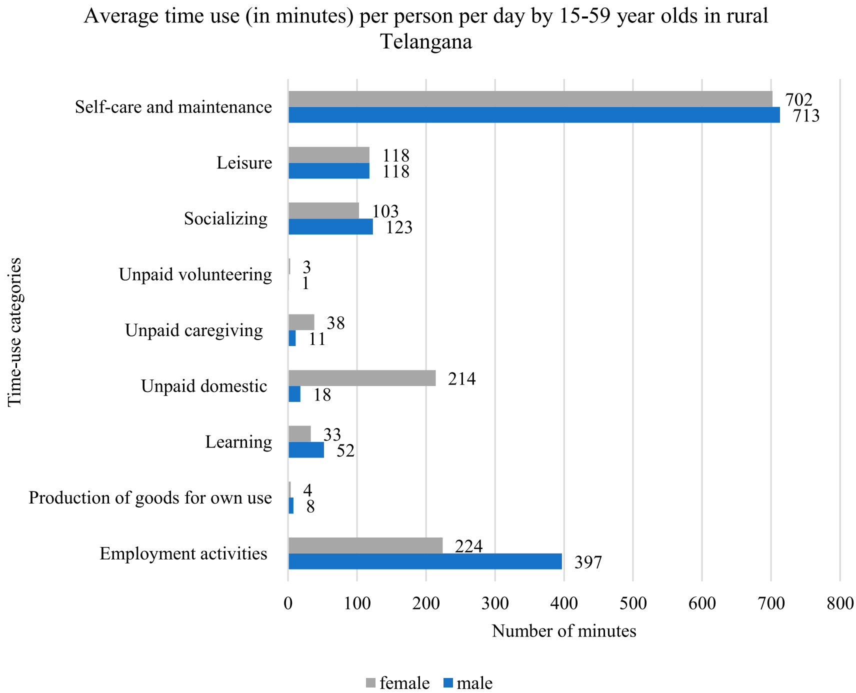

Figure 2 Time use patterns in rural Telangana.
Source: Authors, based on cumulative data extracted from the India Time Use Survey-2019, National Statistical Office, Government of India.

were translated into Telugu, the local language. The survey was carried out by enumerators living in the same district and who spoke the local language. Information on household characteristics was collected from the household head. In addition, individual food intake data were collected daily based on a twenty-four-hour recall throughout the four weeks (Gibson and Ferguson 2008). During the daily visits, enumerators also collected time use information at one hour-intervals based on twenty-four-hour recall.[9]

Accelerometers

In addition to questionnaires administered daily, respondents were invited to wear an accelerometer device throughout the length of the data collection. Accelerometers are portable motion sensor devices used in the collection of objective physical activity data in free-living populations (Troiano et al. 2014; Zanello, Srinivasan, and Nkegbe 2017; Zanello et al. 2017, 2019). Raw 30Hz[10] movement data were collected using research-grade, tri-axial Actigraph GT3X + accelerometers worn on the waist by respondents during awake hours of 5:00 am to 11:00 pm. The movement data collected from accelerometers were converted into energy expenditure (in kilocalories) using validated algorithms (Freedson, Melanson, and Sirard 1998). Time-use data collected using questionnaires were matched with energy expenditure data derived from accelerometers to determine activity-specific energy expenditure (Zanello et al. 2019).

While accelerometers provide an effective tool to capture energy expenditure in a free-living population, they are not without limitations. Most importantly, as they capture movements, they do not capture the additional effort involved in carrying weight or activities performed while stationary (Lee and Shiroma 2014). These limitations are particularly relevant for activities typically categorized as domestic or caregiving, potentially leading to a greater underestimation of energy expenditure in women compared to men (Shiroma et al. 2016). A common challenge in physical activity research using accelerometers, especially in studies among free-living populations, is participants not wearing the devices consistently (Troiano et al. 2014). However, in our study, compliance with wearing the accelerometer was high. A full day accelerometer wear rate was between 94–97 percent among the respondents. No sample attrition was recorded during the four weeks of data collection.

The unique dataset used in this study therefore combines information on individual and household sociodemographic characteristics, and individual data on food intake, time use, and physical activity.

EMPIRICAL METHODS

Independent variables

The main independent variables used in this study were time use variables measured as the number of minutes allocated to each of economic, domestic, and leisure activities (Moser 1989). Every recorded activity in the hourly time use data was identified as either the primary or secondary activity to ensure that typical secondary activities such as leisure and childcare are also considered (Ironmonger 2005). In cases where no secondary activities were recorded, a weight of 1 was assigned to the hourly observation. A weight of 0.6 was assigned to primary and weight of 0.4 was assigned to secondary activity, where respondents reported they carried out simultaneous activities (Picchioni et al. 2020). We aggregate each of economic, domestic, and leisure time use data from hourly to day-level. Economic time use includes time spent in agricultural activities such as crop and livestock production, forest produce collection, and related travel. Non-agricultural economic activities are salaried employment, non-farm wage employment in construction and public work schemes, business, petty trading, and professional development training. Domestic and care provision time use include household maintenance and chores, food management, caring for children, elderly, sick, and disabled. Leisure time use includes time allocated to socializing and personal care.

Dependent variables

A set of three dependent variables are used in the analysis to capture the association between time allocation and own and partner's calorie intake adequacy: Physical Activity Level (PAL), Total Individual Energy Intake (EI), and Calorie Adequacy Ratio (CAR). We examine the associations of time allocation with PAL, EI, and CAR outcomes.

Physical activity level (PAL)

Physical Activity Level (PAL) is a measure of the intensity of physical activity over a day (or other time period). To calculate individual PAL, raw 60-second epoch length physical activity data collected from accelerometers were converted to Activity Energy Expenditure (AEE) in kilocalories using a validated algorithm (Freedson, Melanson, and Sirard 1998). PAL is the ratio of Total Energy Expenditure (TEE) to Basal Metabolic Rate (BMR), where TEE is the sum of BMR (energy required to maintain vital physiological processes in the body) and AEE.[11] We compute the BMR using the Harris-Benedict equation (Harris, Arthur, and Benedict 1918). We use PAL as the outcome variable instead of AEE because PAL controls for individual anthropometric differences, allowing for comparisons across different age, gender, and BMI groups. PAL values of 1.40–1.69 reflects sedentary or light activities, 1.70–1.99 moderate activity, and >2.00 indicates vigorous activity in free-living population. PAL has been used to model energy expenditure among free-living populations (Picchioni et al. 2020; Srinivasan et al. 2020; Friedman et al. 2021).

Total individual energy intake (EI)

Total Individual Energy Intake (EI) is the total dietary energy reportedly consumed by individual respondents in the last twenty-four hours. It captures the calorie (kcal) equivalent of food and beverages per-adult day energy consumption (Food and Agriculture Organization 2011; Zanello, Srinivasan, and Nkegbe 2017). We use individual's food intake data recorded through a twenty-four-hour recall to compute the caloric values. The Indian Food Composition tables were used to determine the calorie content of local recipes (Bowen et al. 2011). The United States' National Nutrient Database for Standard Reference was used for calorie conversion of ultra-processed foods (US Department of Agriculture 2019). However, while EI captures caloric availability, the nutritional components of the food, and the quality of diets cannot be ascertained.

Calorie adequacy ratio (CAR)

We use Calorie Adequacy Ratio (CAR) as a measure of nutritional outcomes. CAR is a metric of energy balance which quantifies the overall dietary energy adequacy of an individual based on the ratio of energy intake to energy expenditure (Randolph et al. 1991). We compute CAR as the ratio of energy intake (EI) relative to total energy expenditure (TEE). An individual whose CAR is equal to 1 is classified as energy balanced, a CAR below 1 is classified as being energy deficient, and a CAR value above 1 indicates that the individual is in energy surplus for a given day (Food and Agriculture Organization 2001). The CAR as an indicator of nutritional outcomes allows to measure individual energy intake adequacy. However, its focus on calories prevents measuring the adequacy of the other nutrients necessary for a diverse diet. A person with a CAR equal or above 1 may be deficient in essential nutrients. The description of all dependent and independent variables used in the analysis (including intermediate variables) is presented in Table 1.

Empirical strategy

The actor-partner interdependence model (APIM)

The Actor-Partner Interdependence Model (APIM) explains dyadic relationships by incorporating the concept of non-independence between two linked individuals with the statistical methods to test such interdependence (Cook and Kenny 2005). The APIM postulates that own (actor) and partner's characteristics simultaneously influence the outcomes of both individuals. This methodological approach assumes correlations in the characteristics and outcomes of individuals within the same unit (for example, household). Conventional statistical procedures assume independent observations but ignoring nonindependence of observations between linked individuals will likely lead to biased statistical estimates (Cook and Kenny 2005). Non-independence in the observations of two linked persons may arise as a result of *common fate, mutual influence* and *partner effects* (Kenny and Cook 1999). APIM focuses on modeling the interdependence between two individuals through partner effects. Partner effects measure the bi-directional influence of one person on the other member of the dyad. This contrasts intrahousehold behavior theories that posits that individual outcomes are determined either by individual preferences or by altruism (Fafchamps and Quisumbing 2007). APIM approach has been used to study dyadic relationships, for example, in the

Table 1 Description of variables

	Variable description
Dependent variables	
Physical Activity Level	Ratio of total energy expenditure and basal metabolic rate over a 24-hour period
Total Individual Energy Intake (Kcal/day)	Total amount of calories from food consumption over a 24-hour period
Calorie Adequacy Ratio	Ratio of daily energy intake to energy expenditure
Independent variables	
Age	Age in years
Literacy	Dummy for whether an individual can read and write
Domestic activity	Total amount of hours spent in domestic work per day
Economic activity	Total amount of hours spent in economic work per day
Leisure	Total amount of hours spent in leisure per day
Accelerometer wear	Daily accelerometer wear compliance between 5am – 10pm
Day 1	Dummy for the first day of the week when data was collected
Day 2	Dummy for the second day of the week when data was collected
Day 3	Dummy for the third day of the week when data was collected
Day 4	Dummy for the fourth day of the week when data was collected
Day 5	Dummy for the fifth day of the week when data was collected
Day 6	Dummy for the sixth day of the week when data was collected
Number of adult women (18–64 years)	Total number of adult women ages 18–64, within the household
Number of adult men (18–64 years)	Total number of adult men ages 18–64, within the household
Number of children (0–1 years)	Total number of male and female children between ages 0 and 1 years old within the household
Number of infants (2–12 years)	Total number of male and female children between ages 2 and 12 years old within the household

(*Continued*)

Table 1 Continued.

	Variable description
Independent variables	
Number of adolescents (13–17 years)	Total number of male and female adolescents between ages 13 and 17 years old within the household
Female	Dummy for if gender of respondent is a woman
Male	Dummy for if gender of respondent is a man
Irrigation	Dummy for if household adopts irrigation system
Land cultivated (acres)	Total area of land cultivated by household
Asset index	Index of sum of values of household assets
Land preparation	Dummy for agricultural season whether agricultural season is when land preparation takes place
Sowing	Dummy for agricultural season whether agricultural season is when sowing and seeding takes place
Land maintenance	Dummy for agricultural season whether agricultural season is when land maintenance takes place
Harvest	Dummy for agricultural season whether agricultural season is when harvest takes place
Self-reported health	Dummy for if self-reported health reduced the amount of work done at work and home
Caste	Dummy for if respondent belong to the backward caste, scheduled caste if otherwise

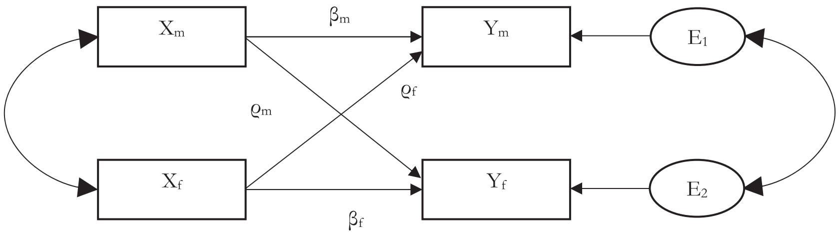

Figure 3 Path depiction of the APIM model (adapted from Kenny, Kashy, and Cook 2006)

Notes: X_m = independent variable of the male; X_f = independent variable of the female; Y_m = outcome variable of the male; Y_f = outcome variable of the female; β_m = male own (actor) effects; ρ_m = male partner effects; σ_f = female own (actor) effects; π_f = female partner effects; E_1 and E_2 = error term.

analysis of health behaviors in parent–adolescent dyads (Fleary and Joseph 2022), work division, communication, and couples' relationship satisfaction (Carlson, Miller, and Stephanie 2020). APIM is used in this study to predict the influence that time allocation of spouses has on own and partner's PAL, EI, and CAR outcomes. The household is treated as the unit of analysis.

We assess own (intrapersonal) and partner (interpersonal) effects of time use on dependent variables of PAL, EI, and CAR using the APIM for dyadic data depicted in Figure 3 (Cook and Kenny 2005). To treat individuals as nested within a dyad, we use the gender of each respondent as the distinguishing variable within couples – and to capture role-specificity of individuals. This differentiation allows for estimating the main components of the APIM: own effects – β_m, β_f and partner effects – ρ_m, ρ_f; by using the main independent variables – X_m, X_f; and the dependent variables – Y_m and Y_f. Own effects (β_m, β_f) capture the association between own independent variables and dependent variables ($X_{m;}$ and Y_m; X_f and Y_f for male and female, respectively), while partner effects (ρ_m, ρ_f) capture the association between own independent variables and partner's dependent variable (Xm and Y_f; X_f and Y_m). E_1 and E_2 control for the correlation within couples. Interdependency between couple occurs when the partner effects ρ_m, ρ_f are significantly associated with the dependent variables (Kenny et al. 2006).

In the APIM model, to estimate own (β_m, β_f) and partner (ρ_m, ρ_f) effects of the time-use variables on the dependent variables of PAL, EI, and CAR, we arrange the dyadic data in a pairwise structure as shown in Table 2.[12] Each row of data includes the household identifier, the gender of the individual, the outcome variable for the individual, and the characteristic(s) of the individual. Additionally, the last two columns of Table 2 include the individual characteristics and partner characteristics each multiplied by a dummy variable Z which is equal to 0 for "own" and

Table 2 Data structure for estimation of APIM model

Household (*j*)	Individual (gender) *i = female (f), male (m)*	Own outcome variable Y_{ji}	Own explanatory variable X_{ji}	Own explanatory variable x Z Z=0	Partner explanatory variable x Z Z=1
1	Female (f)	y_{1f}	x_{1f}	x_{1f} x Z	x_{1m} x Z
1	Male (m)	y_{1m}	x_{1m}	x_{1m} x Z	x_{1f} x Z
2	Female (f)	y_{2f}	x_{2f}	x_{2f} x Z	x_{2m} x Z
2	Male (m)	y_{2m}	x_{2m}	x_{2m} x Z	x_{2f} x Z

Notes: Subscript j denotes households. j = 1 . . . . n where n is the number of households in the sample. Gender of the partners is denoted by subscript i = female (f), male (m); Y_{ji} denotes own outcome variable; X_{ji} denotes own explanatory variable ("Own" explanatory variable is also the "Partner" variable for the partner in the household); Z is a dummy variable equal to zero for "own" and equal to 1 for "partner" in any given household.

equal to 1 for "partner." Arranging the data in this way yields equations where the outcome for each individual is a function of the individual's characteristics and the partner's characteristics.

Own and partner effects – couple composition, context, and the endogeneity of time-use variables

Ordinary least squares, structural equation modeling, and multilevel modeling can be used in the analysis of the APIM. We apply a multilevel model (MLM) to analyze the APIM framework. This allows for the simultaneous estimation of hierarchies in the nested data – two individuals (level-1) nested in a household (level-2) – while accounting for the inherent nonindependence within each couple. To obtain the actor and partner effects by male and female gender, the random two-intercepts model for MLM using the restricted maximum likelihood method (Raudenbush, Brennan, and Barnett 1995; Kenny et al. 2006; Rabe-Hesketh and Skrondal 2012) estimates fifteen separate panel equations with separate observations for each day of the form $Y_{ijt} \epsilon \{PAL_{ijt}, EI_{ijt}, CAR_{ijt}, CAR_{ijt} > 1, CAR_{ijt} < 1\}$ and k = {Economic, Domestic, and Leisure time uses}:

$$\begin{aligned} Y_{ijt} = {} & \alpha^k_m\, \delta_i + \alpha^k_f\, (1 - \delta_i) + \beta^k_m\, X^k_{mjt}\, \delta_i + \beta^k_f\, X^k_{fjt}\, (1 - \delta_i) \\ & + \rho^k_m\, X^k_{mjt}\, (1 - \delta_i) + \rho^k_f\, X^k_{fjt}\, \delta_i \\ & + \theta^k_j \bar{X}^k_j + \omega^k I_j + \sigma^k\, H_j + \gamma^k C_t + \tau^k Z_s + \varepsilon^k_{ijt} \end{aligned} \tag{1}$$

where i is the person (subscript m = male, f = female), j is household, and t is day of the week; male α_m and female α_f intercepts; δ_i indicates that the person is male, female is $(1 - -\delta_i)$; $X^k_{mjt}\delta_i$ is the time spent in activities type k by the male in the jth household in t^h period (day); $X^k_{fjt}\ (1 - -\delta_i)$ is the time spent in activities type k by the female in the jth household in t^h period (day); $X^k_{mjt}(1 - -\delta_i)$ is the time spent in activities type k by the male partner in the jth household in t^h period (day); $X^k_{fjt}\ \delta_i$ is the time spent in activities type k by the female partner in the jth household in t^h period (day); $\bar{X}^k_j$ is the mean of couple time use; I_j is a vector of couple-mean centered variables of age and literacy;[13] H_j is vector of household sociodemographic characteristics such as irrigation system, size of cultivated land, household composition and assets index, and controls such as accelerometer wear, self-reported health, caste; C_t is day dummies; Z is seasonal (land preparation, sowing, land maintenance, and harvest) dummies; and the error term is $\varepsilon_{ijt} = \zeta_j + \mu_{ij}$ where ζ_j is household component, and individual-specific component μ_{ij}.

The composition of groups, their contexts, and the endogeneity of variables are likely sources of bias in multilevel analysis of APIM. For instance in our analysis, if higher couple literacy is associated with higher CAR for household j, comparing own and partner effects among couples is confounded by higher estimates among more literate couples (Bingenheimer, Stephen, and Raudenbush 2004; Rabe-Hesketh and Skrondal 2012). This confounding by average household level characteristics is referred to as compositional effects (Duncan, Jones, and Moon 1998). We address compositional effects by including couple-mean centered variables of age and literacy in Equation 1 (Rabe-Hesketh and Skrondal 2012).

In addition to bias that may be introduced by compositional effects, individual's patterns of time use is known to correlate with unobserved household-level characteristics such as sociocultural norms, resulting in level-2 endogeneity (Kevane and Wydick 2001). We used the Mundlak or "including-the-group-means approach" to address level-2 endogeneity of the time use variables (Mundlak 1978). This was done by including the means of couple time use variables in Equation 1. The Mundlak approach results in own and partner time use effects that captures pure within-couple variation, which is unaffected by level-2 endogeneity.

Further, to ascertain the exogeneity of the within-couple time use estimates, we conduct post regression tests of equal between and within time use effects (Rabe-Hesketh and Skrondal 2012). Results show that the within-couple effects are uncorrelated with the between couple time use effects. However, the Mundlak approach can produce biased estimates due to other omitted variables, and the effects of time-invariant variables may not be consistent, as the within and between effects are estimated separately in Equation 1 (Hanchane and Mostafa 2012). This limitation is addressed by the instrumental variable or Hausman-Taylor (HT) approach (Hausman and Taylor 1981). The HT approach can consistently estimate models with endogenous time-invariant variables and time-variant variables,

Table 3 Groups of variables

Exogenous time-varying variables	Seasonality dummies, day dummies, accelerometer wear, self-reported health
Exogenous time-constant variables	Caste, age, sex, and literacy
Endogenous time-varying variables	Own and partner economic, domestic, and leisure time use variables
Endogenous time-constant variables	Number of women, number of men, number of children, number of adolescents, number of infants, irrigation system, land size, asset index

to produce estimates which are uncorrelated with the residuals. In Equation 2, household-level (level 2) factors not captured in the model could have influenced differently, the patterns of time use of women and men (level 1). The HT method first estimates individual-level effects of the time-varying variables. This estimation produces residuals which are then regressed on time-invariant variables. Regressing the residuals on the exogenous variables produces between-household effects, which are uncorrelated with the time-varying individual-level variables. The produced between-household effects act as instrumental variables (Rabe-Hesketh and Skrondal 2012). As such, using the HT approach requires independent variables to be classified into four kinds as: exogenous time-varying variables, endogenous time-varying variables, exogenous time-constant variables, and endogenous time-constant variables. These are presented in Table 3.

In addition to this criterion, the number of exogenous time-varying variables must be equal or higher than the number of the endogenous time-constant variables. Both conditions are satisfied in Equation 2, where we estimated nine[14] separate regression models where each outcome variable PAL, EI, and CAR depend on each set of economic, domestic, and leisure activities of the form $Y_{2ijt} \in \{PAL_{ijt}, EI_{ijt}, CAR_{ijt}\}$ and k = {Economic, Domestic, and Leisure}:.

$$
\begin{aligned}
Y_{2ijt} = {} & (\beta_{2i} + \zeta_j) + b_{2m}^{k} X_{mjt}^{k,\,end} \delta_i \\
& + \beta_{2f}^{k} X_{fjt}^{k,\,end} (1 - \delta_i) \\
& + \rho_{2m}^{k} X_{mjt}^{k,\,end} (1 - \delta_i) + \rho_{2f}^{k} X_{fjt}^{k,\,end} \delta_i \\
& + \pi_{ij}^{k} P_{ijt}^{k} + \omega_2^{k} I_j + \tau_2^{k} Z_s \\
& + \gamma_2^{k} C_t + \varepsilon_{ijt}^{k}
\end{aligned} \tag{2}
$$

where i is the person (subscript m = male, f = female), j is household, and t is on day t; superscript *end* indicates endogenous variables; subscript 2 here distinguishes Equation 1 from Equation 2; $(\beta_{2i} + \zeta_j)$ is the intercept;

δ_i indicates that the person is male = 1, female = $(1 - \delta_i)$; $X_{mjt}^{k, end}$ is the time spent in activities type k by the male in the jth household in t^h period (day); $X_{fjt}^{k, end}$ is the time spent in activities type k by the female in the jth household in t^h period (day); $X_{mjt}^{k, end}(1 - \delta_i)$ is the time spent in activities type k by the male partner in the jth household in t^h period (day); $X_{fjt}^{k, end}\ \delta_i$ is the time spent in activities type k by the female partner in the jth household in t^h period (day); P_{ijt}^{k} is a vector of gender and literacy; I_j is a vector of household sociodemographic characteristics such as irrigation system, size of cultivated land, vector of household composition and assets index, and controls such as accelerometer wear, self-reported health, caste; Z is seasonal (land preparation, sowing, land maintenance, and harvest) dummies; C_t is daily dummies; and error term = ε_{ijt}. Own and partner time use variables were designated as related to components in the random intercept $(\beta_{2i} + \zeta_j)$ in Equation 2. The regression analysis was carried out using the "xthtaylor" command in Stata software (Hausman and Taylor 1981; StataCorp 2013; Castellano, Sophia Rabe-Hesketh, and Skrondal 2014). The other form of endogeneity in MLM is the level-1 endogeneity of level-1 covariates. For instance, individual preference for certain activities may influence the amount of time spent on such activity. However, level-1 endogeneity in MLM is not directly testable (Rabe-Hesketh and Skrondal 2012). Post-regression estimates of the own and partner effects of each time-use category were computed as the percentage change in dependent variable divided by the percentage change in the independent variable for Equations 1 and 2.

RESULTS

Descriptive statistics

Table 4 presents descriptive statistics of household-level characteristics. On average, households in our sample cultivate around ten acres of land, which is greater than the three acres district average (Government of Telangana 2021). There is however variability in the sample with 35 percent being smallholders, 35 percent medium, and 30 percent large farmers based on classification of landholding by the Indian Ministry of Agriculture and Farmers Welfare.[15] The average household size of 4.3 is slightly below the Indian national average of 4.6 people (UNDESA 2019), with the number of men household members slightly higher than the number of women household members. The respondents belonged to the backward caste, while one household identifies as belonging to the scheduled caste.

Descriptive statistics of individual-level characteristics are reported in Table 5. An average PAL value of 1.55[16] suggests that men and women

Table 4 Descriptive statistics of household-level characteristics

	Mean	*SD*	*Min*	*Max*
Asset index	0.00	1.68	– 3.59	4.02
Land cultivated (acres)	10.00	7.06	2.47	29.65
Irrigation system (yes = 1, no = 0)	0.50	0.50	–	–
Number of adult males (18–64 years)	1.70	0.90	1.00	4.00
Number of adult females (18–64 years)	1.55	0.58	1.00	3.00
Number of infants (0–1 years)	0.05	0.22	0.00	1.00
Number of children (2–12 years)	1.10	0.99	0.00	3.00
Number of adolescents (13–17 years)	0.35	0.73	0.00	2.00
Caste (whether backward caste)	0.95	0.01	–	–

Notes: The asset index was computed by projecting data on households' ownership of equipment, means of transportation, consumer goods, and living characteristics using the principal component analysis technique (Filmer and Pritchett 2001). SD = standard deviation.

spend a significant amount of time engaged in light and moderate-intensity activities. There are indications of calorie deficits among survey participants. Energy intakes for men and women are below the Indian recommended daily dietary allowance (RDA) of 2,730 and 2,230 kcal for moderately active people (National Institute of Nutrition 2011). On average, men have a higher energy intake than women (158 kcals/day more). However, relative to their energy expenditure needs, men also have higher energy shortfalls compared to women. This translates to 978,82 kcals and 636,87 kcals calorie deficits for men and women respectively. Using CAR values, about 57 percent of men respondents have an average daily CAR value below 1, while about 86 percent of women respondents have an average daily CAR value below 1. The CAR values indicate more women than men are experiencing undernutrition.

On average, men were older than women, with mean ages of around 40 years old and a significant difference of 5.5 years. In terms of literacy, defined as the ability to read and write, a substantial gap was observed: 30 percent of men were literate, compared to only 5 percent of women, marking a significant difference of 25 percentage points. When it came to daily activities, men spent significantly less time on domestic and care activities, averaging twenty-seven minutes per day, while women spent considerably more time, averaging 206 minutes per day. Conversely, men engaged more in economic activities, averaging 516 minutes per day, compared to women, who averaged 420 minutes per day. Men also spend on average seventy-two minutes more per day than women in leisure activities. Similar unequal pattern of intrahousehold work division have been reported in developed countries (Bittman et al. 2003).

Table 5 Descriptive statistics of individual-level characteristics by gender.

	Men		*Women*		
	Mean	*SD*	*Mean*	*SD*	*Mean difference (Men – Women)*
Dependent variables					
Physical Activity Level (PAL)	1.53	0.31	1.56	0.26	– 0.02
Energy Intake (kcal/day)	1751.18	543.86	1593.13	510.83	158.05***
Calorie Adequacy Ratio (CAR)	0.85	0.29	0.99	0.38	– 0.15***
Proportion having CAR less than 1	0.56	0.02	0.86	0.02	0.29***
Independent variables					
Age (years)	39.84	10.15	34.29	9.55	5.55***
Literacy (can read and write)	0.30	0.02	0.05	0.01	25.00***
Domestic and care activities (minutes/day)	27.11	52.05	205.5	103.05	– 178.39***
Economic activities (minutes/day)	516.32	136.51	419.36	135.76	96.96***
Leisure (minutes/day)	327.32	102.55	254.89	91.73	72.43***
Accelerometer non-wear (minutes/day)	31.07	87.98	36.86	108.52	– 5.79
Self-reported health	2.99	0.11	2.99	0.11	0.00

Notes: SD = standard deviation. ***, **, * denote significance at the 1, 5, and 10 percent levels, respectively. Own and partner time use variables are dummy variable-based, as such, they are not included in Table 3.

Own and partner effects

As explained earlier, we run fifteen separate regressions such that own and partners' time spent in economic, domestic, care, and leisure activity were regressed on the outcome variables of PAL, EI, CAR, CAR < 1, and CAR$> \, = 1$. Table 5 reports an overview of own and partner effects elasticities computed post-MLM analysis of the Mundlak approach in Equation 1. The own and partner elasticities were computed as the percentage change in the dependent variable relative to the percentage change in independent variable (that is, time use) in minutes. The time use coefficients can be interpreted as the effect on the dependent variable, of a one minute change in the time devoted to an activity category. Full regression tables are reported in the Online Appendix. The effect sizes in Table 6 are expressed in percentages.

Physical activity level (PAL)

The highest PAL effect is observed in the time allocated to economic activities, followed by domestic and care activities. Conversely, the smallest PAL effect is noted in leisure activities, for both women and men. A 1 percent increase in the time allocated to economic work leads to a 10 and 8 percent increase in own PAL for men and women, respectively. Men's economic time use is associated with a 2 percent reduction in women's PAL. This suggests that men's economic time use has a positive partner effect by reducing women's PAL. Regarding domestic and care activity, a negative association is observed between time spent on domestic and care work and PAL for both men and women. Although very small, men's domestic and care time use has a positive partner effect on women's PAL, while women's domestic and care time use has no significant partner effect on men's PAL. Furthermore, given that men spend considerably less time on domestic and care activities, the equal PAL effect size observed for domestic and care activity among men and women is notable. This may be attributed to men engaging in short duration but more energy-intensive activities, in contrast to women performing longer duration but less energy-intensive tasks. Leisure time use is inversely related to PAL, with a more pronounced effect among women than men. A 1 percent increase in the time allocated to leisure is associated with a 5 percent reduction in PAL for women and a 4 percent reduction for men. Additionally, a 1 percent increase in men's leisure time use increases women's PAL by 1 percent.

Total individual energy intake (EI)

No significant effects on energy intake were observed for men across all three activity categories. Women's energy intake appears to increase by 6

Table 6 Own and partner elasticities of time use relative to PAL, EI, and CAR (CAR, CAR < 1, and CAR > = 1)

	PAL	*EI*	*CAR*	*CAR < 1*	*CAR> = 1*
Economic activities					
Male own	0.10***	– 0.01	– 0.09***	– 0.03	– 0.02
	(0.01)	(0.02)	(0.03)	(0.03)	(0.02)
Female own	0.08***	0.06***	– 0.00	0.03	0.04
	(0.01)	(0.02)	(0.02)	(0.02)	(0.03)
Male partner	– 0.02***	– 0.07***	– 0.05*	– 0.06***	– 0.06
	(0.04)	(0.02)	(0.03)	(0.02)	(0.04)
Female partner	0.01	0.06***	0.02	0.03	0.00
	(0.01)	(0.02)	(0.03)	(0.02)	(0.02)
Mean household	– 0.09	– 0.04	– 0.15	– 0.31	0.01
	(0.23)	(0.39)	(0.37)	(0.23)	(0.27)
Domestic activities					
Male own	– 0.01***	– 0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)
Female own	– 0.01*	– 0.04***	– 0.04***	– 0.02**	– 0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.04)
Male partner	0.00**	0.01*	0.00	0.00	0.01**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Female partner	– 0.01	– 0.04***	– 0.03*	– 0.02	0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Mean household	0.07	0.20	0.25	0.05	0.15
	(0.12)	(0.15)	(0.25)	(0.08)	(0.18)
Leisure activities					
Male own	– 0.04***	– 0.02	0.01	– 0.00	0.01
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Female own	– 0.05***	0.00	0.05***	0.02	0.01
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Male partner	0.01	– 0.01	– 0.03	0.01	– 0.02
	(0.01)	(0.02)	(0.02)	(0.02)	(0.03)
Female partner	– 0.00	– 0.00	0.01	– 0.01	– 0.00
	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Mean household	– 0.13	0.25	0.58	0.05	– 0.09
	(0.18)	(0.39)	(0.61)	(0.26)	(0.37)

Notes: Restricted maximum likelihood post-regression elasticity estimates of the effects of own and partners time use in economic, domestic, and leisure time use on dependent variables – Physical Activity Level (PAL), Energy Intake (EI), Calorie Adequacy Ratio (CAR), Calorie Adequacy Ratio less than 1 (CAR < 1), Calorie Adequacy Ratio greater or equals to 1 (CAR > = 1). Mean Household is the average household time use that accounts for household-level contextual effect of time use. Standard errors in parenthesis. ***, **, * denote significance at the 1, 5, and 10 percent levels, respectively.

percent with each 1 percent increase in time spent on economic activities. These patterns of intrahousehold food allocation indicate that time spent in economic activities is a significant, but not the only, determinant of intrahousehold food distribution. The significant partner effects observed in domestic and care time use confirm couple interdependence in this category and in terms of energy intake. We also observe contrasting partner effects on energy intake; men's time spent in economic activity is correlated with a decrease in the quantity of food calories consumed by his spouse, whereas women's time spent in economic work is positively associated with the energy intake of men. Given that the coefficient estimate for male partner economic time use (− 0.07) is lower than that for female partner economic time use (0.06), the effects of women's time spent in economic work on the couple's energy adequacy is large enough to offset the reduced calorie intake due to male partner effects. In other words, women and their spouses benefit more when the women spend time in economic work. This finding is consistent with studies indicating that women's participation in economic work improves not only their nutritional outcomes but also those of other household members (Ruel, Quisumbing, and Balagamwala 2018).

We also observe that women's energy intake declines with increasing time allocated to domestic and care activity, in contrast to the increasing effect observed with time spent in economic work. This finding contradicts the positive nutritional outcomes associated with domestic and care work reported in a previous multicountry study (Komatsu et al. 2018). The male partner EI effects of domestic and care activity indicate an increase in women's EI as men engage in domestic and care activities. This pathway is further validated by the EI effects observed in economic activities, where men's participation in economic activities is seen to negatively influence women's EI. For both women and men, there is no statistically significant relationship between EI and leisure time use.

Calorie adequacy ratio (CAR)

Results show that a 1 percent increase in men's economic time use leads to a 9 percent decrease in CAR, with no corresponding significant relationship observed for women. This contradicts the observations from the previous section, where women's economic time use significantly predicted EI but not CAR, in contrast to the findings for men. Such an outcome underscores the importance of accounting for energy requirements in nutrition assessments. Regarding partner effects, we note a decrease in women's CAR with an increase in men's economic time use: a 1 percent increase in men's economic activity participation results in a 5 percent decrease in women's CAR.

The effect of women's domestic and care time use on women's CAR mirrors that of men's economic activities on men's CAR. Similar to the observations for EI, women's domestic and care time use reduces women's CAR, while economic activities tend to reduce men's CAR. In addition to own effects, female domestic and care time use is also negatively associated with the CAR of their spouses. Our results reveal no significant effects of men's domestic and care time use on CAR, neither in their own nor in partner effects.

The association between leisure time use and CAR shows that for every 1 percent time spent in leisure, women's CAR increases by 5 percent. Corresponding own male effects are not significant, and there are no partner effects of leisure on CAR for both men and women.

We decompose CAR into energy sufficient ($CAR \geq 1$) and energy deficient ($CAR < 1$) groups to provide additional insights on intra-couple time allocation by their energy adequacy status. Calorie adequacy tends to decrease with increasing own domestic and care time use among energy-deficient women. Among women with a calorie adequacy ratio greater than 1, CAR appears to increase with male partner domestic and care time use. There are no significant effects observed in the relationship between mean couple time use and CAR among the calorie- deficient and sufficient groups.

Robustness checks

To assess the robustness of regression results to the different estimation methods of the MLM, we compare magnitudes and significance values between coefficient estimates of the restricted maximum likelihood (REML) and full information maximum likelihood (FIML) for all models. Estimates are similar and our conclusions hold for both REML and FIML parameter estimation methods. However, our preferred approach is the REML methods, as it is more suitable with estimations of small sample sizes compared to the FIML (Peugh 2010). The regression tables and post regression elasticities tables of the FIML are presented in Online Appendix Tables A4–7. Equation 2 regression results are presented in Table 7. Post-regression elasticity estimates of the Hausman-Taylor estimator are quite like the Mundlak approach already described in subsections above, except for the insignificant female partner domestic and care time use effect on CAR in the Mundlak approach and the insignificant male partner leisure time use on PAL in the Hausman-Taylor approach.

DISCUSSION AND CONCLUSION

While time-use patterns of women have been hypothesized to be responsible for the persistence of malnutrition among women; previous empirical studies have mainly examined the effects of women's time-use allocations on children's nutrition. We contribute to the literature

Table 7 Own and partner elasticities of time use relative to PAL, EI, and CAR using Mundlak and Hausman-Taylor (HT) approaches

	PAL		*EI*		*CAR*	
	Mundlak	*HT*	*Mundlak*	*HT*	*Mundlak*	*HT*
Economic activities						
Male own	0.10***	0.10***	– 0.01	– 0.01	– 0.09***	– 0.09***
	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)	(0.03)
Female own	0.08***	0.08***	0.06***	0.06***	– 0.00	– 0.01
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Male partner	– 0.02***	– 0.03**	– 0.07***	– 0.07***	– 0.06**	– 0.05*
	(0.01)	(0.01)	(0.02)	(0.01)	(0.03)	(0.03)
Female partner	0.01	0.01	0.06***	0.07***	0.02	0.02
	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)	(0.03)
Mean household	– 0.09		– 0.04		– 0.15	
	(0.11)		(0.39)		(0.37)	
Domestic activities						
Male own	– 0.01***	– 0.01***	– 0.00	– 0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Female own	– 0.01*	– 0.01*	– 0.04***	– 0.04***	– 0.04***	– 0.04***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Male partner	0.00**	0.00**	0.01*	0.01*	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Female partner	– 0.01	– 0.01*	– 0.04***	– 0.04***	– 0.02*	– 0.03*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Mean household	0.08		0.20		0.25	
	(0.12)		(0.15)		(0.25)	
Leisure activities						
Male own	– 0.04***	– 0.04***	– 0.02	– 0.02	0.01	0.01
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Female own	– 0.05***	– 0.05***	0.00	0.00	0.05***	0.05***
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Male partner	0.02*	0.01	– 0.01	– 0.01	– 0.03	– 0.03
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Female partner	– 0.00	– 0.00	– 0.01	– 0.01	0.01	0.01
	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Mean household	– 0.13		– 0.25		0.58	
	(0.18)		(0.39)		(0.61)	

Notes: Elasticities of multilevel model estimates of the effects of own and partners time use in economic, domestic, and leisure work on dependent variables using Mundlak and the Hausman-Taylor (HT) approaches – Physical Activity Level (PAL), Energy Intake (EI), Calorie Adequacy Ratio (CAR). "Male (female) own" is male (female) time use effect on own outcome. Mean Household is the average household time use that accounts for household-level contextual effect of time use. "Male (female) partner" is male (female) time use effect on female (male) outcome. Standard errors in parenthesis. ***, **, * denote significance at the 1, 5, and 10 percent levels, respectively.

on time allocation and nutritional externalities by looking at own and partner effects of intra-couple time allocation on nutritional outcomes among households in Jogulamba district in rural Telangana, India. Women tend to spend more time in domestic and care activities in addition to economic activities, while men predominantly allocate more time to economic activities.

The main finding of our analysis is that interdependencies between men and women in households have an important influence on nutritional outcomes. Nutritional outcomes for individuals are not determined by their own characteristics and endowments alone but also by their spouses' characteristics and endowments. Specifically, increase in economic time allocation by men, and an increase in domestic and care time allocation by women tend to diminish both their own and their partners' food intake and caloric adequacy. Increasing time spent in economic work is linked to improved nutrition for women, whereas for men, nutritional improvements are associated with engaging in less physically intensive tasks, such as domestic and care work. Partner effects reveal a negative link between women's caloric adequacy and increase in men's economic time use, and a similar negative association exists between men's caloric adequacy and increase in women's domestic and care time use. We see that the greater participation of women in economic activities is rewarded with better nutritional improvements relative to when men participate in economic activities, which suggests that opportunities for women to participate in economic activities has the potential to lead to improved nutritional outcomes in rural households.

Our analysis, incorporating both physical activity level and energy intake, highlights levels of physical activity play an important role in caloric (in-) adequacy outcomes. This result underscores the significance of considering physical activity information in individual nutrition (energy requirement) assessments in rural areas of LMICs.

Implications of study findings for development interventions

The understanding that resources managed by women often lead to better household nutritional outcomes than when those same resources are controlled by men has been a foundational premise for many development and agricultural interventions. This approach is predicated on the belief that women, when empowered with resources, are more likely to allocate them in ways that enhance the nutritional well-being of their households. This concept has been influential in shaping strategies that specifically target women with the aim of achieving improved nutrition across households (Ruel, Quisumbing, and Balagamwala 2018). This article underscores the contribution of women's economic work to securing own nutrition and that of other members in line with existing literature.

Our findings reinforce the critical role that women's economic participation plays in securing not only their own nutritional well-being but also that of other household members. This aligns with existing literature which finds positive impact of women's economic activity on household nutrition (Kabeer 2001; Quisumbing and Maluccio 2003). By engaging in economic work, women contribute significantly to household's resources, which in turn can be leveraged to improve the nutritional status of the entire family. However, our findings suggest that women's empowerment programs focusing solely on increasing women's productive assets may not guarantee improvements in nutritional or other outcomes, as these outcomes also depend on personal and partner time allocations. To enhance nutritional outcomes, women should no longer be regarded as the *sole proprietor* of household nutrition. Development interventions should extend beyond improving autonomy for women, as current evidence indicates that women in rural LMICs are already experiencing burdens in terms of time and energy expenditure. Intrinsically, the trade-offs to nutrition resulting from women's empowerment or those occurring through the process of rural transformation can be minimized by encouraging cooperation between spouses, especially regarding intrahousehold sharing of domestic work. Indeed, changes in the norms surrounding intrahousehold work division – supporting a gender-equal distribution of economic and domestic work – are necessary to alleviate nutritional insecurity among both women and men. However, as spousal cooperation tends to vary across sociodemographic contexts, it is important to understand these contexts to tailor policy interventions aimed at advancing women's empowerment (Kabeer 2010; Ragasa, Aberman, and Mingote 2019; Lecoutere and Wuyts 2021; Spark, Sharp, and Koczberski 2021).

Regarding whether increasing women's economic labor will not be detrimental to women's health, growing evidence from the feminization of agriculture literature reveals that increasing women's employment opportunities, especially in the agricultural sector, has not always led to women's empowerment. This is due to social norms and gender-intensified constraints such as lack of productive assets, lower pay, and higher unpaid work burdens among women relative to men (Da Corta and Venkateshwarlu 1999; Garikipati 2006; Asadullah, Niaz, and Kambhampati 2021). Policymakers concerned about women's empowerment should address these constraints and ensure that increases in women's economic work are accompanied by a reduction in their domestic and care work burdens. The way in which work and food are shared between spouses will likely embody "unequal interdependence," where women bear higher labor burdens relative to men (Kabeer 2001). Yet, paid economic work constitutes the beginning of "the breaking of traditional social norms" for some women, especially in countries like India where women's agricultural employment alone accounts for 58 percent of the 17 percent total women's labor force participation (Banerjee,1997; ILO 2022).

Limitations and further research

The innovative methodology used to collect and triangulate multiple data streams is not without shortcomings. The sample size cannot be considered representative of the country where the data was collected but rather an exemplary case study. Our empirical analysis is supported by simulation studies that have proven that fixed-effects estimates (unlike variance components) and standard errors of the multilevel analysis are not necessarily biased as a result of sample size limitation (Peugh 2010; Bell et al. 2014; Huang 2018). Nevertheless, weak significance values should be interpreted with caution. Also, due to statistical software limitations, we have not examined heterogeneities across households through cross-level effects of household characteristics or seasonality that may mediate the level of spousal interdependency observed in this study. For instance, whether individual characteristics, type of work, or income levels moderate own and partner effects.

Further, household composition has been shown in earlier literature to determine the division of domestic work within couples with small children (Lundberg 1988). Indeed, households in our sample are composed of more than the two individuals that were sampled. Even if we had no data for the other household members, we controlled in our analysis for the presence of other members by including household size in the vector of household characteristics as well as included a vector of seasonality to control for seasonal changes in time allocation.

Food intake data are known to be subjected to under-reporting due to social desirability and recall bias, particularly in terms of food consumed outside the home. Under-reporting bias in our study may be larger for men than women concerning calories derived from alcohol consumption and food consumed outside the home. Also, cultural aspects of intrahousehold food sharing such as the order of food servings and the tendency to allocate more nutritious meals to men – are not explicitly considered in this study due to data limitations. Given the focus of this article on calories, the indicators of nutritional outcomes are not comprehensive to understand the nutrient adequacy and healthiness of diets. These are aspects that future work may seek to improve upon.

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ACKNOWLEDGMENTS

We would like to thank our project partner at the National Institute of Rural Development and Panchayati Raj (NIRDPR) in India for their tireless work and dedication. Special thanks to Dr. Nithya Gowdru. Finally, we are grateful to all respondents for contributing their time and insights to this research.

FUNDING

This data collection was funded by a research grant awarded under the Innovative Methods and Metrics for Agriculture and Nutrition Actions

Programme (IMMANA Grants #2.03, 2016–2020) funded by the Foreign, Commonwealth & Development Office of the UK Government and Bill and Melinda Gates Foundation.

NOTES

1 Own effects capture intra-individual outcomes (for example, the effect of women's time use in a specific activity on their own nutritional outcome) while partner effects capture interpersonal outcomes (for example, the effect of women's time use in a specific activity on the spouse's nutritional outcome).

2 A large body of literature looked at intrahousehold dynamics to understand the paradigms of household behavior (see Fafchamps and Quisumbing [2007] for a review). The economic theory of household behavior proposed by the unitary model aggregates utility of household members (Becker 1981). Collective models contrarily posit independence in individual preferences and in the process of decision making. They argue that intrahousehold allocation is guided by bargaining even when couples cooperate (McElroy and Horney 1981; Chiappori 1992; Lundberg and Pollak 1993; Apps and Rees 1997). The drawback to the collective approach is when bargaining for food and other goods like healthcare and leisure is bounded by cultural norms, the approach produces outcomes akin to the unitary model (Agarwal 1997; Duflo and Udry 2004).

3 "Schedule" refers to schedules in the Indian constitution identifying socially and economically deprived/marginalized caste groups and tribal (indigenous) groups as being entitled to affirmative actions in education, employment, and development programs (Dushkin 1967).

4 $1.00 USD averaged 62.78 Indian Rupees in 2014 (Reserve Bank of India 2022).

5 The MGNREGA has led to an increase in agricultural wages and a subsequent tightening of the agricultural labor market. In some instances, this agricultural labor shortage has been linked to shrinking farm plots in places where mechanization of farm work is elusive (Reddy et al. 2014).

6 Data was collected prior to the COVID-19 pandemic.

7 Data were collected in two communities – one using rainfed agriculture and one using irrigation infrastructure. The stratification of the sample households by landholding size control for differences in socioeconomic characteristics across the two agricultural systems.

8 In India, kharif crops are monsoon crops such as rice, maize, sugarcane, and groundnut planted in July and harvested around October. Rabi crops are winter crops such as wheat, barley, carrot, and chickpea planted in November and harvested around April and May.

9 All personal information that would allow the identification of any person(s) described in the article has been removed. The data used is contained in Zanello et al. (2020).

10 1Hz (Hertz) is one cycle per second.

11 TEE is the sum of BMR, AEE, and Thermal Effect of Feeding (TEF). TEF is energy required for metabolism, but TEF data is not available for this study. However, we assume the effect of this limitation to be minimal, since TEF accounts for only about 5–10 percent of TEE (FAO 2001).

12 For simplicity, the illustration in Table 2 includes only one characteristic (explanatory variable) for each individual. The analysis can be extended to cases where there are several characteristics associated with each individual (for example, time spent in different types of activities).

[13] Couple mean centering of age and literacy was obtained by subtracting the household mean from individual observation.

[14] CAR > 1 and CAR < 1 was dropped as dependent variables in Equation 2 because of the largely insignificant effects produced in Equation 1.

[15] Smallholders < 4.94 acres, medium 4.94–9.88 acres, and large farmers > 12.35 acres.

[16] PAL values are classified as sedentary or light (1.40–1.69), active or moderately active (1.70–1.99), and vigorous (2.00–2.40) in free-living populations (FAO 2001).

SUPPLEMENTAL DATA

Supplemental data for this article can be accessed online at https://doi.org/10.1080/13545701.2025.2548289.

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