



Sharing the Load: How Do Coresident Children Influence the Allocation of Work and Schooling in Northwestern Tanzania?

Sophie Hedges¹ · David W. Lawson² · Jim Todd^{1,3} · Mark Urassa³ · Rebecca Sear¹

Published online: 9 September 2019
© Population Association of America 2019

Abstract

Economic and evolutionary models of parental investment often predict education biases toward earlier-born children, resulting from either household resource dilution or parental preference. Previous research, however, has not always found these predicted biases—perhaps because in societies where children work, older children are more efficient at household tasks and substitute for younger children, whose time can then be allocated to school. The role of labor substitution in determining children’s schooling remains uncertain, however, because few studies have simultaneously considered intrahousehold variation in both children’s education and work. Here, we investigate the influence of coresident children on education, work, and leisure in northwestern Tanzania, using detailed time use data collected from multiple children per household ($n = 1,273$). We find that age order (relative age, compared with coresident children) within the household is associated with children’s time allocation, but these patterns differ by gender. Relatively young girls do less work, have more leisure time, and have greater odds of school enrollment than older girls. We suggest that this results from labor substitution: older girls are more efficient workers, freeing younger girls’ time for education and leisure. Conversely, relatively older boys have the highest odds of school enrollment among coresident boys, possibly reflecting traditional norms regarding household work allocation and age hierarchies. Gender is also important in household work allocation: boys who coreside with more girls do fewer

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s13524-019-00818-x>) contains supplementary material, which is available to authorized users.

✉ Sophie Hedges
sophie.hedges@lshtm.ac.uk

¹ Department of Population Health, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, UK

² Department of Anthropology, University of California, Santa Barbara, CA, USA

³ National Institute of Medical Research, Mwanza, Tanzania

household chores. We conclude that considering children as both producers and consumers is critical to understanding intrahousehold variation in children's schooling and work.

Keywords Education · Tanzania · Children's work · Household composition · Birth order

Introduction

Time allocation can differ substantially between coresident children, especially in modernizing populations where children attend school while contributing to the household economy. This variation has important long-term implications for individual well-being, economic, and reproductive success. Children's time in both school and work offers opportunities for human capital generation and potential exposure to risks, such as the lack of parental supervision or dangerous work activities (Bock 2002). Demographers, economists, and anthropologists have long been interested in intrahousehold differences in time allocation, including variation by birth order and age order (i.e., relative age within a household). Time allocated to education is frequently framed as a measure of parental investment: it is costly both directly and through the opportunity costs of children's lost work contributions. Taking this perspective, economists and evolutionary anthropologists have predicted that parents will favor earlier-born children, either as an inadvertent consequence of household resource dilution or strategic parental preference (Edmonds 2006; Hertwig et al. 2002; Jeon 2008).

Economic models of parental investment focus on siblings as competitors for finite parental resources, predicting a trade-off between the number of dependents and investment in each one—that is, a quantity-quality trade-off (Becker 1960). In studies of educational outcomes, this perspective is also referred to as *resource dilution theory* (Downey 2001). Children in larger families are predicted to be disadvantaged, with later-born children particularly disadvantaged because unlike earlier-born offspring, they experience sibling competition for finite parental resources without a period of exclusive parental investment (Hertwig et al. 2002; Parish and Willis 1993). Later-born children may also experience a period of lower competition after older siblings leave the parental home, but exclusivity in parental attention is generally deemed more influential in early childhood (Hertwig et al. 2002). Families may also get wealthier over their life cycle, which could advantage later-borns, but this effect is better considered an impact of parental age rather than birth order (Lawson and Mace 2009).

Evolutionary anthropologists have also modelled the trade-off between quantity and quality of offspring (Lawson and Borgerhoff Mulder 2016), generally predicting early-born advantage. An evolutionary perspective predicts that parents act to maximize their inclusive fitness (i.e., the long-term production of descendants) via both direct reproduction and assisting their relatives. As a consequence, parents are predicted to bias investment toward offspring with the greatest likelihood of survival and successful reproduction (Trivers 1972). Within a sibship, earlier-born children are closer to maturity and have lower mortality risk than later-borns, and therefore have greater reproductive value (expected number of future children), so that parents can be more certain of the payoff to their investment (Jeon 2008; Sear 2011). Furthermore, biased

investment in earlier-born children is anticipated in growing populations, where fitness is maximized by minimizing generation time (Jones and Bliege Bird 2014).

A close focus on parental investment, however, neglects the fact that in subsistence contexts, children are typically producers as well as consumers (Kramer 2002, 2005, 2011). Indeed, opposing predictions about time allocation to education arise from models taking children's work as their starting point, with parents anticipated to allocate children's time to optimize overall household production. Children's time allocation changes with age; very young children devote time largely to leisure as they begin to develop skills by learning through play. Their ability to carry out productive work increases with age as they gain strength and skill (Bock 2002; Gurven and Kaplan, 2006; Kramer 2005). In households with multiple children, earlier-born (i.e., relatively older) children are expected to be more productive (and in the case of paid work, command higher wages) and consequently are predicted to be preferentially allocated work. If earlier-born children are more likely to be allocated work, this should free later-born children's time to attend school. A focus on labor substitution therefore predicts, in opposition to parental investment biases, that later-born children will be more likely to be enrolled in school (Basu and Van 1998; Edmonds 2006; Lee and Kramer 2002).

With models of parental investment and labor substitution making contrasting predictions, our attention turns to the empirical literature. Research has found mixed results about the influence of coresident children on children's time spent in school and work. This may arise from a focus on either education or work rather than both simultaneously, preventing an explicit consideration of the role of labor substitution in determining education outcomes. Here, we take a holistic approach to children's time allocation and simultaneously investigate how the presence of coresident children influences children's time spent in education, work, and leisure in northwest Tanzania. As such, we overcome an important methodological limitation common across many prior studies of children's time allocation. We also promote theoretical synthesis by using an adapted version of embodied capital theory, an integrated theoretical framework that draws on both economic and evolutionary models of parental investment (Kaplan 1996; Kaplan et al. 2015). Specifically, embodied capital theory predicts that parents will strategically allocate time and resources across the household to optimize long-term investment in children. This parental investment is aimed at maximizing parental reproductive success (or at least, parental behavior is shaped by mechanisms that in the past have maximized reproductive success). Despite this assumption that individuals' behavior is shaped by maximizing long-term reproductive success, in practice other outcomes, such as education or income, are typically used as proxies of fitness, aligning these models with conventional economic approaches (Kaplan et al. 2015). The economic literature also draws attention to the short-term needs of the household, highlighting the trade-off between producing enough to sustain the household in the present and investing in children's education and skills for the future (Edmonds 2006). Here, then, we assume that children's time allocation is shaped both by parental investment biases toward those who will produce the greatest returns in the long-term and by decisions to preferentially allocate work to those who are currently most productive or for whom other uses of time are least valuable. Such allocation may be influenced by both parents' and children's decisions (Gurven and Kaplan 2006).

We review evidence regarding birth/age order and children's time allocation from previous empirical studies of low-income settings where education and children's work

coexist. We then outline our predictions regarding educational investment and children's work at our study site, where we anticipate strong scope for labor substitution effects in children's time allocation, given the important contributions that children make to the household economy in this setting (Hedges et al. 2018). We also extend prior research by investigating the influence of all coresident children—not just siblings—because in this context (as in many others), a high proportion of children are coresident with children other than siblings. Throughout, we integrate a consideration of the gendered aspects of labor substitution, stratifying our analyses by gender and testing whether coresident children of the same and opposite sex play specific roles. Prior research in this region has confirmed that children's work is highly gendered, with girls taking on the majority of household tasks, and boys predominantly involved in farming work (Hedges et al. 2018). As such, our study has implications for understanding both birth/age order and gender biases in modernizing contexts.

Prior Research on Birth/Age Order and Children's Time Allocation

Studies of high-fertility subsistence populations have reported evidence for preferred investment in earlier-born children, with later-born males receiving lower wealth transfers at marriage and inheritance in many contexts (e.g., Borgerhoff Mulder 1998; Gibson and Gurmu 2011; Hrdy and Judge 1993; Mace 1996). On the other hand, detailed longitudinal work on children's work among Mayan agriculturalists highlights the role of labor substitution, with children taking on different roles as a family matures. Here, earlier-born children's work subsidizes later-born children while they are too young to contribute; then as later-born children grow and become more productive, earlier-born children leave home (Kramer 2005; Lee and Kramer 2002). These results are not necessarily incompatible because investment in adulthood (e.g., wealth transfers at marriage) does not conflict with time allocation during childhood.

Educational investment, on the other hand, necessarily conflicts with work contributions to the household. Studies from Brazil, Nicaragua, Guatemala, Nepal, and Ethiopia have suggested that investment and time allocation patterns reflect labor substitution, with earlier-born children working more and being less likely to be in school (Dammert 2010; Emerson and Souza 2008; Fafchamps and Wahba 2006; Haile and Haile 2012). Other studies, generally using aggregated, nationally representative data sets, have found that earlier-born children had lower educational attainment or reduced school attendance and have attributed this to hypothesized labor substitution effects (Huisman and Smits 2015; Kumar 2016; Lindskog 2013; Lloyd and Gage-Brandon 1994; Parish and Willis 1993; Rammohan and Dancer 2008; Ryan et al. 2017). However, smaller-scale studies in Ethiopia, Malawi, and Tanzania found that later-born children received less educational investment (Gibson and Lawson 2011; Gibson and Sear 2010; Hedges et al. 2016). These early-born biases were more evident in wealthier households, perhaps because demand for child labor is lower among these households reducing scope for labor substitution.

All these studies are cross-sectional, making it difficult to account for how households may be strategic about the timing of investment and household time allocation, potentially levelling out differences between children over the household life cycle. Studies in South Africa and Malawi have reported that earlier-born children progress through school faster, suggesting that parents may invest more in older children so that

they complete their education faster and then become available to substitute for younger children's work (Liddell et al. 2003; Moyi 2010). Similarly, in Kenya, earlier-born children attain more education, but this effect is lessened in larger families, possibly because older siblings who complete their education are able to work and thus subsidize younger siblings' education (Gomes 1984).

Labor substitution effects are therefore not mutually exclusive from investment biases and may differ by gender if boys and girls have different patterns of work. In many modernizing contexts, children's work is predominantly household chores and childcare. These are often female responsibilities, and girls generally work more than boys, meaning that labor substitution effects may be seen more strongly for girls than for boys (Edmonds 2006). Several studies have found evidence of earlier-born disadvantage in schooling or workload for girls but not boys (Dammert 2010; Edmonds 2006; Glick and Sahn 2000; Heissler and Porter 2010; Kevane and Levine 2003; Parish and Willis 1993; Rosati and Rossi 2003). Additionally, some studies have suggested that having sisters is particularly beneficial for schooling (Canagarajah and Coulombe 1993; Morduch 2000).

The question of how the presence of substitute workers affects children's work and education thus remains complicated. As noted earlier, a key limitation of previous studies is their focus on education; very few have examined work patterns within households, making it difficult to assess the extent to which differences by birth order represent labor substitution or effects such as parental investment biases. Where work is investigated, many studies have looked only at paid or farm work rather than household chores (e.g., Emerson and Souza 2008; Patrinos and Psacharopoulos 1995), often using a binary outcome indicating whether a child works, which may obscure the nuances of intrahousehold time allocation. Studies are also often limited to how biological siblings influence each other (e.g., Huisman and Smits 2015), but in contexts with child fostering and alternative living arrangements, this neglects many of the substitute workers available to children. Finally, although large, nationally representative data sets are important in identifying large-scale trends, smaller-scale studies that compare multiple households within a similar subsistence context avoid the potential for confounding between individual and group-level variables (i.e., the ecological fallacy) (Lawson and Ugglia 2014). We build on previous literature from anthropology, economics, and demography, using detailed data on children's time allocation and education in an area undergoing rapid modernization in Tanzania. Reflecting the high levels of fostering in this context, we include all children of school age within a household.

Setting and Predictions

In Tanzania, government primary schools do not charge school fees, but families pay costs, such as uniforms, stationery, and exam fees. Children generally start school at age 7, although delayed entry and grade repetition are common. There are seven years of primary education, four years of basic secondary education, and two years of advanced secondary education. The quality of schooling is a cause for concern in Tanzania; pass rates for secondary school exams are as low as 40 %, and many children leaving primary school are unable to read or write (Hivos/Twaweza 2014; Pritchett 2013). In interviews with local teachers, the lack of school infrastructure and equipment

was frequently cited as a challenge, with teachers struggling to maintain discipline in large classes. During focus groups, adolescents and parents cited the long distances to school and harsh punishments (including beatings) as challenges to school attendance. Youth unemployment is common, and some parents complained that having attended school, children were no longer willing to help with farming activities and often sat idle at home.

In Tanzania, fostering is common, even for children who have both parents alive. Many children reside with grandparents or other relatives because it provides them better access to school, provides help with household work, or aligns with family preferences (see also Lawson et al. 2017). In our sample, only 65 % of children are the biological children of the household head, meaning that a large proportion of children live in alternative arrangements (Hedges et al. 2019). Even among children who are the biological children of the household head, many live with school-age stepsiblings, half-siblings, cousins, or nieces and nephews. We therefore do not focus on number of siblings or birth order but instead look at age rank within the household, defining children resident in the same household as potential substitute laborers according to their relative age and gender.

Children who are relatively older within the household are likely to be more efficient than younger children at various productive tasks, and previous research has shown an increase in work with age (Hedges et al. 2018). We therefore expect that households will favor allocating older children's time to production, freeing younger children's time for school:

Prediction 1: Increasing age order (i.e., living with older children) will be associated with increased probability of enrollment in school, decreased time spent in work, and increased leisure time.

Furthermore, those who are not enrolled in school are expected to substitute for the labor of children who are enrolled. Thus, we predict the following:

Prediction 2: Those not enrolled in school will work more when coresident children are enrolled in school, and schoolchildren will work less when coresident children are not enrolled.

Finally, in Sukuma society, work is gendered: domestic work and childcare are predominantly carried out by girls and women, and farm work and cattle herding are male activities (Hedges et al. 2018; Varkevisser 1973). We therefore predict the following:

Prediction 3: For both enrolled and unenrolled children, the number of opposite-gender children will reduce time spent in gender-inappropriate work; the number of girls will reduce the time boys spend in household chores, and in households that farm or keep cattle, the number of boys will reduce the time girls spend in farm work.

These predictions assume that within a household, members have similar priorities, and that children have similar levels of autonomy in their time allocation. However, these

assumptions may not hold completely in this context. In focus groups, we heard several anecdotes of conflict between parents or guardians and children who did not wish to attend school, and children who wanted to attend school but could not because of responsibilities at home. Additionally, it was noted that older teenagers, particularly boys, have more freedom in determining their time allocation. Age and gender effects may therefore also reflect differing levels of autonomy between children.

Data and Methods

Data Collection

The data collection for this study took place at the Kisesa Health and Demographic Surveillance Site (HDSS) in Mwanza region, northwestern Tanzania. The HDSS was set up in 1994 to collect demographic data in an area comprising six villages (Kishamawe et al. 2015). For this study, data were collected in two of the six villages, representing the most- and least-rural villages in the HDSS. The Sukuma are the main ethnic group in the area. Households were traditionally reliant on farming and cattle herding and lived in dispersed homesteads, but livelihoods have diversified such that many families are engaged in petty trading and small businesses. The least-rural village is now better described as a town, situated on a main road, with public transport links to the city and a central market. In the most-rural village, the majority of households continue to farm, and many own cattle (Hedges et al. 2018).

The HDSS provided a sampling frame of all households at the previous round of data collection, together with the ages of household members. This sampling frame was then restricted to households with members aged 7–19 (the ages of formal schooling in Tanzania), from which 550 households were randomly sampled. Households are self-defined in the HDSS as “a group of people living together in the same compound, who regularly eat together from the same pot” (Kishamawe et al. 2015:1852). Data collection was carried out by three fieldworkers who had all previously been trained and employed at the HDSS (only two conducted surveys at any given time). Fieldworkers each had one day of training one-to-one with the lead author who was managing data collection. Training emphasized the need for consistency across interviews and the need to take a nonjudgmental and sensitive approach, and presented hypothetical scenarios to check for the fieldworker’s understanding of the goals of the research. At the beginning of the study, one fieldworker was trained, and then the other fieldworkers observed a day’s worth of interviews, in addition to undergoing office-based training. This extensive training ensured a consistent script and approach between interviewers.

Household surveys were carried out using Google Nexus 7 tablets with Open Data Kit (ODK) Collect software (Brunette et al. 2013). The survey recorded information about household members’ age and gender; adult members’ education and occupation; and the household head’s marital status, ethnicity, and religion. Then a series of questions was asked about the household’s assets, landownership and uses, livestock ownership, and business involvement. Based on observations made during fieldwork, assets were defined as *basic* (chair, bed, mosquito net), *intermediate* (bicycle, radio, sofa, cupboard, clock, or sewing machine), or *high-value* (TV, refrigerator, or

motorbike). This was followed by a set of nine questions pertaining to food security, based on the Food and Agricultural Organization (FAO) Household Food Insecurity and Access Scale (Coates et al. 2007). For each child in the household aged 7–19, an additional survey was answered by their parent or guardian, collecting information on their parents' marital status, education, and occupation; their siblings (although not whether siblings are coresident); education; and work history.

Of a total of 1,387 eligible children, 1,278 children were followed up (92.1 %). The majority of those not followed up were away at boarding school (3.8 % of total sample) or traveling (2.6 %). Five additional children were dropped from the analysis: three who were listed as the spouse of the household head, and two who were employees of the household. Direct observation of activities through scan sampling is generally preferable to time diary methods because it avoids recall error and social desirability bias, and provides a representative description of all activities (Altmann 1974; Baksh 1989; Borgerhoff and Caro 1985). However, practical difficulties in conducting scan samples due to large distances between households and ethical concerns precluded the use of observation. Many time allocation studies use proxy reports, but this can lead to underestimation of time spent working (Dammert and Galdo 2013; Dillon et al. 2010; Janzen 2018). We therefore asked children to self-report their activities on the previous weekday (or the previous Friday if the interview was done on a Monday), from when they woke up until they went to sleep. Time use was recorded on a diagram, with rows corresponding to different activities and columns corresponding to half-hour periods. The time and duration of different activities were indicated by shading the corresponding cells (Fig. 1). Data from the diagrams were coded into broader categories, including household chores, farm work, market work, and leisure time (see the next section). We acknowledge the problems associated with self-report data as well as recall bias associated with time allocation reporting. It is likely that there may be some overestimation of school enrollment and attendance because of the social desirability of education in this area. Children's recall of their time allocation may also include some error if, for example, habitual or short-duration activities are overlooked or if children overreport time spent working. During interviews, fieldworkers were able to cross-check some timings—for example, meals or leaving for school—between children within the same household, reducing some recall error. The short time frame for recall,



Fig. 1 Time allocation diagram.

of a maximum three days previously but primarily just one day, should also reduce recall error. We include a binary variable indicating whether the time allocation interview was done on a Monday or another day in time allocation analyses to account for the longer recall period for children interviewed on a Monday, who were asked about the previous Friday rather than answering “yesterday” as for other days.

Outcome Variables

Whether a child was enrolled in school at the time of the study is used as a binary outcome, *enrolled*, where 1 indicates that the child was enrolled. Time use was recorded in half-hour blocks, from 5 a.m. to 12 a.m., giving a maximum of 38 blocks (equivalent to 19 h) for any given activity. For each activity category, the outcome is therefore the total count of half-hour blocks spent in that activity. The activity categories used are as follows. *Education* includes travel to and from school, school time, and studying after school. *Household chores* include cleaning, cooking, collecting water or fuel, childcare, running errands, and food processing. *Farm work* includes *cattle herding* (also treated as a separate category in some analyses), working in the fields, feeding animals, and milking. *Market work* includes any work done outside the household: for example, petty trading, shop-keeping, and making things to sell (e.g., baskets, doughnuts, ice lollies). *Overall work* is the total sum of household chores, farm work, and market work. Finally, *leisure time* includes playing, watching TV, resting or sleeping, and visiting friends or family.

Explanatory Variables

Ordering children residing in the same household by age and gender enabled us to sum the number of older and younger children for each child and the number of older and younger boys and girls. Within households, the numbers of boys and girls enrolled in school were summed to give the total number of schoolboys and girls, and this number was subtracted from the total number of children in the household to give the number of out-of-school children. Similarly, the numbers of boys and girls within households were summed to give the total number of male and female children. We generated an *age order* variable by numbering children so that the eldest child in the household has age order 1, the second child has age order 2, and so on. We also generated an *age order by gender* variable by ordering girls and boys separately by age and numbering them.

Data Analysis

Multiple children are sampled per household. However, likelihood-ratio tests comparing multilevel models with ordinary least squares regression indicate limited evidence for differences between model forms (online appendix, Table S2), and exploratory analyses confirm that multilevel analysis does not substantively alter our overall pattern of results. For enrollment analyses, we therefore use logistic regression models. Distributions of time use data usually contain many zeros. An individual child may not engage in certain activities—for example, a child who is not enrolled in school does not spend time in education, and a child whose household does not keep cattle does not spend time cattle herding—thus leading to structural zeros. Additionally, sampling

zeros arise because a child may not do the activity during the sampling period. These zeros violate the assumption of normality, making common approaches, such as linear regression or tobit models, inappropriate. Additionally, time use data are often right-skewed and overdispersed. The Poisson-gamma distribution, or negative binomial regression, is more flexible and can model both exact zeros and a continuous component, so this is the approach we use here (Brown and Dunn 2011).

Analyses are stratified by gender, but we do not directly test for differences in outcomes between boys and girls because we have explored this in detail elsewhere (Hedges et al. 2018). We include covariates that we believe to be associated with the explanatory variables and outcomes of interest. Child's age is associated with both work and education; previous work suggested a linear relationship between age and work as well as a U-shaped relationship between age and education (Hedges et al. 2018). We investigated using an age-squared term, but this had no impact on the overall results; for simplicity, then, we present analyses using the linear age term. In this area, fostering is relatively common, with many children living with close kin (mainly grandparents) and a few with more distant relatives. Because older children are more likely to be fostered, we include a control for child residence (with parents, close kin, or distant kin) in age order analyses and repeat age order analyses for nonfostered children only in order to investigate whether age order effects are separate from fostering effects. We include a variable indicating town or village residence. Household resource availability is likely to be associated with household composition and to affect educational investment and time allocation. In this context, food security was thought to be the best measure of household resources because it provides a contemporary measure of resource availability, meaningful across the different livelihoods in this area. We also use a categorical asset variable, indicating whether households own basic, intermediate, or higher-value assets.

We use the number of older children as a predictor together with the number of younger children to compare the effects of having older substitutes with the effects of having younger children for whom to substitute. However, we do not include a variable indicating the total number of children in the household to avoid overadjusting. To further compare the effects of being later-born independently of the total number of children, we run additional sensitivity analyses (see the online appendix), with models including the overall age variable and the total number of children in the household, acknowledging that there is some multicollinearity between variables. We finally conduct additional analyses to explore age order effects in more detail by using a categorical age order variable to compare oldest, middle, and youngest children. All analyses are carried out in Stata.

Results

Household and Child Characteristics

Household size varies widely, with a mean of 7.6 members and 3.1 children aged 7–19 (Table 1). Nearly three-quarters of households participate in farming (i.e., grow crops or keep animals), and roughly one-quarter of households keep cattle. Nineteen percent of households have only basic assets, 59 % have intermediate assets (such as a bicycle or a

Table 1 Descriptive statistics on household characteristics

Household Composition	Mean (SD)/%	Range
Household Size (mean)	7.6 (3.1)	2–19
Children Aged 7–19 (mean)	3.1 (1.7)	1–10
Household Characteristics (%)		
Residence		
Village	52.3	
Town	47.7	
Household farms		
No	26.6	
Yes	73.4	
Household keeps cattle		
No	73.9	
Yes	26.1	
Household assets		
Higher-value	21.4	
Intermediate	59.2	
Basic	19.4	
Household is food-insecure		
No	50.3	
Yes	49.7	
<i>N</i>	441	

radio), and 21 % have higher-value assets (such as a TV or refrigerator). Approximately one-half of households are classed as food insecure.

Eighty-one percent of children are currently enrolled in school, with enrollment being higher for girls (Table 2; see also Hedges et al. 2018). Very few children in our sample have no siblings. Approximately one-third have only full siblings, just more than one-half have both full siblings and half-siblings, and roughly 12 % have only half-siblings. However, because the household roster is completed with household members' relationship to the household head, we do not have direct information on the relationships of household members to one another, and we cannot therefore be sure which children have resident siblings or half-siblings. Among the 26 % of children who live apart from their parents, most live with close kin (grandparents, aunts, or uncles), and some live with more-distant kin. Girls are more likely than boys to live with distant kin.

Seven percent of children have no coresident children aged 7–19; girls are more likely than boys to be an only child (chi-squared = 3.7, $p = .06$). We exclude these children from our main analyses because they do not have substitute laborers available. Boys who are only children are marginally more likely to be enrolled than other boys; girls who are only children do not differ in their enrollment but do spend more time in household chores than girls with coresident children (Table S1, online appendix).

Table 2 Descriptive statistics on child characteristics, by gender

	Male	Female	Total
<i>N</i>	632	641	1,273
Currently Enrolled in Education (%)			
No	20.6	17.5	19.0
Yes	79.4	82.5	81.0
Age Order Within Household (%)			
Only child	5.5	8.3	6.9
Oldest	26.3	22.8	24.5
Middle child	41.5	40.9	41.2
Youngest	26.7	28.1	27.4
Child Lives With (%)			
Parent(s)	76.1	72.4	74.2
Close kin	18.1	18.9	18.5
Distant kin	5.9	8.7	7.3
Types of Siblings (%)			
No siblings	3.2	3.0	3.1
Only half-siblings	10.0	13.1	11.5
Only full siblings	35.8	32.0	33.9
Full siblings and maternal half-siblings	15.3	14.8	15.1
Full siblings and paternal half-siblings	26.1	25.6	25.8
Full siblings and both maternal and paternal half-siblings	9.7	11.5	10.6

Prediction 1: Increasing Age Order (Living With Older Children) Will Be Associated With Increased Enrollment, Decreased Work, and Increased Leisure Time

We find different effects of the number of older children for boys and girls (Table 3 and Fig. 2). For boys, in contrast to our prediction, an increasing number of older children (both boys and girls) is associated with a lower probability of enrollment, although this association is not statistically significant. The number of younger children in the household, however, is associated with a greater probability of enrollment. For girls, the association is consistent with our prediction; the number of older children in the household increases the probability of enrollment. The same associations are seen when looking at number of older or younger children of the same gender. The effects of the age order variables echo these findings; increasing age order is associated with lower probability of enrollment for boys and higher probability of enrollment for girls (results shown in the online appendix, Table S2). For both genders, living in town (vs. village) and having more household assets increase the probability of being enrolled; while these associations are not always significant, the odds ratios indicate a greater effect for boys than for girls. There is some suggestion that being fostered by distant kin is negative for enrollment, and increasing age is associated with lower odds of being enrolled.

We further predicted that living with older children would be associated with doing less work and having more leisure time. Table 4 presents the incidence rate ratios (IRR)

Table 3 Models testing Prediction 1, that increasing age order (i.e., living with more older children) will be associated with higher odds of school enrollment, run separately for boys and girls and adjusting for (1) number of younger and older children and (2) number of younger and older children of the same gender

	Boys		Girls	
	(1)	(2)	(1)	(2)
Number of Younger Children	1.38** [1.11,1.72]		1.08 [0.87,1.33]	
Number of Older Children	0.90 [0.70,1.16]		1.58* [1.08,2.31]	
Number of Younger Boys/Girls		1.45** [1.12,1.88]		0.91 [0.69,1.22]
Number of Older Boys/Girls		0.84 [0.61,1.16]		1.62† [0.95,2.75]
Child Lives With (ref. = parent(s))				
Close kin	0.82 [0.41,1.63]	0.75 [0.38,1.48]	2.06 [0.81,5.24]	2.06 [0.82,5.17]
Distant kin	0.50 [0.18,1.38]	0.53 [0.19,1.51]	0.44† [0.18,1.08]	0.46† [0.19,1.12]
Household Food Security	1.04† [0.99,1.09]	1.04† [0.99,1.09]	1.04 [0.99,1.10]	1.04 [0.99,1.10]
Household assets (ref. = basic)				
Higher-value	2.87* [1.01,8.17]	3.11* [1.10,8.82]	1.52 [0.48,4.84]	1.80 [0.57,5.67]
Intermediate value	1.81† [0.91,3.58]	1.94† [0.99,3.82]	1.62 [0.69,3.81]	1.83 [0.78,4.28]
Town (ref. = village)	5.40*** [2.73,10.67]	5.04*** [2.60,9.75]	2.53* [1.23,5.19]	2.39* [1.17,4.87]
Age (years)	0.56*** [0.49,0.64]	0.58*** [0.52,0.65]	0.53*** [0.45,0.62]	0.53*** [0.45,0.61]
<i>N</i>	590	590	578	578

Notes: Data shown are odds ratios (exponentiated coefficients) from logistic regression models. Values in brackets are 95 % confidence intervals.

†*p* < .10; **p* < .05; ***p* < .01; ****p* < .001

from negative binomial regression models of overall work and leisure time (for boys) and chores and leisure time (for girls). The IRR indicates the effect of the independent variable on the expected number of events. For example, in the first column, a boy enrolled in school experiences 0.3 times the events (half-hours of work) that an out-of-school boy experiences. For both genders, there is little association between the overall number of older and younger children and time spent in work or leisure time. However, because work is primarily shared between children of the same gender, it may be more relevant to examine the effect of older and younger children of the same gender. Again, for boys, there is little association between number of older and younger boys and work

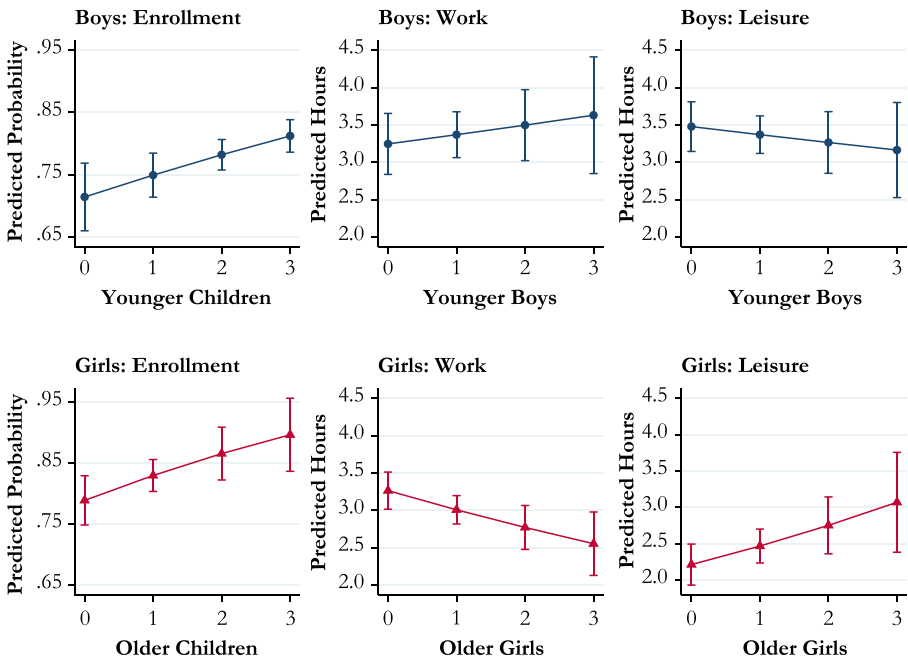


Fig. 2 Results from models testing Prediction 1, that increasing age order will be associated with higher odds of school enrollment, less time spent in work, and more time spent in leisure. Models were run separately for boys and girls. School enrollment models show the predicted probability of school enrollment from logistic regression models. Work and leisure models show predicted hours from negative binomial regression models. Also shown are 95 % confidence intervals.

or leisure time, although there is a nonsignificant trend of more work and less leisure as the number of younger boys increases (Fig. 2). For girls, the number of older children is associated with marginally more leisure time (Table 4), and the number of older girls is associated with less time spent doing chores and more time spent in leisure (Fig. 2). Models using age order and age order by gender give similar results; there are no associations between age order and work or leisure time for boys or girls, but increasing age order among household girls is associated with more chores and less leisure time for girls, with oldest girls doing more chores and having least leisure time overall (online appendix, Table S3). Additionally, girls who live only with boys appear to do slightly more work and have slightly less leisure time, and boys who reside only with girls appear to do slightly less productive work (online appendix, Fig. S1).

There is some evidence for labor substitution between girls, with both older girls and those living only with boys working more. This appears to improve school enrollment for girls living with more older girls. For boys, however, the association between number of older children and enrollment is the opposite of that predicted, with little evidence of labor substitution of older boys for younger ones—perhaps because cattle herding is traditionally allocated to younger boys. We therefore test for an interaction between cattle ownership and number of younger boys to see whether the positive effect of younger boys on enrollment is confined to households that own cattle, but the interaction is not significant (Table 5). We then look at time spent herding in

Table 4 Models testing Prediction 1, that increasing age order (i.e., living with more older children) will be associated with less time spent in work and more time spent in leisure, run separately for boys and girls and adjusting for (1) number of younger and older children and (2) number of younger and older children of the same gender

	Boys		Girls		Boys		Girls	
	Total Work	Leisure	Chores	Leisure	Total Work	Leisure	Chores	Leisure
	(1)				(2)			
Number of Younger Children	1.04 [0.97,1.12]	1.02 [0.96,1.09]	0.99 [0.94,1.04]	0.98 [0.91,1.06]				
Number of Older Children	0.98 [0.92,1.05]	1.01 [0.96,1.07]	0.99 [0.94,1.03]	1.07† [1.00,1.14]				
Number of Younger Boys/Girls					1.04 [0.94,1.14]	0.97 [0.89,1.05]	1.02 [0.95,1.09]	0.98 [0.87,1.09]
Number of Older Boys/Girls					0.99 [0.90,1.09]	1 [0.93,1.08]	0.92* [0.86,0.99]	1.12* [1.01,1.23]
Child Lives With (ref. = parents(s))								
Close kin	1.02 [0.81,1.27]	0.94 [0.78,1.14]	1 [0.86,1.18]	1.04 [0.83,1.31]	1.01 [0.81,1.27]	0.96 [0.79,1.17]	1 [0.86,1.18]	1.05 [0.83,1.31]
Distant kin	1.14 [0.81,1.61]	1.19 [0.89,1.60]	1.07 [0.87,1.33]	1.51* [1.10,2.08]	1.14 [0.81,1.60]	1.20 [0.90,1.61]	1.08 [0.87,1.33]	1.50* [1.09,2.06]
Enrolled (ref. = no)	0.34*** [0.27,0.43]	0.45*** [0.37,0.56]	0.58*** [0.49,0.70]	0.24*** [0.18,0.33]	0.34*** [0.27,0.43]	0.46*** [0.38,0.57]	0.58*** [0.49,0.69]	0.24*** [0.18,0.32]
Household Food Security	1.01 [0.99,1.02]	0.99 [0.98,1.00]	1 [0.99,1.01]	1.02† [1.00,1.03]	1 [0.99,1.02]	0.99 [0.98,1.00]	1 [0.99,1.01]	1.02* [1.00,1.03]
Household Assets (ref.= basic)								
Higher-value	0.91 [0.65,1.26]	1.11 [0.84,1.47]	0.81† [0.64,1.03]	1.08 [0.76,1.53]	0.91 [0.66,1.27]	1.14 [0.86,1.50]	0.82 [0.65,1.04]	1.09 [0.77,1.55]

Table 4 (continued)

	Boys		Girls		Boys		Girls	
	Total Work	Leisure	Chores	Leisure	Total Work	Leisure	Chores	Leisure
	(1)				(2)			
Intermediate value	0.95 [0.75,1.20]	1.09 [0.89,1.34]	0.94 [0.80,1.12]	0.92 [0.72,1.19]	0.95 [0.75,1.20]	1.12 [0.91,1.37]	0.94 [0.79,1.11]	0.94 [0.73,1.21]
Town (ref.= village)	0.71** [0.58,0.87]	1.07 [0.90,1.26]	0.98 [0.85,1.13]	0.98 [0.80,1.20]	0.71*** [0.57,0.87]	1.05 [0.88,1.24]	0.99 [0.86,1.13]	0.97 [0.79,1.20]
Monday Interview (ref. = other day)	0.92 [0.73,1.15]	1 [0.82,1.21]	1.01 [0.87,1.18]	0.94 [0.75,1.18]	0.91 [0.72,1.14]	1 [0.82,1.21]	1.02 [0.88,1.19]	0.93 [0.74,1.17]
Age (years)	0.98 [0.95,1.03]	0.94*** [0.90,0.97]	1.05** [1.02,1.08]	0.88*** [0.84,0.92]	0.99 [0.96,1.03]	0.95*** [0.92,0.97]	1.03* [1.01,1.06]	0.87*** [0.84,0.91]
N	590	590	578	578	590	590	578	578

Notes: Data shown are odds ratios (exponentiated coefficients) from logistic regression models. Values in brackets are 95 % confidence intervals.

† $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

households that own cattle, to look for evidence of younger boys substituting for older boys' herding work. Having more younger boys in the household is associated with less time spent herding. This suggests that younger boys may substitute for older boys' herding.

Table 5 Models further exploring Prediction 1, that the number of younger boys will be associated with higher odds of school enrollment in cattle-owning households and in cattle-herding households, with less time spent herding: Boys only

	Enrollment (odds ratios) ^a	Time Spent Herding (incident rate ratios) ^b
Number of Younger Boys	1.37 [†] [0.98,1.91]	0.75* [0.57,0.99]
Cattle-Owning Household (ref. = no cattle)	0.70 [0.33,1.49]	
Cattle-Owning Household × Number of Younger Boys	1.12 [0.72,1.76]	
Number of Older Boys	0.86 [0.62,1.18]	0.92 [0.57,1.49]
Child Lives With (ref. = parent(s))		
Close kin	0.75 [0.38,1.50]	0.98 [0.33,2.90]
Distant kin	0.54 [0.19,1.52]	0.71 [0.11,4.56]
Household Food Security	1.04 [†] [0.99,1.09]	1.08 [†] [1.00,1.17]
Household Assets (ref. = basic)		
Higher-value	3.38* [1.16,9.85]	0.06** [0.01,0.50]
Intermediate value	2.03* [1.01,4.06]	0.68 [0.19,2.49]
Town (ref. = village)	4.40*** [2.11,9.15]	0.28 [0.04,2.13]
Age (years)	0.58*** [0.52,0.65]	0.82* [0.71,0.96]
Enrolled (ref. = no)		0.27* [0.09,0.79]
Monday Interview (ref. = other day)		0.96 [0.37,2.52]
<i>N</i>	590	220

Note: Values in brackets are 95 % confidence intervals.

^a From logistic regression models.

^b From negative binomial regression models.

[†] $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

Prediction 2: Substitution Between Schoolchildren and Out-of-School Children

Our second prediction was that out-of-school children would work more in households with more schoolchildren, whereas schoolchildren would work less in households with more out-of-school children. For out-of-school girls, living with more schoolboys marginally decreases time spent doing chores (Table 6). This is the opposite of what we expected. Out-of-school girls may take on schoolboys' other tasks, such as farming or market work, with schoolboys taking on girls' chores, which are more easily combined with school. However, we do not find other evidence of this: for example, schoolboys do not affect out-of-school girls' time spent in farm work (results not shown). In line with our prediction, we do see that out-of-school girls do more chores when there are more schoolgirls, suggesting that they may be preferentially allocated household chores. We find no evidence that the number of out-of-school children is associated with reduced work for schoolchildren (online appendix, Table S4).

Table 6 Models testing Prediction 2, that out-of-school children will work more when coresident with more schoolchildren, run separately for out-of-school boys and out-of-school girls and adjusting for (1) number of schoolboys and (2) number of schoolgirls

	Out-of-School Boys		Out-of-School Girls	
	(1)	(2)	(1)	(2)
Number of Schoolboys	1.04 [0.93,1.17]		0.87 [†] [0.75,1.01]	
Number of Schoolgirls		0.97 [0.85,1.11]		1.23** [1.06,1.43]
Number of School-Aged Children	1.01 [0.91,1.11]	1.03 [0.95,1.12]	0.98 [0.89,1.08]	0.86** [0.78,0.95]
Household Food Security	1 [0.98,1.02]	1 [0.98,1.02]	1 [0.98,1.02]	1 [0.97,1.02]
Household Assets (ref. = basic)				
Higher-value	1.52 [0.88,2.62]	1.54 [0.88,2.69]	0.90 [0.58,1.40]	0.88 [0.57,1.35]
Intermediate value	1.07 [0.81,1.43]	1.08 [0.81,1.44]	1.07 [0.76,1.51]	1.02 [0.73,1.43]
Town (ref. = village)	0.52*** [0.37,0.73]	0.51*** [0.36,0.73]	1.32* [1.01,1.73]	1.28 [†] [0.99,1.67]
Monday Interview (ref. = other day)	1.01 [0.71,1.43]	1.01 [0.71,1.43]	1.13 [0.82,1.56]	1.12 [0.82,1.54]
Age (years)	1.02 [0.98,1.05]	1.02 [0.98,1.06]	1.04 [0.98,1.11]	1.04 [0.98,1.10]
<i>N</i>	124	124	103	103

Notes: Data shown are incident rate ratios. Values in brackets are 95 % confidence intervals.

[†] $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

Prediction 3: Substitution Between Boys and Girls for Gendered Work

Finally, we predicted that girls would reduce boys' time spent in chores and that boys would reduce girls' time spent in farm work. Figure 3 indicates that girls do appear to substitute for boys' chores, with boys living with five coresident girls spending roughly two hours less per day doing household chores compared with boys living with no coresident girls. Although the trend for girls suggests that boys do substitute somewhat for girls' farm work, this result does not reach statistical significance (online appendix, Table S5), perhaps because girls and boys do different types of farm work. The confidence intervals for girls living with one or zero boys are also very large, suggesting that farming households may have more boys, meaning it is rare for girls to live in farming households with few boys. Households that farm do have slightly more boys on average (1.6 compared with 1.3, $t = -1.79$, $p = .04$), which may explain the lack of strong evidence that boys substitute for girls' farm work.

Discussion

We investigated predictions derived from embodied capital theory regarding the distribution of investment and economic theory on labor substitution. Our first prediction was that (relatively) older children within households would be preferentially allocated work and therefore be less likely to be enrolled in school. We found support for this prediction for girls only: older girls are preferentially allocated work, and the presence of older girls is associated with a higher probability of school enrollment for younger girls, who also spend less time in household chores and more time in leisure. For boys, we found the opposite: boys with more younger boys in the household have the highest odds of school enrollment. Older boys do not work less than younger boys, however,

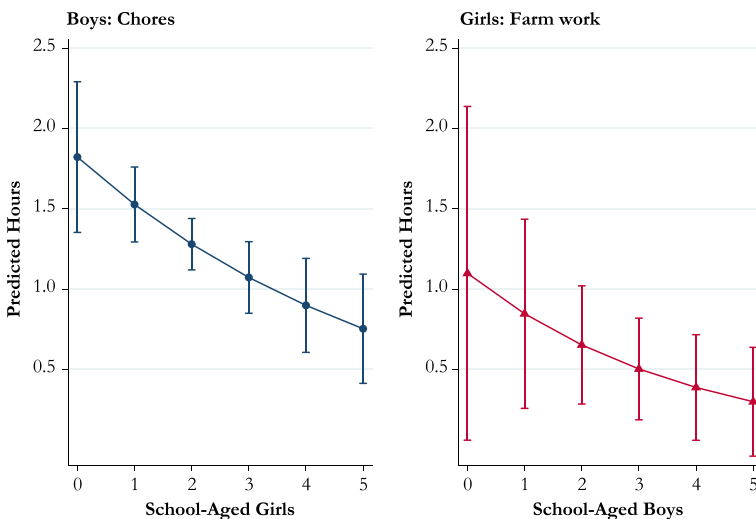


Fig. 3 Results from models testing Prediction 3, that the number of coresident opposite-gender children will reduce time spent in gender-inappropriate work. Models were run separately for boys and girls and show predicted hours of work from negative binomial regression models. Also shown are 95 % confidence intervals.

except that younger boys in cattle-owning households are preferentially allocated herding work, suggesting that younger boys may be substituting for the labor of older boys in cattle-herding households at least. We discuss our interpretation of this pattern of results in the next subsection.

Our second prediction was that out-of-school children would substitute for the work of schoolchildren, whose time spent in other activities, such as studying, might be more valuable. Overall, we did not find strong support for this prediction, although out-of-school girls do work more when there are more schoolgirls in the household, suggesting that they may be taking over some of the schoolgirls' chores. Schoolchildren did not work less in households with out-of-school children. This may be because household responsibilities are valued as part of a child's socialization and duties to their household, with past work among the Sukuma noting that parents believe that children should help their household in order to stop them getting spoiled (Varkevisser 1973). During our study, the majority of parents or guardians agreed that it is important and useful for children to help with household work. Work may therefore also be a way for children to gain embodied capital in the form of skills or experience that they cannot learn in school, and so parents may perceive that household work is beneficial for all children rather than preferring that unenrolled children substitute for schoolchildren.

Finally, we predicted that labor substitution would be gendered, given established differences in male and female work in this context (Hedges et al. 2018). Supporting our prediction, we found that the availability of girls within a household reduces the time spent by boys in household chores. We found less evidence that boys substitute for girls in farm work. This may be due to preferential fostering of boys into farming households, although we lack supporting data to test this conjecture. It may also reflect lower autonomy of girls, who may be less able to avoid being allocated work.

Why Are Results More Consistent With Labor Substitution for Girls Than for Boys?

We predicted that work would be preferentially allocated to older individuals because skill and strength generally increase with age, meaning that older individuals will be more efficient. For girls, this is the pattern that we observed. Given that our analyses are based on cross-sectional data, it is possible that this finding partially reflects cohort effects, such as increasing education rates or changes in children's work. However, given that it is boys' farm work that has changed the most in recent years (rather than girls' domestic work, which has remained similar) and given that these results remain after adjustment for child age, we are not convinced that these age order patterns can be explained as cohort effects. In contrast to girls, boys seem to benefit in terms of school enrollment when more younger boys are available in a household. This cannot easily be explained by younger boys substituting for older boys' work: only in cattle-owning households is the number of younger boys associated with older boys doing less work.

This pattern is the opposite of what we predicted: labor substitution models predict that more skilled or productive individuals should be preferred for household labor. It may instead reflect traditional practices regarding inheritance and age hierarchies within families. In traditional Sukuma law, early-born sons were favored, inheriting more land and taking the role of household head if their father died (Varkevisser 1973). This early-born preference is also in line with evolutionary predictions about parental investment biases. In this area, a son's marriage requires parents to pay brideprice,

whereas a daughter's marriage brings cattle or money into the household. Parents may therefore delay certain sons' marriages in order to afford the brideprice, whereas daughters' marriages are less restricted. Because earlier-born boys can marry earlier, prioritizing their marriage and reproduction gives the greatest return to investment in the long term. A similar pattern was observed among Gabbra pastoralists in Kenya, where older sons had much higher reproductive success than younger sons, but daughters' reproduction was not much influenced by birth order (Mace 1996). This preference for earlier-born sons may also manifest in the allocation of work to younger sons where possible, to free older sons' time for other activities, or just to relieve them from the discomforts of tasks such as cattle herding. This tradition of a family age hierarchy appears to continue into the present day, with parents preferring to invest in earlier-born boys' education.

A lack of strong labor substitution effects overall for boys echoes findings from our previous study, which showed minimal trade-offs between work and school for boys not involved in herding work (Hedges et al. 2018). In the local area, livelihoods have shifted away from subsistence agriculture, and landholdings and herd sizes have decreased, reducing the demand for boys' work (Wijsen and Tanner 2002). This appears to make boys' everyday work quite compatible with school, eliminating the need for substitution between boys not in cattle-owning households.

Girls' labor substitution fits better with predictions from embodied capital models. Household chores such as food processing and cooking may be more sensitive to the gains in efficiency associated with gains in skill. Additionally, chores are frequently combined with being responsible for any other children present. In this case, it is beneficial to have the most senior girl available to do this because she will have the most experience and authority. The value of older girls' work was also seen in our previous study, in which the trade-off in time allocation between work and school was much greater among older than younger girls, suggesting that the opportunity costs of girls' work increase with age (Hedges et al. 2018).

Birth Order, Education, and Modernization

Labor substitution effects may help to explain some of the varied results regarding differential investment by birth order reviewed in the Introduction. Where children are still producers, their work contributions are likely to influence decisions about investment in education, favoring children whose work is less important to the household. However, as livelihoods shift away from subsistence agriculture toward market integration or formal work, and children's contributions become less important to their households, parents may invest more in earlier-born children. This may explain why early-born biases in education are more evident in industrialized countries, where children are primarily consumers and make negligible work contributions to their households (e.g., Price 2008; Steelman et al. 2002). Studies in lower-income settings have found that age order biases in education are more evident in wealthier households (Gibson and Lawson 2011; Gibson and Sear 2010; Hedges et al. 2016)—perhaps because wealthier households are less reliant on children's work given that they can hire outside help or because they are less reliant on subsistence farming.

Changes in age order biases may also help to explain the differing effects of family size on education during the course of the demographic transition. Economic theory predicts a

quantity-quality trade-off between family size and educational investment such that in larger families, fewer resources are available per child, and so children are less likely to be educated (Becker 1960). However, in many pre-transition societies, children are producers as well as consumers, alleviating the trade-off between quantity and quality of children (Kramer 2011). Across Africa, many studies actually reported a positive effect of the number of siblings or coresident children on schooling, perhaps because children have a lower individual burden of work (Al-Samarrai and Peasgood 1998; Chernichovsky 1985; Cornwell et al. 2005; Gomes 1984; Lloyd and Blanc 1996; Roth 1991). However, this effect appears to reduce and then reverse as modernization and fertility decline occur (Eloundou-Enyegue and Williams 2006; Marteleto 2010). In pre-transition settings, the payoffs to education are frequently uncertain because of poor quality schools and high youth unemployment, meaning that parents may benefit more by pursuing a bet-hedging strategy or by using older children's work to reduce the opportunity costs of younger children's schooling (Liddell et al. 2003). Both wealth and modernization improve the payoffs to education and reduce the value of children's work as households become less reliant on subsistence farming and no longer have to fetch water and fuel. As modernization occurs, it may therefore become more beneficial to parents to bias investment toward earlier-born children and ultimately to limit fertility.

Limitations

Data on household composition were collected through a household roster, with all individuals in the household linked to the household head. Thus, it is difficult to subsequently relate other individuals within the household to one another. We can link biological children of the household head together as siblings, but we do not know whether they are half- or full siblings; for other children, it is difficult to reconstruct relationships other than that with the household head. This is a common limitation of demographic data but one that has not often been questioned (Madhavan et al. 2017; Randall et al. 2011). An additional limitation of the household roster approach is that it assumes that household members have equal access to household resources (when in fact there may be within-household differences in food security or access to assets) and involvement in household decision-making (Randall et al. 2011).

This study is also limited by its cross-sectional nature, introducing the possibility that age differences may partially be explained by cohort effects—for example, by rising education rates or changes in children's work. Although we do not think that this is the case for reasons discussed earlier, longitudinal data would allow these trends to be more thoroughly investigated and enable changes over a household's lifetime to be investigated—for example, whether it is the timing or overall level of investment that differs by age order. If work tasks change considerably with age (rather than just skill or productivity in tasks), labor substitution might be expected to occur predominantly between children of similar ages, whereas children of different ages might specialize in different work. We do not have enough data on specific work tasks at different ages to investigate this here, but future work could further expand on age profiles of children's work and the effects of household age configurations—for example, comparing households with a wide age range of children with households with a narrower age range.

Finally, we examined only one measure of educational investment: school enrollment. Progression through school or academic attainment may show different associations with household composition.

Conclusion and Implications

Embodied capital theory frames education as a form of parental investment in children's embodied capital while also recognizing the role of work in children's skill acquisition and socialization. Research in this vein has focused primarily on the long-term benefits of educational investment and less on the short-term implications for children's time allocation in contexts where children's work remains valuable. By contrast, economic models of labor substitution have placed greater focus on the short-term costs and benefits of children's time allocation. Bringing together literature from both these fields, we frame both work and education as forms of embodied capital and consider how parental investment biases, alongside short-term economic considerations, affect children's time allocation. We demonstrate that the presence and characteristics of other coresident children have important implications for children's work and education. Work by relatively older girls enables younger girls to allocate more time to attend school, and out-of-school girls alleviate the burden of household chores for schoolgirls. For boys, traditional age hierarchies appear to favor older boys in education access, and a gendered allocation of household work is seen, with girls substituting for boys' household chores. This study highlights the complexities of decision-making regarding educational investment and children's time allocation in transitioning contexts, indicating that multiple factors influence these decisions, from the availability of substitute workers, the relative value of a child's work contributions according to their age and gender, to traditional gender and family norms. We reinforce the importance of including work in studies of children's education in modernizing contexts, particularly recognizing the value of children's work and its role in influencing education decisions within households.

Acknowledgments We thank the directors of the National Institute of Medical Research, Mwanza, for supporting this study; and our fieldwork team, especially Holo Dick, Pascazia Simon, and Vicky Sawalla, who conducted interviews. We extend special thanks to all our participants from Kisesa and Welamasonga and to the headteachers in the area who allowed us to conduct interviews in their schools. This work was supported by the UK Economic and Social Research Council through the Bloomsbury Doctoral Training Centre, Grant Reference Number 1360209. We are grateful for helpful comments and feedback from Abbey Viguier, Anushé Hassan, Alyce Raybould, Laura Brown, Susie Schaffnit, and four anonymous reviewers.

References

- Al-Samarrai, S., & Peasgood, T. (1998). Educational attainments and household characteristics in Tanzania. *Economics of Education Review*, *17*, 395–417.
- Altmann, J. (1974). Observational study of behavior: Sampling methods. *Behaviour*, *49*, 227–266.
- Baksh, M. (1989). The spot observations technique in time allocation research. *Cultural Anthropology Methods*, *1*(2), 1–3.
- Basu, K., & Van, P. H. (1998). The economics of child labor. *American Economic Review*, *88*, 412–427.

- Becker, G. S. (1960). An economic analysis of fertility. In National Bureau of Economic Research (Ed.), *Demographic and economic change in developed countries* (pp. 209–240). New York, NY: Columbia University Press.
- Bock, J. (2002). Evolutionary demography and intrahousehold time allocation: School attendance and child labor among the Okavango Delta Peoples of Botswana. *American Journal of Human Biology*, *14*, 206–221.
- Borgerhoff Mulder, M. (1998). Brothers and sisters. *Human Nature*, *9*, 119–161.
- Borgerhoff Mulder, M., & Caro, T. M. (1985). The use of quantitative observational techniques in anthropology. *Current Anthropology*, *26*, 323–335.
- Brown, J. E., & Dunn, P. K. (2011). Comparisons of Tobit, linear, and Poisson-gamma regression models: An application of time use data. *Sociological Methods & Research*, *40*, 511–535.
- Brunette, W., Sundt, M., Dell, N., Chaudhri, R., Breit, N., & Borriello, G. (2013). Open Data Kit 2.0: Expanding and refining information services for developing regions. In *ACM HotMobile '13: Proceedings of the 14th Workshop on Mobile Computing Systems and Applications* (article 10). Jekyll Island, Georgia: ACM. <https://doi.org/10.1145/2444776.2444790>
- Canagarajah, S., & Coulombe, H. (1993). *Child labor and schooling in Ghana*. (Ghana: Labor Markets and Poverty background paper). Washington, DC: World Bank.
- Chemichovsky, D. (1985). Socioeconomic and demographic aspects of school enrollment and attendance in rural Botswana. *Economic Development and Cultural Change*, *33*, 319–332.
- Coates, J., Swindale, A., & Bilinsky, P. (2007). *Household Food Insecurity Access Scale (HFIA) for measurement of household food access: Indicator guide* (v. 3). Washington, DC: FHI 360/FANTA.
- Cornwell, K., Inder, B., Maitra, P., & Rammohan, A. (2005). *Household composition and schooling of rural South African children: Sibling synergy and migrant effects* (Monash Economics working papers). Clayton, Australia: Department of Economics, Monash University.
- Dammert, A. C. (2010). Siblings, child labor, and schooling in Nicaragua and Guatemala. *Journal of Population Economics*, *23*, 199–224.
- Dammert, A. C., & Galdo, J. C. (2013). *Child labor variation by type of respondent: Evidence from a large-scale study* (IZA Discussion Paper No. 7446). Bonn, Germany: Institute for the Study of Labor.
- Dillon, A., Bardasi, E., Beegle, K., & Semeels, P. M. (2010). *Explaining variation in child labor statistics* (IZA Discussion Paper No. 5156). Bonn, Germany: Institute for the Study of Labor.
- Downey, D. B. (2001). Number of siblings and intellectual development. *American Psychologist*, *56*, 497–504.
- Edmonds, E. V. (2006). Understanding sibling differences in child labor. *Journal of Population Economics*, *19*, 795–821.
- Eloundou-Enyegue, P. M., & Williams, L. B. (2006). Family size and schooling in sub-Saharan African settings: A reexamination. *Demography*, *43*, 25–52.
- Emerson, P. M., & Souza, P. A. (2008). Birth order, child labor, and school attendance in Brazil. *World Development*, *36*, 1647–1664.
- Fafchamps, M., & Wahba, J. (2006). Child labor, urban proximity, and household composition. *Journal of Development Economics*, *79*, 374–397.
- Gibson, M. A., & Gurmu, E. (2011). Land inheritance establishes sibling competition for marriage and reproduction in rural Ethiopia. *Proceedings of the National Academy of Sciences*, *108*, 2200–2204.
- Gibson, M. A., & Lawson, D. W. (2011). “Modernization” increases parental investment and sibling resource competition: Evidence from a rural development initiative in Ethiopia. *Evolution and Human Behavior*, *32*, 97–105.
- Gibson, M. A., & Sear, R. (2010). Does wealth increase parental investment biases in child education? *Current Anthropology*, *51*, 693–701.
- Glick, P., & Sahn, D. E. (2000). Schooling of girls and boys in a West African country: The effects of parental education, income, and household structure. *Economics of Education Review*, *19*, 63–87.
- Gomes, M. (1984). Family size and educational attainment in Kenya. *Population and Development Review*, *10*, 647–660.
- Gurven, M., & Kaplan, H. (2006). Determinants of time allocation across the lifespan: A theoretical model and an application to the Machiguenga and Piro of Peru. *Human Nature*, *17*, 1–49.
- Haile, G., & Haile, B. (2012). Child labour and child schooling in rural Ethiopia: Nature and trade-off. *Education Economics*, *20*, 365–385.
- Hedges, S., Borgerhoff Mulder, M., James, S., & Lawson, D. W. (2016). Sending children to school: Rural livelihoods and parental investment in education in northern Tanzania. *Evolution and Human Behavior*, *37*, 142–151.

- Hedges, S., Sear, R., Todd, J., Urassa, M., & Lawson, D. W. (2018). Trade-offs in children's time allocation: Mixed support for embodied capital models of the demographic transition in Tanzania. *Current Anthropology*, 59, 644–654.
- Hedges, S., Sear, R., Todd, J., Urassa, M., & Lawson, D. W. (2019). Earning their keep? Fostering, children's education, and work in north-western Tanzania. *Demographic Research*, 41, 263–292. <https://doi.org/10.4054/2019.41.10>
- Heissler, K., & Porter, C. (2010). *Know your place: Ethiopian children's contributions to the household economy* (Working Paper No. 61). Oxford, UK: Young Lives.
- Hertwig, R., Davis, J. N., & Sulloway, F. J. (2002). Parental investment: How an equity motive can produce inequality. *Psychological Bulletin*, 128, 728–745.
- Hivos/Twaweza (2014). *Are our children learning? Literacy and numeracy across East Africa* (Report). Nairobi, Kenya: Twaweza.
- Hrdy, S. B., & Judge, D. S. (1993). Darwin and the puzzle of primogeniture: An essay on biases in parental investment after death. *Human Nature*, 4, 1–45.
- Huisman, J., & Smits, J. (2015). Keeping children in school: Effects of household and context characteristics on school dropout in 363 districts of 30 developing countries. *SAGE Open*, 5(4), 1–16. <https://doi.org/10.1177/2158244015609666>
- Janzen, S. A. (2018). Child labor measurement: Whom should we ask? *International Labour Review*, 157, 169–191.
- Jeon, J. (2008). Evolution of parental favoritism among different-aged offspring. *Behavioral Ecology*, 19, 344–352.
- Jones, J. H., & Blythe Bird, R. (2014). The marginal valuation of fertility. *Evolution and Human Behavior*, 35, 65–71.
- Kaplan, H. (1996). A theory of fertility and parental investment in traditional and modern human societies. *American Journal of Physical Anthropology: Yearbook of Physical Anthropology*, 39(S23), 91–135.
- Kaplan, H., Bock, J., & Hooper, P. L. (2015). Fertility theory: Embodied-capital theory of life history evolution. In J. Wright (Ed.), *International encyclopedia of the social & behavioral sciences* (2nd ed., pp. 28–34). Oxford, UK: Elsevier.
- Kevane, M., & Levine, D. I. (2003). *Changing status of daughters in Indonesia* (Working Paper No. C03-126). Berkeley: Center for International and Development Economics Research, University of California, Berkeley.
- Kishamawe, C., Isingo, R., Mtenga, B., Zaba, B., Todd, J., Clark, B., ... Urassa, M. (2015). Health & Demographic Surveillance System profile: The Magu Health and Demographic Surveillance System (Magu HDSS). *International Journal of Epidemiology*, 44, 1851–1861.
- Kramer, K. L. (2002). Variation in juvenile dependence: Helping behavior among Maya children. *Human Nature*, 13, 299–325.
- Kramer, K. L. (2005). Children's help and the pace of reproduction: Cooperative breeding in humans. *Evolutionary Anthropology: Issues, News, and Reviews*, 14, 224–237.
- Kramer, K. L. (2011). The evolution of human parental care and recruitment of juvenile help. *Trends in Ecology & Evolution*, 26, 533–540.
- Kumar, S. (2016). The effect of birth order on schooling in India. *Applied Economics Letters*, 23, 1325–1328.
- Lawson, D. W., & Borgerhoff Mulder, M. (2016). The offspring quantity-quality trade-off and human fertility variation. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 371, 20150145. <https://doi.org/10.1098/rstb.2015.0145>
- Lawson, D. W., & Mace, R. (2009). Trade-offs in modern parenting: A longitudinal study of sibling competition for parental care. *Evolution and Human Behavior*, 30, 170–183.
- Lawson, D. W., Schaffnit, S. B., Hassan, A., Ngadaya, E., Ngowi, B., Mfinanga, S. G. M., ... Borgerhoff Mulder, M. (2017). Father absence but not fosterage predicts food insecurity, relative poverty, and poor child health in northern Tanzania. *American Journal of Human Biology*, 29(3), 1–16.
- Lawson, D. W., & Uggla, C. (2014). Family structure and health in the developing world: What can evolutionary anthropology contribute to population health science? In M. Gibson & D. W. Lawson (Eds.), *Applied evolutionary anthropology: Darwinian approaches to contemporary world issues* (pp. 85–118). New York, NY: Springer.
- Lee, R., & Kramer, K. L. (2002). Children's economic roles in the Maya family life cycle: Cain, Caldwell and Chayanov revisited. *Population and Development Review*, 28, 475–499.
- Liddell, C., Barrett, L., & Henzi, P. (2003). Parental investment in schooling: Evidence from a subsistence farming community in South Africa. *International Journal of Psychology*, 38, 54–63.
- Lindskog, A. (2013). The effect of siblings' education on school-entry in the Ethiopian highlands. *Economics of Education Review*, 34, 45–68.

- Lloyd, C. B., & Blanc, A. K. (1996). Children's schooling in sub-Saharan Africa: The role of fathers, mothers, and others. *Population and Development Review*, 22, 265–298.
- Lloyd, C. B., & Gage-Brandon, A. J. (1994). High fertility and children's schooling in Ghana: Sex differences in parental contributions and educational outcomes. *Population Studies*, 48, 293–306.
- Mace, R. (1996). Biased parental investment and reproductive success in Gabbra pastoralists. *Behavioral Ecology and Sociobiology*, 38, 75–81.
- Madhavan, S., Myroniuk, T. W., Kuhn, R., & Collinson, M. A. (2017). Household structure vs. composition: Understanding gendered effects on educational progress in rural South Africa. *Demographic Research*, 37, 1891–1916. <https://doi.org/10.4054/DemRes.2017.37.59>
- Marteletto, L. (2010). Family size, adolescents' schooling and the demographic transition: Evidence from Brazil. *Demographic Research*, 23, 421–444. <https://doi.org/10.4054/DemRes.2010.23.15>
- Morduch, J. (2000). Sibling rivalry in Africa. *American Economic Review: Papers & Proceedings*, 90, 405–409.
- Moyi, P. (2010). Household characteristics and delayed school enrollment in Malawi. *International Journal of Educational Development*, 30, 236–242.
- Parish, W. L., & Willis, R. J. (1993). Daughters, education, and family budgets: Taiwan experience. *Journal of Human Resources*, 28, 863–898.
- Patrinós, H. A., & Psacharopoulos, G. (1995). Educational performance and child labor in Paraguay. *International Journal of Educational Development*, 15, 47–60.
- Price, J. (2008). Parent-child quality time: Does birth order matter? *Journal of Human Resources*, 43, 240–265.
- Pritchett, L. H. (2013). *The rebirth of education: Schooling ain't learning*. Washington, DC: Center for Global Development.
- Rammohan, A., & Dancer, D. (2008). Gender differences in intrahousehold schooling outcomes: The role of sibling characteristics and birth-order effects. *Education Economics*, 16, 111–126.
- Randall, S., Coast, E., & Leone, T. (2011). Cultural constructions of the concept of household in sample surveys. *Population Studies*, 65, 217–229.
- Rosati, F. C., & Rossi, M. (2003). Children's working hours and school enrollment: Evidence from Pakistan and Nicaragua. *World Bank Economic Review*, 17, 283–295.
- Roth, E. A. (1991). Education, tradition, and household labor among Rendille pastoralists in northern Kenya. *Human Organization*, 50, 136–141.
- Ryan, S., Koczberski, G., Curry, G. N., & Germis, E. (2017). Intra-household constraints on educational attainment in rural households in Papua New Guinea. *Asia Pacific Viewpoint*, 58, 27–40.
- Sear, R. (2011). Parenting and families. In V. Swami (Ed.), *Evolutionary psychology: A critical introduction* (pp. 215–250). West Sussex, UK: Wiley-Blackwell.
- Steelman, L. C., Powell, B., Werum, R., & Carter, S. (2002). Reconsidering the effects of sibling configuration: Recent advances and challenges. *Annual Review of Sociology*, 28, 243–269.
- Trivers, R. L. (1972). Parental investment and sexual selection. In B. Campbell (Ed.), *Sexual selection and the descent of man* (pp. 136–179). Chicago, IL: Aldine.
- Varkevisser, C. M. (1973). *Socialization in a changing society: Sukuma childhood in rural and urban Mwanza, Tanzania*. The Hague: Centre for the Study of Education in Changing Societies.
- Wijzen, F., & Tanner, R. (2002). *"I am just a Sukuma": Globalization and identity construction in northwest Tanzania*. Amsterdam, the Netherlands: Rodopi.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.