

A Systematic Testing and Comparative Assessment of Three Time Use Methods: Evidence from
Four Sub-Saharan Countries

by

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Defense Date: March 21, 2024

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Thesis submitted in partial fulfillment of the requirements for the degree of Master of
Science in the Duke Global Health Institute in The Graduate School of
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ABSTRACT

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Abstract

In sub-Saharan Africa, women are burdened with gendered tasks of cooking and fuel gathering, leading to time poverty, gender inequality, unhappiness, physical health issues due to unclean cooking methods, and broader social implications including employment limitations and adverse effects on household food security. This scenario underscores an urgent need to scrutinize and reveal the existing patterns of time use, especially for women. By applying pairwise correlation and ordinary least squares regression analyses, this study assesses the consistency across three distinct time use methods and delves into potential causes for any observed discrepancies especially for time use on fuel preparation and acquisition, as well as cooking. Data sourced from primary cooks across four Sub-Saharan African countries indicate that: (a) there is significant difference in time use that is recorded across time use methods; and (b) individual and household characteristics, and specific behaviours related to cooking and fuel activities, partially account for the observed time gaps in both cooking activities and fuel preparation and collection. This research contributes to the field by: 1) highlighting the challenges in achieving consistent time measurements, underscoring the variations that different methods can produce; and 2) providing insights on the influence of individual and household factors, as well as cooking and fuel-related behaviours, on the perception and reporting of time use. These findings suggest directions for developing more reliable and valid methods for time use research, especially for interventions aimed at reducing the burden of uncompensated work on women in sub-Saharan Africa.

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1. Introduction

In sub-Saharan Africa, women dedicate a substantial portion of their time to the task of cooking and gathering fuel, a routine and gendered process deeply embedded in their daily lives (Ardrey et al., 2021; Lambe et al., n.d.; Rubiano-Matulevich & Viollaz, 2019). For instance, in sub-Saharan Africa, women typically work 6.9 hours daily, dividing their time between 3.5 hours of unpaid labor and 3.4 hours of paid employment. Conversely, men work an average of 6.0 hours each day, with 1.2 hours dedicated to unpaid tasks and 4.8 hours to paid jobs (Eissler et al., 2022). It might reveal a hidden facet of gender inequality, where women are disproportionately burdened with unpaid activities compared to men. Evidence shows that while over 70% of children in various African countries, residing in homes that use polluting fuels for cooking, are tasked with gathering wood or water, it is predominantly women and girls who devote more time to these activities (World Health Organization, 2016). On the other hand, women and girls are also constrained on their available time for education and leisure, even after taking time spent on labor market and household chores into consideration (Wodon & Blackden, 2006; World Health Organization, 2016). Consequently, women are at a higher risk than men of facing time poverty, a condition marked by a diminished capacity to freely decide how to allocate one's own time, due to the demands of extensive work hours (Eissler et al., 2022). Furthermore, time use on cooking and fuel gathering also affect women's life satisfaction and happiness. Research from Kenya indicates that women express lower levels of satisfaction when collecting water or firewood compared to engaging in household chores. Additionally, the findings reveal that women report higher happiness when employed and lower happiness when they perceive their primary activity as "having nothing to do" (Cook et al., 2022).

What is more, this activity is frequently characterized by using unclean energy sources of fuel (i.e., wood, charcoal and dung) and antiquated stoves, which generate a lot of emissions to the atmosphere and contribute to household air pollution by inefficient burning of solid biomass fuels (Ardrey et al., 2021; Kyayesimira & Muheirwe, 2021; Pratiti et al., 2020). This polluted environment engenders serious health issues, including noncommunicable diseases, stroke, ischemic heart disease, lung cancer, and chronic obstructive pulmonary diseases in low- and middle-income countries (Das et al., 2017). Based on estimates of solid fuel use for cooking in 2012, exposure to household air pollution causes 4.3 million premature deaths each year, (Kyayesimira & Muheirwe, 2021; Sambandam et al., 2015). Exposure to household air pollution not only has deleterious health effects, but also has important social consequences due to this uncompensated dedication of time, including lowering women's ability to find a job in the labor market (Dong & An, 2015; Floro & Komatsu, 2011; Phillip et al., 2023; Rubiano-Matulevich & Viollaz, 2019; Simkovich, Goodman, et al., 2019; Van Buskirk et al., 2021), negatively affect household's food and nutrition security outcomes (Jada & Van Den Berg, 2022).

In this case, many scholars (Krishnapriya et al., 2021; Onyeneke et al., 2019; Prah et al., 2020; Simkovich, Williams, et al., 2019) claim that there is an urgent need to scrutinize and reveal the existing patterns of women's time use, and also distribute improved cooking stoves so that women's time is saved. While there is ongoing debate about whether improved cooking stoves can reduce the time women spend cooking and gathering fuel, the methods used to measure time savings are inconsistent. What is more, the reliability and feasibility of time use methods vary based on the activity being recorded and the method used. Studies have found that simpler methods and detailed time diaries can provide consistent results for regular activities like paid work, but may differ for irregular or less frequent activities such as shopping or specific agricultural tasks. These

discrepancies highlight the importance of selecting appropriate measurement techniques based on activity frequency and the potential for recall bias, which can be influenced by factors like the participant's psychological state. Additionally, the practicality of these methods also depends on their cognitive demands and the associated costs, necessitating a balance between accuracy and feasibility, especially in contexts where respondent bias might affect the results. In this case, this study explores the discrepancies between the time measures recorded by three distinct time use methods and attempts to elucidate the reasons behind the existence of such discrepancies, if any. This study holds significant value, as different methods are commonly employed in fieldwork concerning time use, yet limited work compares the results derived from these varied approaches. Also, this study could potentially unveil critical insights that further refine and enhance the efficacy and accuracy of data collection methods in future studies, thereby contributing to more robust and reliable findings in the domain of time-use research. For example, in assessing whether improved cooking stoves decrease cooking and fuel gathering time for women, the hypothesis that improved cooking stoves contribute to time savings would gain more credibility if "different" time use methods consistently yield data supporting this assertion. Last, understanding how individuals allocate their time is key to crafting approaches that aid those bogged down by drudgery activities.

The structure of this study is organized in the following manner: Initially, the literature review offers an overview of various time use methods, along with their advantages and disadvantages. Following this, the detailed time measurements for each activity across three distinct time use methods are provided, after presenting the methods utilized in this study. Subsequently, a comparative assessment and regression analysis are given to evaluate the consistency of time use methods and to explore the potential causes of any observed discrepancies in time measurements. Finally, robustness checks are conducted to verify the validity of our primary analysis.

2. Literature review

Creating tools to accurately measure and analyze time use patterns is crucial, as time is a fundamental resource in the fight against poverty, and for enhancing living standards (Wodon & Blackden, 2006). In prior work, women have been argued to spend at least double the time that men spend on uncompensated tasks, such as household chores (Dong & An, 2015). This disproportionate responsibility for household tasks restricts not only women's opportunities to earn income, but also limits their access to education, leisure, and social interactions (Dinkelman & Ngai, 2022; Wodon & Blackden, 2006). Fully documenting these inequalities requires comprehensive measurement of time use; yet research on the relative accuracy of different types of time-use elicitation techniques remains limited. Indeed, inconsistencies in the selection and application of various measures render comparisons across setting and across time extremely challenging (Seymour et al., 2017).

Existing methods for time use measurement in applied research can be grouped into five basic categories: “stylized” time use questions, traditional time diaries, hybrid time diaries, the experiential sampling method, and observational approaches. All except the latter rely on surveys with the individuals whose time use is being captured.

- a) “Stylized” time use questions focus on a limited number of specific activities of interest and are the predominant method for time use measurement in most field studies. Respondents are asked about the duration of the activities in question and are typically allowed to report this duration in different units, e.g., minutes or hours (Council et al., 2000). The advantage of these questions is clear: They are relatively efficient to ask (assuming that the activities of interest are not so numerous), straightforward to understand and implement, and therefore can be cost-effective (Council et al., 2000). These advantages

notwithstanding, a study in Uganda (Seymour et al., 2017) found negligible differences in interview durations when the “stylized” method was used rather than the more labor-intensive traditional time diary. Furthermore, a tendency for individuals to overstate time spent on socially beneficial activities using the “stylized” method is also found (Hirway, 2021). For example, parents often report spending more time reading to their children with this method compared to the time diary approach (Council et al., 2000). Finally, if the aim of a survey is to understand time use across various categories, the large number of “stylized questions” required may eliminate the relative gain in efficiency that these provide.

- b) The traditional time diary method asks respondents to document their time use allocation across all activities over a fixed period of time, which is typically a day. The diary can be completed in real-time or retrospectively (Council et al., 2000). To address potential ambiguities in activity categorization, activities are typically coded according to standardized activity lists defined in a survey preparation phase. Enumerators then use these codes to categorize respondents’ activity descriptions during interviews, data entry, or analysis (Stafford, 2009). When done retrospectively, the approach is most often implemented by an enumerator during an in-person interview, who begins by recording the time the respondent awoke on the previous day, and then asks the respondent to recount each activity and its duration, in succession, until they reach the end of the day, when the respondent says they went to sleep. Thus, survey enumerators, who must be well trained and proficient in interpreting respondents’ descriptions, play a vital role in eliciting time use with this method (Seymour et al., 2017). A time diary is fairly time intensive to administer, especially if time use patterns of multiple household members are of interest.

It can also fail to capture activities that are relatively short in duration, and its accuracy hinges on respondents being highly attuned to their schedules and how they translate into minutes and/or hours.

- c) The hybrid time diary, introduced by Masuda et al. (2014) and then also suggested in Field et al. (2023) with certain modifications, is designed to help reduce the cognitive burden of traditional time diaries. It has been proposed as a useful, less time intensive alternative to traditional time diaries for use with low-income, low-education respondents who may be unfamiliar with Western time conventions and measurements. In this method, participants allocate tokens, based on their sense of their relative time use during the prior day, across a pre-specified set of activities. For example, if the exercise is done with 24 (48) tokens, each token represents one (a half) hour of time use, that can be allocated to a given activity category. The activities are depicted using cue cards that show images related to it. Once all tokens are allocated across activities, respondents are given the opportunity to revise their allocations, with guidance provided by the enumerator. This method not only streamlines the interview process but also minimizes errors and reduces frustration due to participant exhaustion. It also makes it relatively easy to ask about multi-tasking, since follow-up questions can probe – again using token allocations – whether passive activities (e.g., childcare, or socializing) occurred alongside the main activities, and over what proportion of time allocated to the primary activity. In a study conducted in rural India, Field et al. (2022) found that the method showed more consistency with direct observations of activities by enumerators than traditional time diaries, but that it tended to miss short-duration activities.

- d) The experiential sampling method is substantively different; participants are equipped with a pager, beeper, or adjustable wristwatch, and receive random notifications throughout the day, asking them to report their activity at the time the alert is received. Upon receiving an alert, participants note their activity, and they may also be asked follow-up questions about it (Sonnenberg et al., 2012). On the one hand, this immediate response system reduces the likelihood of recall errors. However, the frequent and potentially intrusive alerts (Gershuny, n.d.) may deter participation among some individuals, introducing a selection bias as certain segments of the target population might opt out of the study. In addition, if an individual is notified during an activity that requires concentration and attention, they may not report until much later, raising questions about what exactly is captured using the approach.
- e) The final main alternative method for time use measurement relies on direct observation, using direct enumerator observation, or tools like cameras, tracking devices, and observation rooms (Seymour et al., 2017). This approach accommodates individuals who may not be literate or familiar with Western concepts of timekeeping, since they are not asked to report anything, thereby removing the necessity for reading, writing, or adhering to specific temporal structures in documenting their activities (ILO Regional Office for Asia & the Pacific & United Nations Development Programme, 2018). It can be very expensive, however, especially when human observers must spend considerable time watching participants go about their daily activities or analyze camera recordings for the same purpose. The use of sensors, on the other hand, may reduce cost but introduce uncertainty concerning the nature of the activities, since they typically only identify where participants go. Some critics additionally argue that this method is prone to Hawthorne

effects, in the sense that participants' awareness that they are being observed alters their behavior (Floro, 1995). Nonetheless, the US National Research Council (2000) contends that under the right conditions, this issue can be mitigated. For instance, reliable data can be gathered from children in daycare or schools, provided that parental consent is obtained.

The appropriateness of these various time use methods is related to both their reliability and feasibility. Regarding reliability, biases in time use measurements can vary based on the activity in question. For instance, Seymour et al. (2017) found that while stylized time use questions and traditional time diaries yield similar results for paid labor, their estimates diverge significantly for activities like shopping. Stafford (1991) theorize that the frequency of an activity influences the accuracy of different measures; more routine activities tend to produce more consistent responses. This insight underscores the need to closely examine irregular activities, which relates to some types of agricultural tasks carried out by rural households, as well as collection of biomass fuel from the environment. The recall period is also important, research suggests using public events as reference points rather than long timeframes like "the past seven days" (Council et al., 2000). Finally, the extent of recall bias can also be conditioned on a participant's psychological state (ILO Regional Office for Asia & the Pacific & United Nations Development Programme, 2018; Seymour et al., 2017). Measuring enjoyment or satisfaction during various activities has therefore emerged as an important research topic in time use accuracy studies.

In terms of feasibility, evaluations typically focus on two main areas: 1) cognitive challenges, which examine the ease of recalling an activity and its duration, and 2) the associated time and financial implications of the elicitation technique (Seymour et al., 2017). For studies aiming to capture relatively limited time use, a few simple "stylized" questions may be deemed most appropriate, but this advantage should be weighed carefully against the potential for bias,

particularly in the context of an evaluation of an intervention, where social desirability may push respondents to answer in strategic ways (e.g., to overstate or understate the benefits obtained).

3. Research design and methods deployed

3.1 Description of time use elicitation methods

In this study, time use data were captured using variants of four of the five method types described above. The three main approaches deployed, at baseline and endline, were 1) “stylized” time use questions; 2) traditional time diaries; and 3) hybrid time diaries (Appendix: Survey 1-3).

3.1.1 “Stylized” time use questions

In this module, respondents (all women primary cooks) were asked to estimate their own (and other household members’) time allocations for 8 specific activities as shown in Figure 1. In order to maximize the information collected, the recall period was specified to be a “typical day during which those specific activities were completed” by the person or by subgroups of other members (namely adult men, other adult women, adolescent girls, and adolescent boys), rather than, for example, the prior day or week. The 8 specific activities were chosen to best overlap with those captured by the other time use methods:

- i. fuel collection or acquisition,
- ii. fuel preparation,
- iii. cooking,
- iv. other work in the kitchen,
- v. other chores (domestic work, water collection, shopping, care for household members),
- vi. tending/herding animals,
- vii. working on one’s own farm, and
- viii. generating income from non-farm work.

We chose to ask about a typical day when the activity was completed rather than the prior day because we were concerned that some activities, especially fuel collection or acquisition, or generating income from non-farm work, might not be daily activities for respondents in our sample. This may introduce bias, however, if a typical day with the specific activity is a difficult concept for some respondents. Moreover, this formulation required that we also ask about the frequency and duration of each such “typical” activity by asking, for days when participants did engage in it, how regularly they did so. All respondents were asked to estimate their time spent on these activities and their frequencies, if they participated in them, in both the rainy and dry seasons, to see if there were differences across periods of the year.

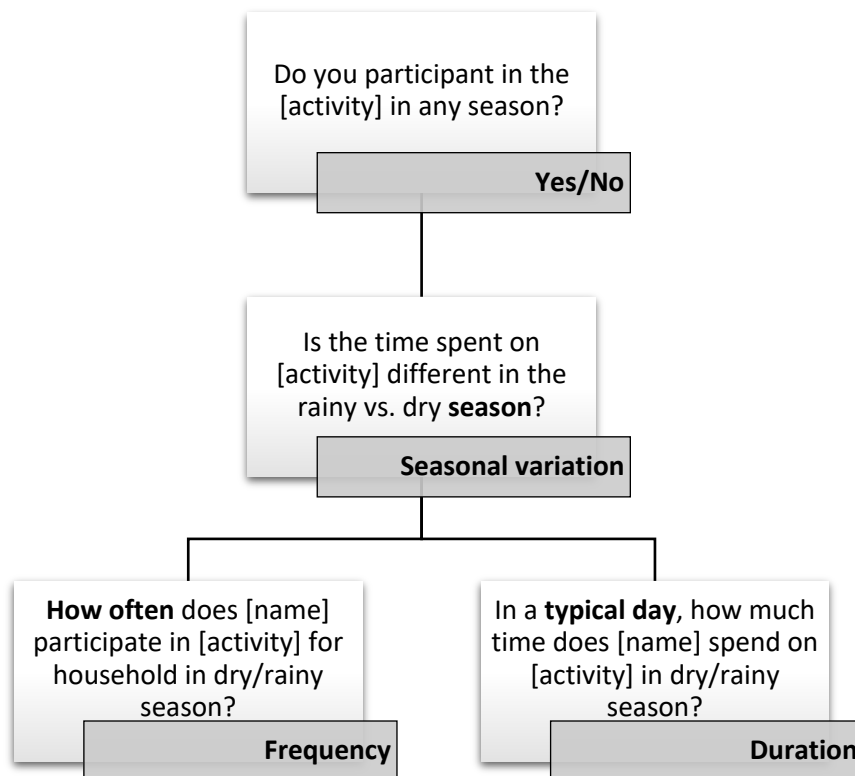


Figure 1: "Stylized" time use question

3.1.2 Traditional time diary

For this method, we divided the prior day into 15-minute intervals. Enumerators began eliciting time use by asking respondents to report the times that they had awoken and gone to sleep at night on the previous day. The activity recall then proceeded from the reported wake-up time and ended at the time they went to sleep at night. Enumerators walked through the day, asking respondents to list each primary activity in succession, how long (approximately) it lasted, and proceeding to the next activity based on their prior response. Once the enumerator reached the sleeping time, they confirmed with the respondent whether all activities from the prior day had adequately been captured, and if not, they made adjustments consistent with the respondents' corrections concerning what had been omitted. In this activity, enumerators were tasked with categorizing and summarizing the activities that respondents reported into a set of pre-specified options provided in the questionnaire. They did this by relying on respondents' descriptions and recollections. Figure 2 provides a straightforward example of how time use is documented: it records wake-up and bedtime, with each time slot labeled according to daily activities.

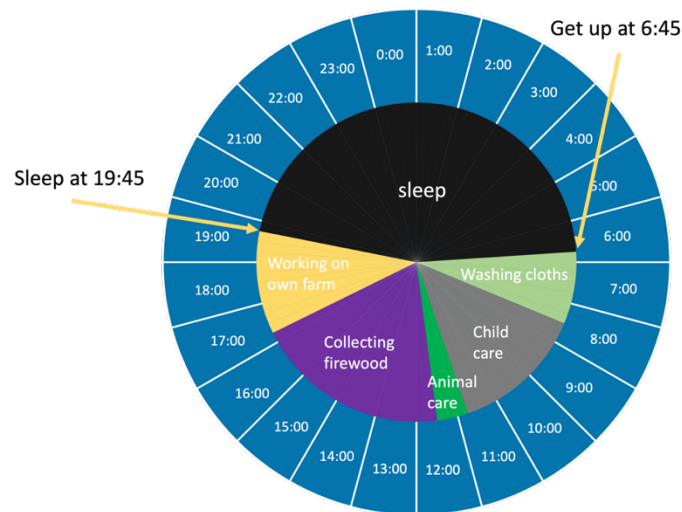


Figure 2: Traditional time diary example

3.1.2 Hybrid time diary

We developed and used a set of nine pictures, representing nine daily activities (i.e., sleeping, unpaid labor, paid labor, fuel collection/preparation, leisure/socializing, self-care, childcare and other household chores). It is important to note that these activity categories did not wholly match those in the “stylized” questions module, which are not exhaustive with respect to potential time uses. In this exercise, respondents were asked to allocate 48 tokens (representing 24 hours, i.e., each token represented 30 minutes) according to their perception of the relative time spent on each activity category (as a primary task) during the previous 24 hours. This exercise was also used to estimate the time spent on passive, or multi-tasking, activities. Specifically, following the allocation of tokens across the primary activities, respondents were asked to allocate additional tokens of a different color on each primary activity, specifying the amount of that activity’s time that also included each of 3 passive (or secondary) activities: Childcare, leisure/socializing, and domestic chores. For example, during cooking, if the responders were also performing childcare, they were asked to put multi-tasking tokens for childcare on the primary cooking activity, in proportion to the amount of time they spent multitasking during cooking. Thus, the number of passive tokens assigned could not exceed the number of primary tokens assigned to cooking; this was verified by the enumerator.

Participant selection for each time use method. Given the time required to complete all of the survey-based time use questions, we only collected “stylized” time use data for all respondents. A random 25% of the baseline sample was then assigned to complete the traditional time diary, and a separate, non-overlapping 25% was assigned to complete the hybrid diary, stratified by country. Respondents completed the same time elicitation modules at baseline and endline. Thus, any given respondent only completes at most two time elicitation exercises in each survey wave, and half of

respondents only complete one (the “stylized” portion). Figure 3 depicts the study design, and Table 1 shows the number of respondents completing each time use elicitation exercise by country, at baseline and endline.

Table 1: Sample assignment (number of respondents) to different time use elicitation methods (baseline/endline)

Country	“Stylized” time use	Traditional time diary	Hybrid time diary
Malawi	1021 / 971	280 / 261	259 / 246
Zambia	993 / 838	248 / 228	276 / 251
Kenya	983 / 455	236 / 102	271 / 133
Tanzania	961 / 881	240 / 222	236 / 215
Total	3958 / 3145	1004 / 813	1042 / 845

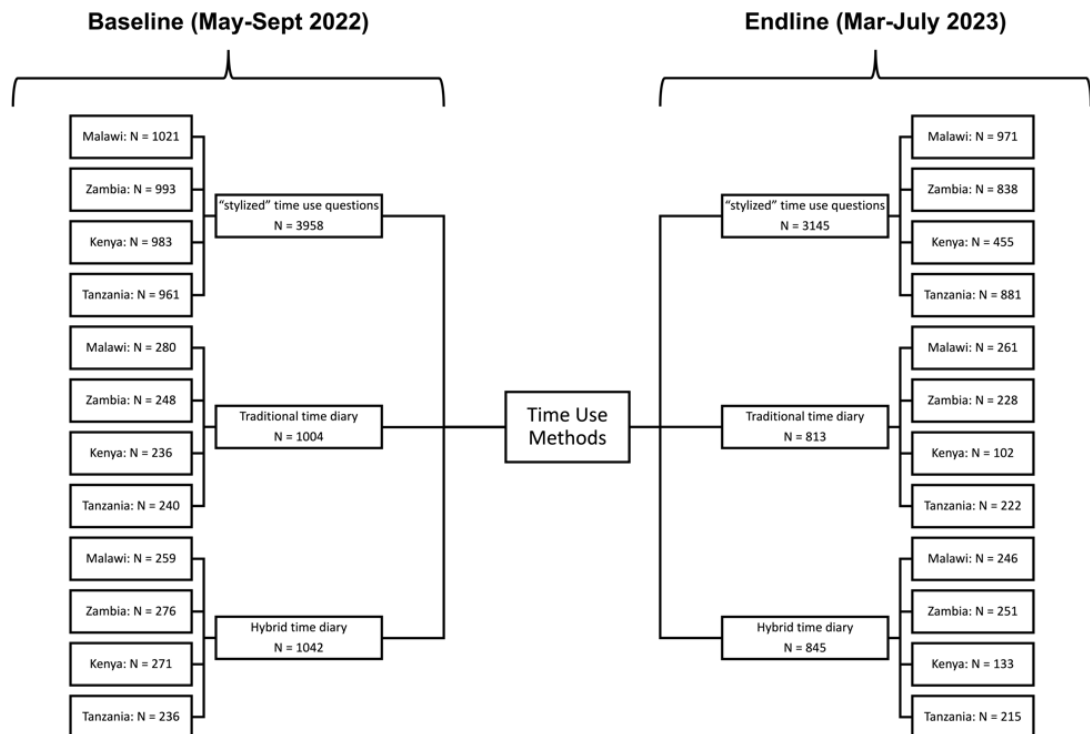


Figure 3: Time use elicitation sample design. Notes: At baseline, all respondents were meant to complete the "stylized" time use questions

Those completing the traditional and hybrid time diaries were sampled randomly from the overall sample to yield non-overlapping subsamples. Respondents re-interviewed at endline completed the same time use elicitation modules as they did at baseline.

3.2 Data

The analysis conducted seeks to understand, first, the degree of consistency across different time use measures, and second, to the extent that there is divergence across measures, whether the divergence can be explained by household and respondent characteristics. To conduct this analysis, we leverage the baseline and endline survey data, which provides both the time use data, and the demographic and socioeconomic details of the primary cooks who responded to the survey, and their households.

Table 2 provides a summary of the characteristics of the baseline sample respondents and their households, that are most relevant to interpreting the results from this analysis. In terms of age distribution of the primary cook, the majority of individuals are aged between 18 and 39 across all countries, with pooled data showing 53% in this age range. Individuals aged larger than 40 are followed, representing 42% in the pooled data. Regarding education level, a significant proportion of individuals have some or no primary education (≤ 8 th grade), with Malawi leading at 73%, and the pooled percentage at 53%. Those who completed primary school (8th grade) are next, with pooled data at 31%. A smaller fraction completed secondary education (12th grade), and even fewer have some university or post-secondary education. In terms of employment status, a majority are employed, with pooled data indicating 64%. However, primary cooks work in farming varied, which make up 63% of employment in Malawi and 39% in the pooled data. The type of occupation is predominantly owning a farm (crops), which ranges from 24% in Zambia to 59% in Malawi, with 36% in the pooled data. Other occupational categories like wage employment, self-

employment in non-farm business enterprises, and self-employment in livestock are less prevalent. Moreover, the role of a housewife represents a significant occupation in both Kenya and Tanzania, accounting for 20% of primary cooks, whereas this occupation is not documented in Malawi and Zambia. When examining the type of cooking fuel used, firewood is the most common with 98% in the pooled data. The use of charcoal and crop residue are also significant, particularly in Malawi (59%) and Kenya (54%) respectively. Other fuel types like dung, biogas, LPG/gas, kerosene, electricity, and ethanol are used to a much lesser extent. Lastly, the table presents the type of firewood acquisition, with most individuals collecting only. Purchase only is more common in Kenya (22%) and the pooled data shows 75% collecting only, ranging from 54% in Tanzania and 96% in Zambia.

Table 2: Baseline sample respondent and household characteristics

Variable (%)	Malawi	Zambia	Kenya	Tanzania	Pooled
N	1,032	1,008	1,022	1,001	4,063
Age group					
age ≤ 18	52 (5%)	90 (9%)	27 (3%)	53 (5%)	222 (5%)
18 < age < 39	542 (53%)	604 (60%)	386 (38%)	613 (61%)	2145 (53%)
age ≥ 40	438 (42%)	314 (31%)	609 (60%)	335 (33%)	1696 (42%)
Education level					
Some or no primary (<8 th grade)	754 (73%)	796 (79%)	390 (38%)	173 (17%)	2113 (52%)
Completed primary (8 th grade)	84 (8%)	53 (5%)	382 (37%)	754 (75%)	1273 (31%)
Some or completed secondary (12 th grade)	185 (18%)	151 (15%)	196 (19%)	65 (6%)	597 (15%)
Some or completed university/ post-secondary)	6 (1%)	8 (1%)	36 (4%)	8 (1%)	58 (1%)
Other technical training	0 (0%)	0 (0%)	14 (1%)	0 (0%)	14 (0%)
Adult literacy program only	3 (0%)	0 (0%)	4 (0%)	0 (0%)	7 (0%)

Some church/mosque school	0 (0%)	0 (0%)	0 (0%)	1 (0%)	1 (0%)
Employment status					
Farming job	655 (63%)	260 (26%)	317 (31%)	348 (35%)	1580 (39%)
Employed	853 (83%)	400 (40%)	686 (67%)	665 (66%)	2604 (64%)
Type of occupation					
Own farm (crops)	614 (59%)	243 (24%)	307 (30%)	297 (30%)	1461 (36%)
Fishing/farm fishing	0 (0%)	5 (0%)	0 (0%)	0 (0%)	5 (0%)
Wage employee, non-farm	12 (1%)	8 (1%)	29 (3%)	6 (1%)	55 (1%)
Wage employee, farm	41 (4%)	12 (1%)	10 (1%)	51 (5%)	114 (3%)
Self-employed non-farm-business enterprise	110 (11%)	117 (12%)	101 (10%)	42 (4%)	370 (9%)
Self-employed – livestock	1 (0%)	2 (0%)	184 (18%)	242 (24%)	429 (11%)
Casual/day laborer	74 (7%)	12 (1%)	51 (5%)	5 (0%)	142 (3%)
Intern/free labor/voluntary work	1 (0%)	1 (0%)	4 (0%)	22 (2%)	28 (1%)
Student	13 (1%)	35 (3%)	13 (1%)	12 (1%)	73 (2%)

Job seeker/unemployed	146 (14%)	406 (40%)	55 (5%)	107 (11%)	714 (18%)
Housewife	0 (0%)	0 (0%)	211 (21%)	204 (20%)	415 (10%)
Retired, disabled, too old and others	20 (2%)	167 (17%)	57 (6%)	13 (1%)	257 (6%)
Type of cooking fuel used					
Firewood	1015 (98%)	994 (99%)	1003 (98%)	981 (98%)	3993 (98%)
Crop residue	612 (59%)	11 (1%)	15 (1%)	2 (0%)	640 (16%)
Dung	2 (0%)	0 (0%)	0 (0%)	1 (0%)	3 (0%)
Biogas	0 (0%)	0 (0%)	2 (0%)	0 (0%)	2 (0%)
Charcoal	276 (27%)	130 (13%)	547 (54%)	116 (12%)	1069 (26%)
LPG/gas	0 (0%)	0 (0%)	134 (13%)	13 (1%)	147 (4%)
Kerosene	1 (0%)	0 (0%)	16 (2%)	0 (0%)	17 (0%)
Electricity	10 (1%)	0 (0%)	0 (0%)	0 (0%)	10 (0%)
Ethanol	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Type of firewood acquisition					
Purchase only	159 (15%)	18 (2%)	46 (5%)	219 (22%)	442 (11%)
Collect only	726 (70%)	967 (96%)	801 (78%)	545 (54%)	3039 (75%)
Purchase & collect	147 (14%)	23 (2%)	175 (17%)	237 (24%)	582 (14%)

Figure 4 show the average time spent by the primary cook on various activities across the different country samples, as recorded at baseline (see Figure 6 in Appendix for time measurements at endline). Note that the time measures recorded by “stylized” time use questions are adjusted by the reported frequency of the activity, since the time use of each activity in a typical day is captured. The adjustment, however, is not made to time measures recorded by traditional and hybrid time diaries because the activities and their corresponding time use are recorded for the prior day, which, at a sample level, reflects the frequency of key activities. As shown, there are major differences recorded across the different time use elicitation methods, but the cooking time estimates appear relatively more consistent, in all four countries. This higher consistency may be related to the fact that the survey respondent was always the primary cook in the household, who would therefore be expected to have fairly precise knowledge of this activity. Another reason for the greater concordance in reported cooking time across elicitation methods could be the fact that preparing meals is a frequent and regular part of daily life in these rural locations, that likely varies less than other activities.

In contrast, for activities that are less frequent or regular, or for which the division of labor is less clear, such as fuel acquisition and preparation (less regular and shared responsibility) or even unpaid and paid work (less regular), the approaches produce less consistent patterns. One plausible explanation for this is recall error. Infrequent activities are more susceptible to memory biases, leading individuals to possibly misremember or overestimate the time they spend. Another possibility is that seasonal variation may lead to differences between what is seen as a typical day relative to the diary measures of the previous day – this could be particularly relevant for labor allocation and fuel collection. They may also overestimate the frequency of engagement in the activity, which would result in our estimating greater time spent per day on an infrequent activity.

Another noteworthy finding is the higher reported time spent on household chores in the hybrid diary when passive time use is included, compared with other time use methods. On the one hand, the hybrid diary may be subject to psychological biases, given that domestic chores tend to be unappealing to most individuals. On the other hand, the hybrid time diary is also the only approach that directly captures multitasking, which may lead to higher reporting of chores, since these may be more commonly completed in a multi-tasking environment. Indeed, women often juggle multiple responsibilities simultaneously, such as tending to household chores while also caring for infants or young children.

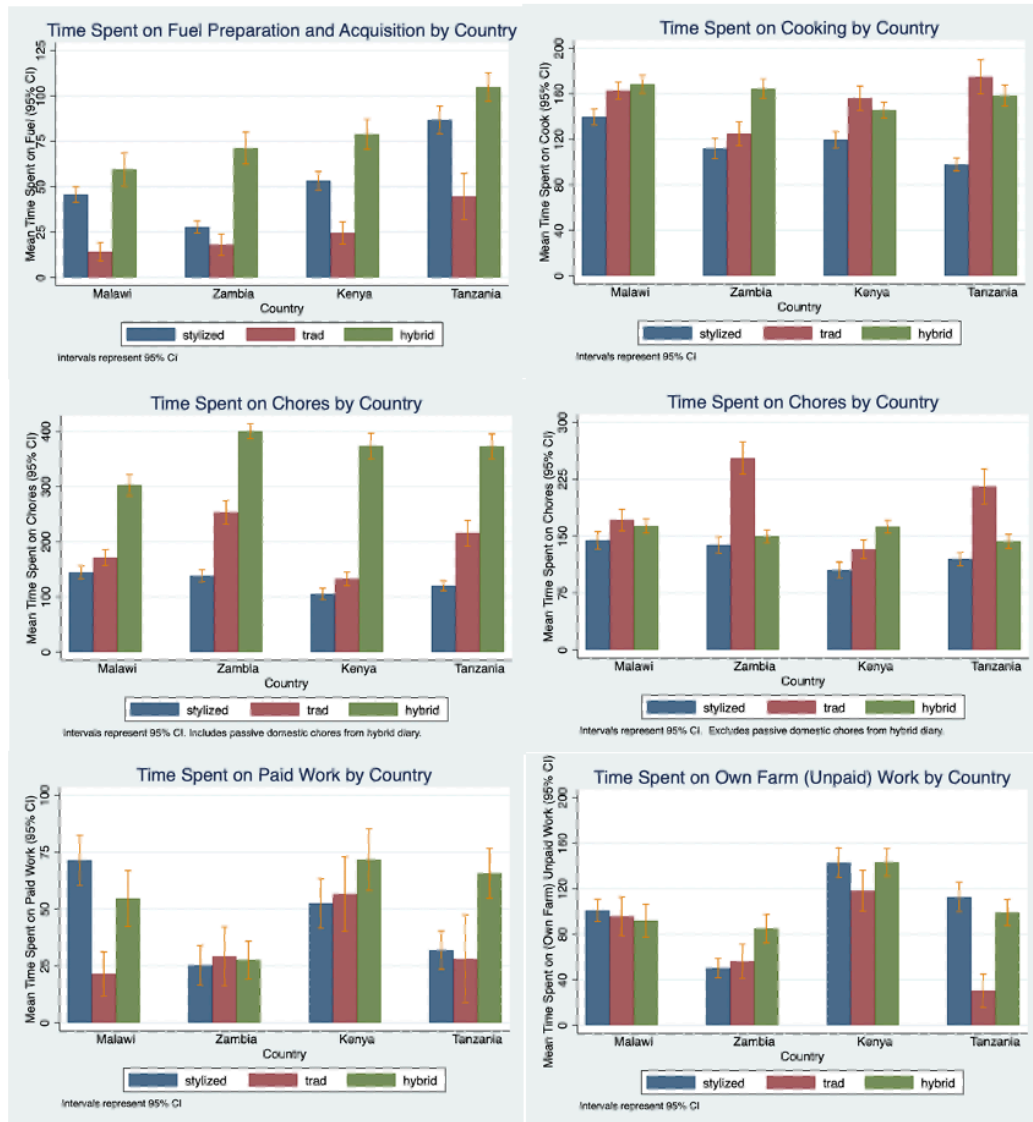


Figure 4: Baseline time use measured in five major activity categories by country: a) fuel acquisition and preparation; b) cooking; c) unpaid work; d) domestic chores; and e) paid work.

4. Economic analysis

Work under this study has two primary objectives. First, it seeks to understand degree of consistency across different time use measures, using both baseline and endline data. Second, to the extent that there is divergence across measures, it seeks to shed light on whether the divergence can be explained by household and respondent characteristics.

For the first aspect, we begin with an examination of the simple pairwise correlations (and their statistical significance) between the time captured by the “stylized” time use questions that all respondents completed, and the a) traditional or b) hybrid time measures, that were completed by randomly-determined subsamples. We do not expect perfect correlation, for several reasons. First, for activities that do not happen daily (such as fuel collection), recall over the prior day, as occurs in the traditional and hybrid diaries, will yield a mix of zeros and larger time amounts, relative to the frequency-adjusted estimates derived from a typical day when the respondent engages in the activity. Second, the prior day may be quite different from a typical day. Finally, as noted in the literature review above, each of these measures are affected differently by recall bias as well as measurement error, that has to do with how people think about time, as well as the frequency of their engagement in the activities being discussed. We expect that correlations will be stronger for a) daily activities, relative to less frequent activities, and b) activities for whom the respondent, as primary cook, is likely more responsible, such as cooking, and domestic chores.

For the second objective, we first develop measures that capture discrepancies in the alternative measures of the primary cook’s time use. We compute the absolute value of the time differences between the “stylized” time use questions and the a) traditional time diary or b) hybrid time diary, for each respondent that completed the former and one of the latter. We then employ

multivariable regression analyses, using Ordinary Least Squares (OLS), to see which respondent or household characteristics influence those discrepancies:

$$Y_{it} = \alpha + X_{it}\beta + \mu_i + v_t + \xi_i + \epsilon_{it} \quad (1)$$

where Y_{it} (listed in Table 3) is the absolute value of the time difference (or its logarithm after adding up 0.1 to correct for right skewness in its distribution) (see Appendix: Figure 5) between “stylized” time use questions and either the a) traditional time diary and b) hybrid time diary, for household i ($i = 1, 2, \dots, n$) at time t ($t =$ baseline, endline); X_{it} is a vector of m explanatory variables; β is the vector of coefficients of X_{it} ; ϵ_{it} is the error term. This regression is estimated including village fixed effects μ_i to capture time-invariant factors specific to a given village that may explain these differences, enumerator fixed effect ξ_i to control for enumerator bias, as well as with an endline indicator fixed effect v_t . Standard errors are clustered at the village level. The $1 \times m$ vector X_{it} comprises the factors listed in Table 4.

Table 3: Outcomes of interest included in equation (1)

Outcome of interest		Description
Fuel activity time gap	tradfuel	Calculated as absolute fuel time gap between “stylized” time use questions and traditional time diary
	log(tradfuel)	Calculated as the logarithm of tradfuel after adding up 0.1
	hybridfuel	Calculated as absolute fuel time gap between “stylized” time use questions and hybrid time diary
	log(hybridfuel)	Calculated as the logarithm of hybridfuel after adding up 0.1
	fuel	Pooled fuel activity time gap
	log(fuel)	Calculated as the logarithm of fuel after adding up 0.1
Cooking time gap	tradcook	Calculated as absolute cooking time gap between “stylized” time use questions and traditional time diary

	log(tradcook)	Calculated as the logarithm of tradcook after adding up 0.1
	hybridcook	Calculated as absolute cooking time gap between “stylized” time use questions and hybrid time diary
	log(hybridcook)	Calculated as the logarithm of hybridcook after adding up 0.1
	cook	Pooled cooking time gap
	log(cook)	Calculated as the logarithm of cook after adding up 0.1

Table 4: Explanatory variables included in equation (1)

Explanatory variables		Description
Fuel and cooking type	Proximity to purchased / collected firewood	Time spent on a single round trip required to obtain firewood, whether purchased or collected (mins/trip)
Fuel type	Means of firewood acquisition	Two indicator variables ‘Purchase on’y’ for households that exclusively buy firewood, an ‘Collect on’y’ for those that only gather it
	# of firewood collectors	The number of individuals in a household who collect firewood
	Frequency of firewood collection	Categorical variable indicating the interval of time of firewood acquisition by the primary cook, where a larger number denotes less frequent acquisition
Cooking type	# of primary cooks	Count of primary cooks in the household
	# of meals per day	The number of meals per day cooked in the household
	Stove satisfaction	Categorical variable representing the primary co’k’s self-reported satisfaction with the household’s primary stove; a larger number indicates greater satisfaction
Primary cook characteristics	Age	Categorical variable for age: Less than 18 yrs, 1–39 yrs, and over 40 yrs (less than 18 yrs is the omitted, reference category)
	Education	A series of indicator variables representing the highest education level attained (less than

		completed primary is the omitted, reference category)
	Lack of sense of western time	The log of the absolute difference between actual and self-reported interview times
	Time use agency	Categorical variable where a higher number indicates less autonomy in time use
	Occupation	A series of indicator variables indicating employment status: 'Farm labor', 'Paid labor', etc. We group own farm labor into one indicator, and employed as another separate indicator.
Household characteristics	Wealth index	PCA-generated index constructed from assets, livestock, access to water, land ownership, access to electricity, and the number of rooms
Other	Enumerator fixed effects	Indicator for the enumerator who conducted the interview
	Endline fixed effect	Indicator for the endline wave of data collection
	Village fixed effect	Indicator for the respondents living in

5. Results

5.1 Simple correlations

Table 5 presents the correlations between the “stylized” time use questions, on the one hand, and the traditional time diary and hybrid time diary, on the other hand, for each of the two sub-samples that completed the latter. The correlations are shown across each of the five activities and separated by country— - Malawi, Zambia, Kenya, Tanzania— - as well as for the overall “pooled” cross-country sample. Nearly all of the correlations are positive, but not all are statistically significant, and the correlations range from weak to moderate, never exceeding 0.5.

Table 5: Pairwise correlations between "stylized" time use questions measures and a) traditional time diary and b) hybrid time diary measures, for each sub-sample that completed the latter.

Country	Activity	Traditional time diary	Hybrid time diary
Malawi	Fuel preparation and acquisition	0.06	0.15***
	Cooking	0.08*	0.23***
	Household chores: Inc. passive	0.08*	0.43***
	Household chores: Exc. passive	n.a.	0.24***
	Unpaid work	0.19***	0.34***
	Paid work	0.25***	0.39***
Zambia	Fuel preparation and acquisition	0.17***	0.19***
	Cooking	0.24***	0.20***
	Household chores: Inc. passive	0.07	0.33***
	Household chores: Exc. passive	n.a.	0.14***
	Unpaid work	0.15***	-0.12***
	Paid work	0.20***	0.34***
Kenya	Fuel preparation and acquisition	0.10*	0.21***
	Cooking	0.17***	0.14***
	Household chores: Inc. passive	0.04	-0.05
	Household chores: Exc. passive	n.a.	0.09*
	Unpaid work	0.37***	0.25***
	Paid work	0.36***	0.38***
Tanzania	Fuel preparation and acquisition	0.19***	0.16***
	Cooking	0.17***	-0.12**
	Household chores: Inc. passive	-0.13**	0.09*
	Household chores: Exc. passive	n.a.	0.16***

	Unpaid work	0.39***	0.35***
	Paid work	0.33***	0.46***
Pooled	Fuel preparation and acquisition	0.17***	0.19***
	Cooking	0.18***	0.11***
	Household chores: Inc. passive	0.04*	0.18***
	Household chores: Exc. passive	n.a.	0.17***
	Unpaid work	0.35***	0.24***
	Paid work	0.28***	0.40***

The pooled sample, which has the greatest statistical power, also shows the most consistent positive and significant correlations between the “stylized” time use questions measures and each of the diaries. Specifically, the correlation is greatest for unpaid and paid work when compared with traditional and hybrid time diaries respectively. Thus, the apparently greater agreement in the mean time spent on cooking does not extend to correlation of the variation in cooking time that is reported across different sample respondents as previously discussed in Figure 1. Additionally, the correlations across measures for the more divergent fuel preparation and acquisition activity are similar (compared with traditional time diary) or higher (hybrid time diary) than those for cooking activity. This result is also against the hypothesis that the correlations will be stronger for daily activities.

The degree of correlation for different activities also varies across countries. For fuel preparation and acquisition, the correlations are all positive, with the mixed significance level by country. Specifically, these moderate correlations can be found in Zambia and Tanzania for both time diaries, and Kenya and Malawi for the hybrid time diary. Cooking activities in Malawi, Zambia and Tanzania show positive correlations with both methods, whereas in Tanzania, there is a positive correlation with the traditional method and a negative one with the hybrid method. Across the board, the correlations are most consistently positive for paid work, for which time use may be particularly salient because of its link to remuneration.

5.2 Regression results

To understand what factors might be driving inconsistencies across these measures, we next conduct the regression shown in equation (1). In this section, we focus on the differences in a) fuel collection and acquisition and b) cooking, given the importance of these activities for this study. This study does not compare the time measurements of other activities, as it focuses on cooking time and fuel gathering, which are more directly influenced by the use of improved cooking stoves.

5.2.1 Regression results for fuel activities

Table 6 shows the regression results for discrepancies between the “stylized” time use questions and two time diaries, for fuel preparation and acquisition. Generally, hybrid time diary tends to have larger time discrepancies than traditional time diary, when compared with the “stylized” time use questions.

First, the fuel variables are highly determinant of the time discrepancies across time use methods. In examining the frequency of firewood acquisition, it is significantly and negatively correlated with the time gap between the “stylized” time use questions and the other two diaries. Thus, primary cooks who participate less frequently in firewood collection tend to have smaller time differences across methods. Interestingly, as the time spent per trip acquiring wood increases, whether purchased or collected, the time gap between the “stylized” time use questions and the other two time diaries increases as well. Moreover, those who exclusively collect firewood have larger time differences except in Model (2) and (3), while those who purchase exclusively have larger differences only in Model (1).

Second, in examining individual characteristics, the regression result uncovers limited trends. Only the highest education level (some or completed post-secondary) is highly correlated

with smaller time discrepancies in the model of comparing with the hybrid time diary and in the pooled model. Time use agency, another variable generally shows statistically significant relationship, where less agency correlates with smaller differences. In addition, compared with primary cooks under 18, cooks above 39 years old tend to report smaller time gap as shown in Model (6).

Third, household characteristics also explains time discrepancies. The wealth index is somewhat negatively correlated with differences. Finally, survey and sample aspects do seem important. At endline, the larger divergence is noticed only in Model (2). For primary cooks living in Tanzania and Zambia, generally they reported smaller time discrepancies compared with those in Malawi, while for those living in Kenya, the reported time discrepancies varie.

Table 6: Regression results for fuel preparation and acquisition time measurement comparisons

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	tradfuel	Log(tradfuel)	hybridfuel	Log(hybridfuel)	fuel	Log(fuel)
Cook is between 18 and 39 yrs old	-2.91	-0.28	-2.73	-0.1	-2.06	-0.14
	-5.18	-0.2	-6.18	-0.15	-4.08	-0.13
Cook is > 39 yrs old	-1.24	-0.25	-5.1	-0.23	-3.66	-0.23*
	-5.38	-0.21	-6.44	-0.15	-4.27	-0.13
# of firewood collectors	0.26	-0.03	-0.72	-0.02	0.006	-0.03
	-1.6	-0.05	-1.61	-0.05	-1.13	-0.04
Time use agency	-0.11	-0.02*	-0.66*	-0.02	-0.39	-0.02*
	-0.3	-0.01	-0.38	-0.01	-0.28	-0.01
Lack of sense of western time	0.36	0.03	-0.56	-0.04	0.15	-0.001
	-0.64	-0.03	-0.91	-0.02	-0.61	-0.02
Education level of the primary cook						
Completed primary (8 th grade)	3.26	-0.01	-1.16	0.07	0.75	0.02
	-3.3	-0.14	-4.03	-0.13	-2.82	-0.1
Some or completed secondary (12 th grade)	0.39	-0.06	-5.4	-0.1	-2.42	-0.08
	-3.09	-0.12	-3.78	-0.12	-2.29	-0.08
Some or completed	4.57	0.32	-46.25***	-1.60***	-20.78**	-0.76*

university/post-secondary						
	-13.17	-0.74	-9.02	-0.41	-8.24	-0.39
Employment status of the primary cook						
Farming job	0.09	0.02	-2.99	-0.11	-1.36	-0.05
	-4.02	-0.12	-4.8	-0.13	-3.13	-0.1
Employed	1.89	-0.08	-4.21	-0.09	-0.69	-0.04
	-3.66	-0.13	-4.49	-0.15	-3.05	-0.11
Firewood acquisition variables						
Purchase time per trip	0.07*	0.002	0.07*	0.003***	0.09***	0.003***
	-0.04	-0.001	-0.04	-0.001	-0.03	-0.001
Collect time per trip	0.17***	0.003***	0.05**	0.0002	0.11***	0.001***
	-0.02	-0.0006	-0.02	-0.0006	-0.01	-0.0005
Less frequent firewood acquisition	-10.47***	-0.51***	-0.13	-0.13***	-5.35***	-0.32***
	-0.7	-0.03	-0.73	-0.03	-0.54	-0.02
Type of firewood acquisition						
Purchase only	13.06**	-0.11	-6.03	-0.25	2.98	-0.18
	-5.89	-0.23	-5.9	-0.23	-4.14	-0.17
Collect only	8.45*	0.18	4.89	0.35*	8.57***	0.31***
	-4.61	-0.14	-4.99	-0.19	-3.13	-0.11
Type of firewood acquisition						
Use charcoal	2.17	-0.04	-3.46	-0.17	-0.6	-0.1
	-3.12	-0.12	-3.16	-0.11	-2.19	-0.08
Use LPG	2.15	0.2	10.83	-0.08	8.77	0.11
	-8.93	-0.29	-8.66	-0.25	-5.68	-0.18
Other						
Wealth index	-1.92	-0.13**	0.26	-0.01	-0.81	-0.08**
	-1.47	-0.05	-1.46	-0.04	-0.94	-0.03
Tanzania	-7.95	-3.04***	8.67	0.06	-2.19	-1.56***

	-18.31	-0.73	-16.36	-0.47	-11.15	-0.49
Kenya	28.89**	1.00***	23.82	-0.41	19.82	0.37
	-13.48	-0.31	-39.82	-1.52	-16.33	-0.81
Zambia	-18.17***	-0.86***	12.29	0.15	10.29*	-0.40**
	-6.39	-0.24	-8.76	-0.25	-5.95	-0.18
Endline	-1.88	0.17*	-1.81	0.02	-1.68	0.07
	-2.65	-0.1	-2.9	-0.09	-1.96	-0.06
Hybrid diary					17.29***	0.62***
					-1.83	-0.06
Constant	58.53***	5.13***	77.99***	4.42***	56.95***	4.33***
	-9.79	-0.3	-12.13	-0.36	-7.97	-0.23
Observations	1,663	1,663	1,832	1,832	3,495	3,495
R-squared	0.4	0.47	0.15	0.17	0.2	0.27

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Standard errors are clustered at the village level. Enumerator fixed effect and village fixed effect are omitted in this table but included in the analysis. Columns (1) and (3) display the results of comparing the time measurement captures by the “stylized” time use questions with that recorded using traditional and hybrid time diaries, respectively. Columns (2) and (4) are the corresponding log transformed results. Column (5) represent the results with pooled sample and column (6) is the corresponding log transformed results.

5.2.2 Regression results for cooking activity

Table 7 shows the regression results for discrepancies between the “stylized” time use questions and the two time diaries, for the cooking activity.

First, among the cooking and fuel type variables, the number of meals prepares per day is significantly positively correlated with these time gaps. Moreover, the number of primary cooks in a household is also significantly and positively correlated with the time gap in Model (3) and (5). Use of LPG, however, shows a significant and negative correlation with time gap when compared with the traditional time diary (Model (1)), indicating that the household using LPG tend to have primary cook reporting higher time discrepancies.

Second, more of the characteristics of the primary cook seem to explain divergences for this category of time use. Being employed or working farm jobs correlates with larger time gaps, though these statistically significant correlations are not found when compared with traditional time diary. Time use agency, again, plays a similar role as in the results for fuel activities, in having a statistically significant relationship, whereby less agency correlates with a smaller time gap when using the hybrid time diary measure.

Third, household characteristics also exhibit relationships with time discrepancies. The wealth index, unlike the findings from fuel-related activities, shows a positive correlation with discrepancies in time measurement. This correlation is evident when comparing "stylized" measures against traditional methods and the combined model analysis. Cooking time disparities are notably greater in Kenya and Zambia than in Malawi. Contrary to the findings related to fuel activities, primary cooks reported significantly larger discrepancies in cooking times during the study endline period.

Table 7: Regression results for cooking time measurement comparison

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	tradcook	Log(tradcook)	Hybridcook	Log(hybridcook)	cook	Log(cook)
Cook is between 18 and 39 yrs old	-2.69	-0.13	-9.79	-0.14	-6.57	-0.17
	-7.35	-0.29	-7.34	-0.22	-4.92	-0.18
Cook is > 39 yrs old	3.01	0.08	-4.85	0.04	-1.64	0.02
	-7.65	-0.29	-7.58	-0.23	-5.4	-0.18
Time use agency	-0.18	-0.003	-0.96**	-0.03	-0.62	-0.01
	-0.52	-0.02	-0.48	-0.02	-0.38	-0.01
Lack of sense of western time	1.15	0.03	0.34	-0.002	0.48	0.01
	-1.18	-0.05	-0.89	-0.03	-0.76	-0.03
Education level of primary cook						
Completed primary (8 th grade)	4.37	-0.03	-0.15	-0.03	2.12	-0.01
	-4.29	-0.16	-4.46	-0.18	-2.91	-0.12
Some or completed secondary (12 th grade)	-1.44	0.02	1.91	-0.08	-0.11	-0.04
	-4.51	-0.15	-5.33	-0.2	-3.28	-0.13
Some or completed university/post-secondary	11.68	-0.1	3.77	0.12	7.68	0.02
	-22.57	-0.51	-13.52	-0.43	-12.96	-0.34
Employment status of primary cook						
Farming job	-3.84	-0.03	-7.46	-0.04	-6.45*	-0.06
	-5.08	-0.17	-4.87	-0.2	-3.63	-0.13
Employed	-5.64	-0.21	-12.64***	-0.09	-9.41***	-0.13
	-5.53	-0.19	-4.1	-0.19	-3.4	-0.13
Cooking aspects						
# of meals	2.05	0.13	5.27*	0.16	4.56**	0.17**
	-3.24	-0.11	-3.01	-0.12	-2.21	-0.08
Satisfaction with stove	-1.57	-0.02	0.15	-0.03	-0.66	-0.03
	-1.59	-0.05	-1.35	-0.05	-1.15	-0.04
# of primary cooks	4.54	0.18*	-0.67	0.13	1.75	0.15*
	-2.92	-0.1	-2.39	-0.1	-2.01	-0.08
Type of fuel used						
Use charcoal	4.65	0.07	-1.79	-0.05	0.96	-0.004

	-4.18	-0.16	-3.85	-0.19	-2.86	-0.13
Use LPG	-22.25**	-0.35	-2.42	-0.2	-9.93	-0.24
	-9.38	-0.29	-7.47	-0.34	-7.002	-0.22
Other						
Wealth index	3.98**	0.09	-1.63	0.05	1.12	0.07*
	-1.73	-0.06	-1.31	-0.06	-1.06	-0.04
Tanzania	10.44	-0.8	-5.04	-0.05	2.84	-0.44
	-13.85	-0.67	-17.01	-0.88	-11.15	-0.61
Kenya	148.4***	2.19***	36.16	0.52	102.8***	1.55**
	-17.2	-0.47	-52.36	-1.22	-32.17	-0.72
Zambia	-28.50***	0.51	106.6***	2.46***	112.3***	2.41***
	-9.59	-0.39	-9.63	-0.43	-7.38	-0.29
Endline	-15.01***	-0.33**	-18.98***	-0.81***	-17.61***	-0.58***
	-3.62	-0.13	-3.65	-0.13	-2.77	-0.09
Hybrid diary					-2.49	-0.30***
					-2.09	-0.09
Constant	64.00***	2.821***	84.03***	3.030***	75.62***	3.100***
	-14.43	-0.56	-14.97	-0.65	-10.58	-0.41
Observations	1,663	1,663	1,832	1,832	3,495	3,495
R-squared	0.152	0.104	0.212	0.168	0.143	0.115

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Standard errors are clustered at the village level. Enumerator fixed effect and village fixed effect are omitted in this table but included in the analysis. Columns (1) and (3) display the results of comparing the time measurement captures by the “stylized” time use questions with that recorded using traditional and hybrid time diaries, respectively. Columns (2) and (4) are the corresponding log transformed results. Column (5) represent the results with pooled sample and column (6) is the corresponding log transformed results.

6. Robustness checks

To confirm the validity of the logarithmic transformation applied to the time measure discrepancies observed between 'stylized' time use questions and the data from two time diaries, we have conducted a robustness check using the inverse hyperbolic sine (IHS) transformation (as delineated in Equation (2)). This method is advantageous as it accommodates non-positive values and mitigates the impact of outliers within the right-skewed distribution of our dependent variables, aligning well with their observed characteristics.

$$\sinh^{-1}(y) = \ln(y + \sqrt{y^2 + 1}) \quad (2)$$

Following calculation of the alternative dependent variables obtained from this transformation, we reapply Equation (1) to assess the consistency and robustness of our initial findings.

6.1 Robustness check regression results for fuel activities

Table 8 presents the findings from this analysis, for fuel related activities. These findings largely align with the primary regression analysis, yet they offer additional details. For example, the data does not support a statistically significant positive association between exclusively purchasing firewood and the time gap compared with the traditional time diary. Instead, a nonsignificant negative correlation is observed indicating that reliance on purchased firewood alone may not significantly alter reported time discrepancies. What is more, the analysis indicates that among primary cooks aged 39 and older, there is no significant correlation observed with the pooled time gap (as shown in Model (3)), although the direction of the effect remains negative.

Table 8: Robustness check results for fuel acquisition and preparation

	(1)	-2	-3
VARIABLES	tradfuel	hybridfuel	fuel
Cook is between 18 and 39 yrs old	-0.19	-0.07	-0.1
	-0.17	-0.13	-0.11
Cook is > 39 yrs old	-0.16	-0.18	-0.16
	-0.18	-0.13	-0.11
# of firewood collectors	-0.02	-0.02	-0.02
	-0.04	-0.04	-0.03
Time use agency	-0.01	-0.01	-0.01*
	-0.01	-0.01	-0.008
Lack of sense of western time	0.02	-0.03	-0.003
	-0.02	-0.02	-0.02
Education level of the primary cook			
Completed primary (8 th grade)	-0.007	0.05	0.02
	-0.11	-0.11	-0.08
Some or completed secondary (12 th grade)	-0.02	-0.1	-0.06
	-0.1	-0.1	-0.06
Some or completed university/post-secondary	0.28	-1.46***	-0.69**
	-0.58	-0.32	-0.31
Employment status of the primary cook			
Farming job	-0.07	-0.08	-0.04
	-0.11	-0.13	-0.09
Employed	0.04	-0.08	-0.02
	-0.1	-0.11	-0.08
Firewood acquisition variables			
Purchase time per trip	0.002**	0.002**	0.003***
	-0.001	-0.001	-0.0008
Collect time per trip	0.003***	0.0003	0.002***
	-0.0005	-0.0005	-0.0004
Less frequent firewood acquisition	-0.42***	-0.11***	-0.26***

	-0.02	-0.02	-0.02
Type of firewood acquisition			
Purchase only	-0.07	-0.25	-0.16
	-0.18	-0.18	-0.14
Collect only	0.22*	0.26*	0.28***
	-0.11	-0.16	-0.09
Type of firewood acquisition			
Use charcoal	-0.04	-0.14	-0.08
	-0.1	-0.09	-0.07
Use LPG	0.15	-0.04	0.11
	-0.24	-0.2	-0.15
Other			
Wealth index	-0.11**	-0.013	-0.07**
	-0.04	-0.034	-0.03
Tanzania	-2.08***	0.14	-1.04***
	-0.57	-0.38	-0.38
Kenya	0.91***	-0.15	0.4
	-0.24	-1.24	-0.64
Zambia	-0.78***	0.21	-0.21
	-0.19	-0.2	-0.15
Endline	0.12	0.01	0.05
	-0.08	-0.07	-0.05
Hybrid diary			0.55***
			-0.05
Constant	5.42***	5.05***	4.85***
	-0.28	-0.31	-0.19
Observations	1,663	1,832	3,495
R-squared	0.493	0.173	0.273

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Standard errors are clustered at the village level. Enumerator fixed effect and village fixed effect are omitted in this table but included in the analysis. Columns (1) and (2) display the results of comparing the time measurement captures by the “stylized” time use questions with that recorded using traditional and hybrid time diaries, respectively. Column (3) represent the results with pooled sample.

6.2 Robustness check regression results for cooking activity

Table 9 presents the results from a robustness check regression analysis centered on cooking activity. These results are again aligned with those from our main analysis, yet they reveal nuances related to individual characteristics and behaviours concerning cooking and fuel-related activities. First, employment status, whether working on a farm or being employed, does not exhibit a significant correlation with the time gap associated with cooking activities, although the direction of the relationship remains consistently negative. Second, the previously significant relationship between household using LPG and the time gap, as compared with records from the “stylized” time use questions, is no longer significant, yet the generally negative relationship persists.

Table 9: Robustness check results for cooking

	(1)	-2	-3
VARIABLES	tradcook	hybridcook	cook
Cook is between 18 and 39 yrs old	-0.11	-0.13	-0.14
	-0.22	-0.17	-0.14
Cook is > 39 yrs old	0.05	0.02	0.004
	-0.22	-0.18	-0.14
Time use agency	-0.003	-0.02	-0.01
	-0.01	-0.02	-0.01
Lack of sense of western time	0.03	0.0008	0.01
	-0.04	-0.02	-0.02
Education level of primary cook			

Completed primary (8 th grade)	-0.002	-0.02	-0.004
	-0.13	-0.14	-0.09
Some or completed secondary (12 th grade)	0.01	-0.06	-0.03
	-0.12	-0.16	-0.1
Some or completed university/post-secondary	-0.05	0.09	0.03
	-0.42	-0.33	-0.27
Employment status of primary cook			
Farming job	-0.04	-0.04	-0.06
	-0.13	-0.16	-0.1
Employed	-0.17	-0.1	-0.12
	-0.15	-0.15	-0.1
Cooking aspects			
# of meals	0.1	0.13	0.14**
	-0.08	-0.1	-0.06
Satisfaction with stove	-0.02	-0.03	-0.03
	-0.04	-0.04	-0.03
# of primary cooks	0.15*	0.1	0.12*
	-0.08	-0.07	-0.06
Type of fuel used			
Use charcoal	0.05	-0.04	-0.003
	-0.12	-0.15	-0.1
Use LPG	-0.3	-0.15	-0.19
	-0.23	-0.26	-0.17
Other			
Wealth index	0.07	0.03	0.05*
	-0.05	-0.05	-0.03
Tanzania	-0.52	-0.02	-0.28
	-0.51	-0.68	-0.47
Kenya	1.96***	0.47	1.38**
	-0.37	-0.95	-0.58
Zambia	0.27	2.07***	2.05***

	-0.3	-0.33	-0.23
Endline	-0.28***	-0.64***	-0.47***
	-0.1	-0.1	-0.07
Hybrid diary			-0.21***
			-0.07
Constant	3.84***	4.05***	4.07***
	-0.44	-0.5	-0.32
Observations	1,663	1,832	3,495
R-squared	0.108	0.175	0.121

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Notes: Standard errors are clustered at the village level. Enumerator fixed effect and village fixed effect are omitted in this table but included in the analysis. Columns (1) and (2) display the results of comparing the time measurement captures by the “stylized” time use questions with that recorded using traditional and hybrid time diaries, respectively. Column (3) represent the results with pooled sample.

7. Discussion

In this study, the time discrepancies as recorded by three distinct time use methods for six distinct activities are examined. Additionally, we conducted an investigation of the respondent, household, contextual, and survey-related variables that are associated with the time differences between “stylized” time use questions and two types of time diaries (traditional and hybrid), among respondents who completed the former and one of the latter two.

When comparing the time measurements, the main result is that there is significant difference in time use that is recorded across time use methods. Figure 2 illustrates this discrepancy, showing that the variation in average reported cooking time is minimal, whereas for four other crucial activities—fuel collection and preparation, household chores, unpaid work on own farm, and paid work—the discrepancies are more pronounced when measured by three distinct time use methods. This disparity is likely due to differential recall bias across the various methods. Specifically, the "stylized" time use questions, which inquire about daily activity times in a typical day, must be adjusted based on the reported frequency of these activities. This adjustment process opens up possibilities for mistakes in both the reported time spent on activities and their frequency. Recall bias can also be a threat in the other two time diaries, however. In traditional time diary, respondents may misreport the duration of time use. For the hybrid time diary, the challenge lies in the distribution of tokens, particularly when some activities are of short duration or occur alongside primary activities, a scenario often that would appear common for activities such as household chores.

Subsequent analysis focused on the pairwise correlations between the "stylized" time use question measures and those obtained from the a) traditional time diary and b) hybrid time diary. The results are mostly positively and statistically significant, especially in the pooled country

sample. However, the correlations are modest, and never exceed 0.5. negative correlations were also observed, possibly due to errors by enumerators or misunderstandings by respondents, issues that become more apparent in comparison with the hybrid time diary, where in the traditional time diary, enumerators aid in reclassifying activities based on the respondents' descriptions. The pairwise correlation results can only suggest the consistency or the degree of agreement of time measurements across three distinct time use methods, rather than the precision or accuracy of the time measurements for each activity.

The further investigation into the time discrepancies also conveys information. As for the characteristics of primary cook, we found that higher education levels tended to correlate with smaller discrepancies for fuel preparation and acquisition, indicating that education may enhance time perception for fuel activities. However, these findings did not extend to time reported for cooking. Age of the primary cook also played a role in fuel time use, with middle aged and older primary cooks reporting smaller discrepancies in cooking time, possibly due to their longer experience doing this activity. Time use agency, as measured by the flexibility of time allocation, shows consistent, significant, and negative correlation with time gaps. There is a possible reason explaining this: increased cognitive load from jumping from multiple activities without control can interfere with time perception and recall. The negative correlation between working on a farm or being employed and a smaller cooking time gap in time use reporting can be attributed to the nature of employment status that individuals who are employed or engaged in farming often have structured schedules and routines, thereby reducing the discrepancies in time use.

The behaviours of fuel related activities and cooking activity also explain the time gap across time use methods. First, a larger number of meals per day correlates with larger time discrepancies, implying that more cooking activities may lead to challenges in reporting consistent

time use on cooking activity. Secondly, having multiple primary cooks in a household correlates with larger discrepancies in reported cooking times, implying that more cooks create confusion over cooking duration estimates, particularly to the main primary cook. For time use in fuel collection and preparation, we found that a number of collection-related variables were highly determinant in positively explaining these differences: more frequent firewood acquisition, time spent per trip acquiring fuelwood, and fuelwood collection (rather than purchase). Some of these results might occur by construction, since infrequent activities entail lower time use, on average, and the time per trip increases the amount of time devoted to the activities. Individuals may be more uncertain or make larger errors in time use reports when activities are more time consuming. The type of firewood acquisition (either exclusively purchase or exclusively collect) is also associated with the consistency of time reporting, with smaller discrepancies among those who exclusively purchase fuel. This result is perhaps due to the nature of purchasing firewood, which is more structured than firewood collection in real life, or may again reflect the lower time requirements of fuel purchases.

Household characteristics are also associated with time differences. The wealth index showed mixed effects: higher wealth was correlated with smaller fuel time differences, but conversely, was associated with larger cooking time differences. Other relevant factors included the type of time diary completed; the discrepancy observed between time use as measured by the hybrid time use diary and the “stylized” time use questions appeared to be larger than the discrepancy noted between time use as measured by the traditional time diary and the “stylized” time use questions. However, this correlation is only found significant for the time use in fuel preparation and acquisition. Meanwhile, discrepancies were lower at endline for cooking, but larger

for fuel time. The former may stem from greater familiarity and experience with the time use elicitation at endline, but the latter suggests that experience along does not explain the trend.

8. Conclusion

This study, conducted in the context of sub-Saharan African, underscores the critical issue of time poverty among women, by focusing on their disproportionate burden of uncompensated work (i.e., cooking and fuel-related activities). The findings of study reveal significant discrepancies in time use data across different time use methods, and shed light on the complexities of consistently capturing how women allocate their time to daily tasks. These discrepancies reflect the issues of gender inequality, social economic constraints and inadequacies inherent in prevalent time use methods.

There are also limitations of this study. First, the application of logarithmic and IHS transformations to the dependent variables create challenges to interpretation. While these transformations are necessary to handle skewed data, the transformed nature makes it difficult to directly understand the marginal effects from the estimated coefficient. Second, the reliability of time use data generated from the “stylized” time use questions is venerable, such as the potential for recall errors by respondents who may not remember their activities accurately, and unit errors by enumerators. These factors should be taken into consideration when evaluating the findings of the study.

However, this study is important because our findings reveal significant variations in reported time measurements across three distinct time use methods, indicating that relying on a single time use method to collect time use could potentially cause substantial biases. These biases can then, further obscure the true status of women’s uncompensated work and its impact on well-being, health status, economic opportunities. In terms of implications, first, the study highlights the need for a nuanced approach when assessing women’s unpaid work in sub-Saharan Africa and suggests that multiple time use methods should be employed to capture a comprehensive picture of

time allocation in order to gain more credibility of conclusions. Second, in practice, in order to alleviate potential bias, enumerator training needs to be carefully organized to emphasize the purposes and processes of distinct time use methods, as well as providing solutions to challenges to valid implementation. Third, based on the study, it is challenging to recommend one method over the others outright, as each has its strengths and weaknesses depending on the activity being measured and the context. However, it seems prudent to use a combination of methods for a more reliable assessment and a more confident conclusion of time savings from improved cooking stoves because it is evident that there are discrepancies among three distinct time use methods. Fourth, future innovation in time use methods that address issues shared by these three distinct time use methods, including cognitive biases, enumerator error and recall issues, could provide a more definitive answer on the best method for such studies. Studies could also investigate the impact of these biases on our understanding of women's economic contributions and well-being.

Appendix A

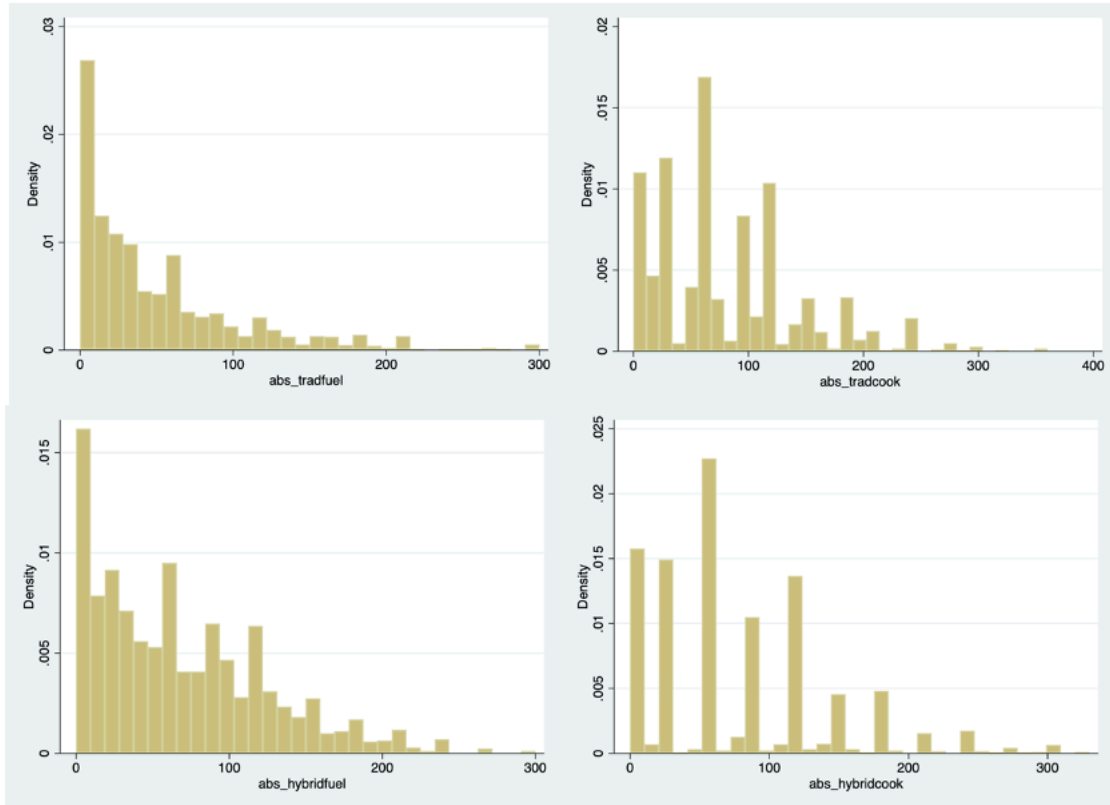


Figure 5. Absolute time differences between the "stylized" time use questions and a) traditional time diary b) hybrid time diary

Appendix B

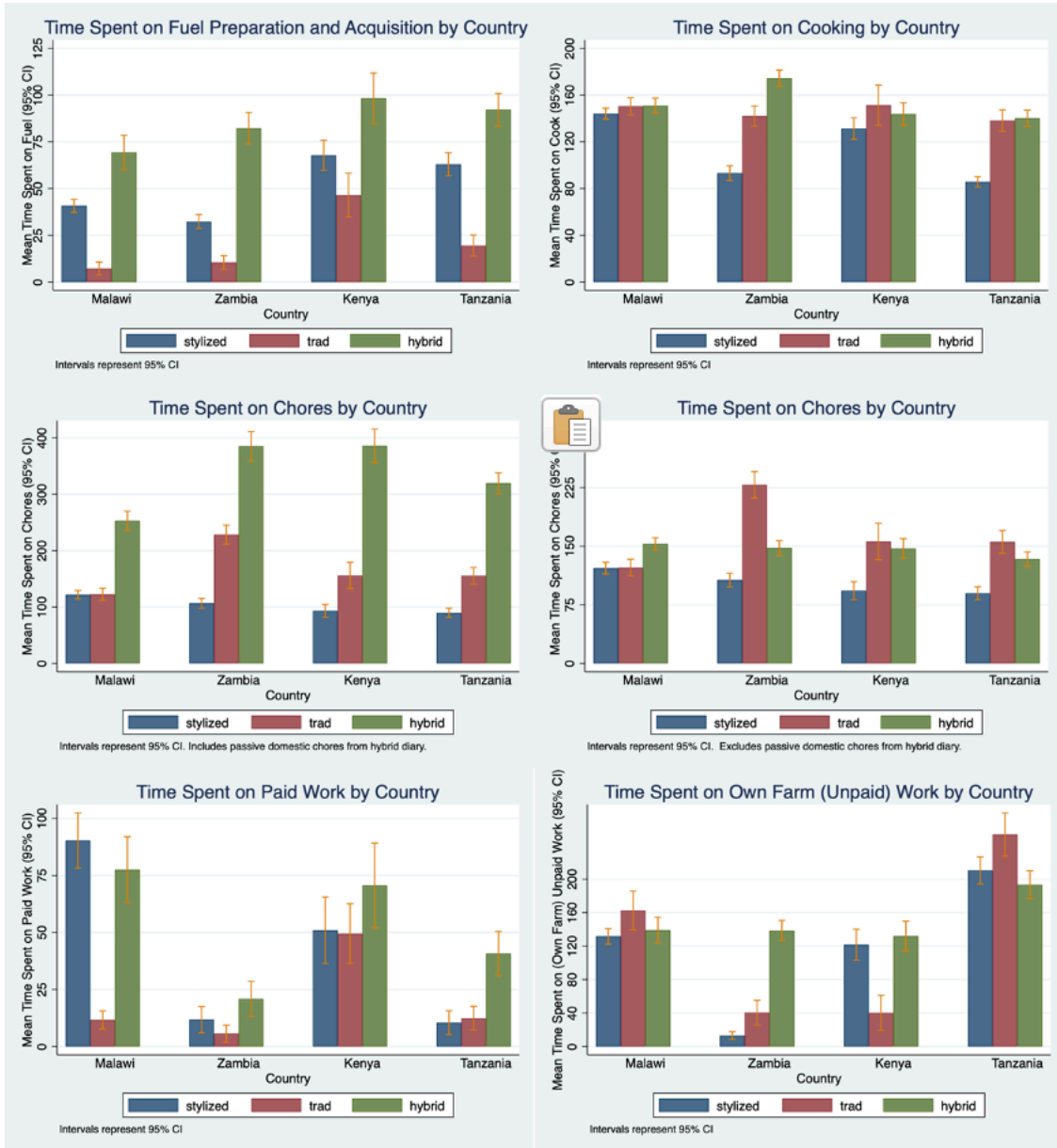


Figure 6: Endline time use measured in five major activity categories by country: a) fuel acquisition and preparation; b) cooking; c) unpaid work; d) domestic chores; and e) paid work.

Appendix C

Survey 1. Household responsibility and time module I (“stylized” time use questions):

For all households

Ask the questions for each of the activities provided below:

- a. Fuel collection or acquisition (purchase and transport to home from market)
- b. Fuel preparation
- c. Cooking (including helping with cooking)
- d. Other work in the kitchen (food preparation or cleaning)
- e. Other household chores (other domestic chores, including shopping, water collection, and care for household members)
- f. Tending / herding of animals
- g. Work on own farm
- h. Income generation (regular job, day labor, work for hire, or home production of goods/services for sale)

3.1.	For each activity X (from list above where X=a-h)									
S.no	3.2X. Does [Name] participate in the activity X in any season, in terms of time use? (Yes, regularly...1, Yes but only rarely...2, and No...3)	3.3X. If "1" in 3.2X, ask: Is the time spent on activity X by [NAME] different in the rainy vs. dry season?	3.4X. How often does [Name] participate in activity X for the household in dry season? [1] Every day [2] 3-4 times in a week [3] 2 times in a week [4] Once a week [5] 2-3 times in a month [6] Once in a month [7] Less than once in a month	3.5X. In a typical day when [NAME] participates in activity in dry season, how much time does [Name] spend on activity X? Record amount and specify unit: [1] Minutes [2] Hours	3.6X. Only if "1" in 3.3X, ask: How often does [Name] participate in activity X for the household in the rainy season? [1] Every day [2] 3-4 times in a week [3] 2 times in a week [4] Once a week [5] 2-3 times in a month [6] Once in a month [7] Less than once in a month	3.7X. Only if "1" in 3.3X, ask: In a typical day when [NAME] participates in activity in the rainy season, how much time does [Name] spend on activity X? Record amount and specify unit: [1] Minutes [2] Hours	Amount	Unit	Amount	Unit
1 Primary Cook										
2 Adult Females (>15)										
3 Adult Males (>15)										
4 Adolescent Girls (<15)										
5 Adolescent Boys (<15)										

Survey 2. Traditional Time Diary (Randomly assigned to subset of households)

Enumerator, please complete the following with the respondent. I would like to ask you how you spend your day yesterday. Please begin by telling me, when did you wake up? (Enumerator, mark the time on the schedule below, with an “x”). At what time did you go to sleep at night? (Enumerator, mark this time on the schedule below, with an “x”. Then ask about the primary activities for all times between the “x” marks. If an activity lasts longer than one period, draw an arrow over all of those times).

Time	Main activity	Time	Main activity	Time	Main activity	Time	Main activity
00:00		06:00		12:00		18:00	
00:15		06:15		12:15		18:15	
00:30		06:30		12:30		18:30	
00:45		06:45		12:45		18:45	
01:00		07:00		13:00		19:00	
01:15		07:15		13:15		19:15	
01:30		07:30		13:30		19:30	
01:45		07:45		13:45		19:45	
02:00		08:00		14:00		20:00	
02:15		08:15		14:15		20:15	
02:30		08:30		14:30		20:30	
02:45		08:45		14:45		20:45	
03:00		09:00		15:00		21:00	
03:15		09:15		15:15		21:15	
03:30		09:30		15:30		21:30	
03:45		09:45		15:45		21:45	
04:00		10:00		16:00		22:00	
04:15		10:15		16:15		22:15	
04:30		10:30		16:30		22:30	
04:45		10:45		16:45		22:45	
05:00		11:00		17:00		23:00	
05:15		11:15		17:15		23:15	
05:30		11:30		17:30		23:30	
05:45		11:45		17:45		23:45	

Codes:

001	Sweeping / cleaning home	011	Collecting firewood	021	Teaching / educating children
002	Washing utensils/plates	012	Collecting other fuel (residues, dung, etc.)	022	Child care (feeding, bathing)
003	Dung cleaning / sanitation	013	Working on own farm	023	Preparing and taking children to and from school
004	Washing clothes	014	Gathering vegetables or items from own farm	024	Milk lactation / breastfeeding
005	Collecting water	015	Shopping for purchase of food or other items	025	Grooming (washing self, brushing teeth, washing face)
006	Other household chores	016	Preparing food or goods for sale in market or elsewhere	026	Resting (sleep, napping, sitting)
007	Making tea or boiling water	017	Working on others' farm	027	Watching TV/listening to radio
008	Cooking food for household (using stove)	018	Animal care (grazing, herding, feeding)	028	Conversing with friends /family
009	Preparing food for household (not using stove)	019	Other work for money (incl. non-farm labor)	029	Studying / reading for oneself
010	Eating or drinking	020	Travel (includes walking)	030	Worship/pray

Survey 3. Hybrid Time Diary (Randomly assigned to a different subset of households)

Kindly recollect the activities that you took part in since you woke up yesterday. I am going to ask you about the time you spent on these activities – sleeping, unpaid labor, paid labor, cooking, fuel collection/preparation, leisure/socializing, self-care (like bathing), childcare, and household chores.

(Show pictures and briefly explain each activity type).

Do you have any questions about any of these categories? If respondent says yes, re-explain the categories in question. If Respondent says no, move forward.

1. When did you sleep the day before yesterday and what time did you wake up yesterday?

(Surveyor: allocate the appropriate number of tokens to the sleep card)

Now, you will divide the remaining chips across these activities based on how much time you spent on each category. There is no need to be exact; you can give us approximate time spent on these activities. Not all categories need to have tokens, but you must allocate all 48 tokens. Also, if you spent time on some other activity that you do not think falls in these categories, please leave those tokens aside based on the time you spent on that other activity. (The respondent will now take the remaining tokens and approximate their time use based on the different categories).

If the respondent has left some tokens aside: I see you have left some tokens to the side. What activities did you have in mind for these tokens? Enumerators: if the other activity falls into one of the existing categories, allocate them to the correct activity (for example “repairing the roof” would fall under “household chore”. If it is another activity, record in the “Other” section.

Ask the respondent: Please examine the allocation of tokens across primary tasks. Does the allocation look reasonable, based on the previous day? If no, ask the respondent to shift to an allocation that would be more accurate, and record that allocation:

3	3	3	3	3	3	3	3	3
.9a. Sleep	.9b. Unpaid labor	.9c. Paid labor	.9d. Cooking	.9e. Fuel collection/preparation	.9f. Leisure/socializing	.9g. Self-care	.9h. Childcare	.9i. Household chores

Surveyor instructions: Multi-tasking categories –

Give respondent tokens in a different color. Explain to the respondent: Please consider whether you were ever doing multiple activities at the same time, where some activities are more “passive” than others, or happening in the background. These activities could be passive childcare, passive leisure/ socializing, or passive household chores, where the main activity requiring attention is different, but the “passive” activity is possible at the same time as the main activity.

Please note that by passive childcare we mean you were simply supervising your child but were primarily involved in some other activity. Do not confuse this with active childcare. For example, you placed x (Enumerator: read the number of tokens allocated to cooking) tokens on cooking. Let’s say you also supervised your child who was playing next to you for half that time—that would count as passive childcare. You would then allocate y (Enumerator: read the number of tokens placed on cooking divided by two) tokens on the cooking category. For each activity above (except sleep), allocate the number of tokens on categories in which you were participating in passive childcare.

Record tokens allocated for:

	a	b	c	d	e	f.	g	h	i.
Passive activity	. Sleep	. Unpaid labor	. Paid labor	. Cooking	. Fuel collection/ preparation	Leisure/ socializing	. Self-care	. Childcare	Household chores
3 .11Childcare									

Passive socializing or leisure is when you are talking with friends or family while mostly doing another activity. For example, if you were collecting firewood for 1 hour and you spent time with a neighbor or friend during that hour, that would count as passive socializing. Please allocate the number of tokens on categories during which you participated in passive socializing/leisure.

P	a	b	c	d	e	f.	g	h	i.
Passive Activity	. Sleep	. Unpaid labor	. Paid labor	. Cooking	. Fuel collection/ preparation	Leisure/ socializing	. Self-care	. Childcare	Household chores
3.1 2 Passive Leisure/Socializing	X					X			

Finally, you can sometimes do some household chores while participating in other major activities we have placed tokens underneath. For example, if you were cooking for 3 hours, and while you were cooking you also swept the floor, that would count as a passive chore. Please allocate the number of tokens on categories during which you participated in passive household chores.

P	a	b	c	d	e	f.	g	h	i.
Passive Activity	. Sleep	. Unpaid labor	. Paid labor	. Cooking	. Fuel collection/ preparation	Leisure/ socializing	. Self-care	. Childcare	Household chores
3.1 3 Passive Household Chores	X								X

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